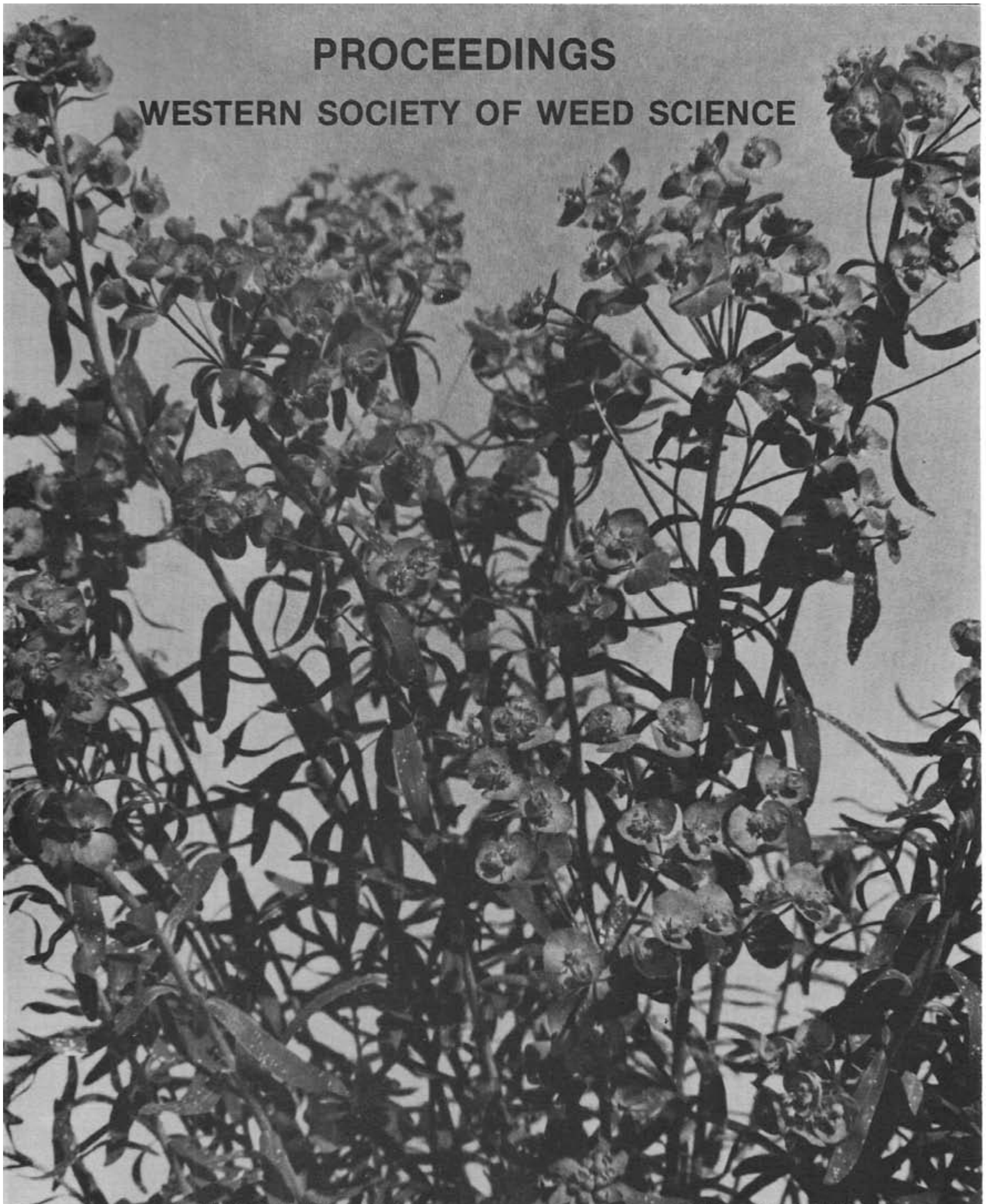
PROCEEDINGS

WESTERN SOCIETY OF WEED SCIENCE



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PROGRAM AND TABLE OF CONTENTS

THE NEXT 39 YEARS

Harvey D. Tripple[1]

PRESIDENTIAL ADDRESS

Last year, Stan Heathman's presidential speech addressed the subject, "Where Do We Stand Today." At that time, the Western Society of Weed Science had a strong financial picture with increasing attendance over the past ten years.

A year later, we are in a stronger financial condition with assets of $42,000 which gives us in excess of a two-year operational budget, saved and set aside as a contingency fund.

As you will see in the next few days, we continue to have excellent annual meetings and attendance this year that will exceed last years.

It sounds like I am painting a very rosy picture for the Western Society of Weed Science at our 39th Annual Meeting. However, these are some "storm clouds" in our weather forecast. Our 1986 Research Report had 196 papers from 106 different authors. However, 26% of those papers involved four people as authors or co-authors.

During our 1986 annual election of officers, only 168 individuals voted for the president. There are 52 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 or encourage each and every member to participate in a manner to the Society. Give a business card to a member of the Executive Committee with a note on it that you would like to serve on a committee, or start thinking about your paper or presentation for the 1987 meeting. The Executive Committee is easily identifiable. We all have brightly colored ribbons on our name tags.

I am sure it is not news to anyone that the American farmer is in serious financial trouble. Forced farm sales occur on a weekly if not daily basis in the rural areas. Those of you that live in large cities really need to ready the local newspaper of a city in the 1000 to 2000 population range. Or better yet, talk to some farmers to obtain an impression of the true farm situation. The bad part of our agricultural situation is that it does not look any better during the next year, and it may take two years for our agricultural economy to recover from depressed agricultural prices. Industry suppliers to agriculture are going out of business or reducing their work force. Prices of farm products are far from being what they need to be to support a viable, profitable agricultural community.

Industry jobs are no longer plentiful. Some of our graduate students are having a difficult time finding positions. Research and extension budgets are being cut. I know of one state that reduced extension funds by 50%. We are in a time of budget reductions and an increasing demand from the agricultural community for advice and recommendations on how they can farm cheaper. What a tremendous opportunity for capable, intelligent, hard

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[1]Regional Manager, Product Development, Monsanto Agricultural Company. Englewood, CO.

working, research scientists. Are you ready for this opportunity or are you one of the eternal pessimists that is going to wait for someone else to solve the problem?

In 1947, wide scale use of selective herbicides such as 2,4-D [(2,4-dichlorophenoxy) acetic acid] began. It is interesting that forty years later, it still is used on a large scale for selective weed control. However, there have been many new products for all kinds of uses developed since that time.

Basic manufacturers and industries have an excellent method of developing new products. Of course, industry is profit motivated, as they should be. As soon as a new product or a new application technique is developed or a cheaper product is developed, the old established product is rapidly replaced. The replacement of dalapon as a herbicide for controlling Johnsongrass by glyphosate, is an excellent example. It will be interesting to see the impact the sulfonylurea area of chemistry has on the 2,4-D cereal grain market in the future.

Basic manufacturers and the herbicide industry will change in the future. They have to change and adapt to new market conditions or they slowly lose business and ultimately no longer participate in the market place. The market place automatically controls products. Farmers use only economical, efficacious products.

Are university people prepared for the changes that they will have to make in the way they teach and the information they present? Are the extension people prepared and current in the new information that needs to be communicated to farmers? How are you going to communicate with farmers in the future?

I would suggest that anyone that is still doing their job the same today as they did five years ago, is not prepared for the future because they are functioning in the past.

Have any of you thought about the changes that will occur in the next 39 years? The new present day products will be the 2,4-D in the year 2025. How will we be controlling weeds in the year 2025? Will there even be weed scientists in 39 years?

In conclusion, I would like to have each and everyone of you returning to your jobs thinking about how you are going to change what you have been doing.

The best reason to make a change is when you hear the traditional answer "THAT'S THE WAY WE HAVE ALWAYS DONE IT."

AGRICHEMICAL ANOMIE: WHY IT WON'T GO AWAY

Len Richardson[1]

Like the farm equipment industry before it, the agrichemical industry has been slow to recognize industry change. Instead, those in the industry are quick to point out that, for some reason, pesticides and related environmental issues simply won't go away. And, of course, those awful environmental organizations are to blame.

Yet somewhere in the dark corner of your mind you wonder if this answer isn't too simple or perhaps more correctly--industry apple sauce. Welcome to the world of agrichemical anomie. Anomie is a feeling that you are being wrenched away from the norm, and it is being replaced by a growing sense of disorientation and anxiety, a feeling that is especially disturbing to someone who, like all of you, is rooted in science.

Indeed there are other signs of change. A court ruling on herbicide spraying of forest land was followed by years of appeals. You read another merger report and see signs of declining sales--the idea strikes you that something bigger is afoot.

It is true, as I will soon outline, that environmental issues have played a major role in the readjustments this industry faces and that Mr. William Ruckelshaus, who was to have been your speaker, was the most important mover and shaker. Yet I want to emphasize that, while the environmental issue won't go away, neither will the wider change which is sweeping our industry.

For example, manufacturers are privately labeling their products to be sold by distributors and co-ops, and there are different trade names for the same chemistry. In addition, both formulators and distributors are becoming manufacturers. In the process, distributors are swallowing up each other and, occasionally, formulators.

Or consider the rush by major manufacturers of herbicides and chemicals to get into the seed business. Monsanto, Stauffer, Ciba-Geigy, Rohm and Haas, Upjohn, and Sandoz all own seed companies.

The agrichemical industry is also playing its part in "merger mania." Consider the case of Sandoz, the Swiss-based company that is about to merge with Velsicol, a company that had previously absorbed Gulf Chemical. Before the Velsicol merger, Sandoz had already acquired Zoecon and Hooker Chemical and product lines from IMC. One could fill a magazine with other tales like this.

So, if you had doubt about real change taking place, forget it--it's really happening; but the question lingers. Why?

The answers are many and complex, but can be boiled down to these five reasons:

1. The increase in environmental fear and tougher regulations. In many ways Bhopal was the final straw in a decade of growing environmental concern spread by various environmental organizations. While the agrichemical industry has long been defensive, it now recognizes that change is required. The NACA FIFRA reform effort is one sign of this change. Another sign is the recent admission by EPA administrator Thomas that pesticides, especially the older, registered pesticides, are the major issue facing the agency.

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How did the environmental issue get out of hand? The answer is law and lawyers. It started with the switch of environmental policy from USDA to the new agency, EPA, which position Nixon helped create under government reorganization. It also cemented forever that law, more than science, would dominate the decision process.

All of this is in fact documented in a Ph.D. thesis which is under lock and key at U.C. Davis, called "The Politics of Nonincremental Domestic Change" by August A. MacIntyre, who worked at and observed EPA during its formulation. It traces the pivotal DDT decision. The copyrighted thesis shows that the key, final DDT decision was made by Ruckelshaus, the lawyer, alone, but a key role was played by an activist judge (how many times have we seen this since?) of the circuit Court of Washington D.C., David Bazelon. Using congressional language under FIFRA, he issued an order transferring the responsibility of proving safety from the Federal Government to the manufacturer. The door was open for Ruckelshaus to make his DDT decision safety by law, not science, became the rule, not the exception. In addition, he filled EPA with activist lawyers.

Now it's not only tough to register new products, but old products are being questioned or taken off the market. Tougher laws, and especially groundwater concerns, have increased and localized liability risks and insurance costs.

This basic change in attitude is encouraging the search for new technology as a hedge against environmental liability. The high cost of such technology encourages mergers for financial and distribution strength.

The first reason for change was the increase in environmental fear and tougher regulations. The second reason for change is:

2. Patent expiration and product saturation. Not only has the saturation point been reached in terms of intensive chemical treatments, but major products have gone, or soon will go, off patent. The world market didn't offer the escape hatch some had hoped for because, internationally, many of the products are already off patent. Major products soon to follow in the footsteps of atrazine are Treflan, Lasso, and Bladex. This encourages proliferation of generic products which in turn encourage formulators and distributors to enter the market.

The first reason for change was the increase in environmental fear. The second reason for change was patent expiration and product saturation. The third reason for change is:

3. New technology. Almost 100 new insecticide candidates were tested in 1984 along with 130 new herbicides and 50 fungicides. In addition to the standard chemistry, many companies are hedging their chemical risk by investing in biotechnology. Then to hedge their distribution risk, chemical-biotech makers are investing in seed companies. Market change also pushes new technology. For example, our most prominent weed control practice, soil incorporation, is in conflict with soil conservation and reduced tillage. The upshot is a rash of postemergence products.

The first reason for change was the increase in environmental fear and tougher regulations. The second reason for change was patent expiration and product saturation. The third reason for change was new technology. The fourth reason for change is:

4. Deregulation of American agriculture. The above trends can only be encouraged by the deregulation of American agriculture, the effort to take government out of farming and making the U.S. farmer competitive with other farmers in the world. Our production per unit of land is already below many industrial countries and even below yields in some developing countries.

The upshot: if a market policy can't cure debt crisis, then planted acres probably won't save the ag chem industry.

The first reason for change was the increase in environmental fear and tougher regulations. The second reason for change was patent expiration and product saturation. The third reason for change was new technology. The fourth reason for change was deregulation of American agriculture. The fifth reason for change is:

5. Internationalization of markets. The focus has changed from the United States to the world markets in agricultural production and the demand for inputs, like agrichemicals. Agricultural production is shifting to the most efficient producer in the world. Likewise, agrichemical companies are consolidating around efficient producers. Is the agrichemical industry prepared for the future? The U.S. will be the environmental standard for the world, but it's easier to develop and register in other parts of the world. As in the case of farmers, the answer is yes and no: some are digging in their heels and looking for the day when yesterday will return. In all, cold, hard economics around the world is shaping the change more than any strategy readily visible at the corporate headquarters of major U.S. producers.

While we may not like it, law, not science, now rules. Thus, in the changed climate I have described, we must change our attitude. That is, on questions of value, superior technical knowledge does not imply that the experts' value system is superior or that data carries the same weight as emotion. It doesn't. We must move away from trying to establish facts to establishing acceptable options, from providing correct answers to reaching agreed conclusions.

REGISTRATION REQUIREMENTS FOR NEW PESTICIDES

T.F. Armstrong, E.E. Debus, and F.S. Serdy[1]

The Federal Insecticide, Fungicide, and Rodenticide ACT (FIFRA) authorizes the Environmental Protection Agency (EPA) to regulate the labeling of all pesticides in the United States. The basic purpose of FIFRA is to ensure that pesticides used in the United States perform their intended function without causing unreasonable adverse effects on man or the environment.

The EPA data requirements for pesticide registration were finalized on October 28, 1984. Prior to this 1984 date, the various chemical company registrants were complying with "proposed" guidelines from the EPA. The final guidelines, specifically called 40 CFR Part 158 Data Requirements for Pesticides Registration, specify the types and minimum amounts of data and information the EPA requires in order to make regulatory judgements about the risks and benefits of various kinds of pesticides and the types and minimum amounts of data and information that an applicant for registration must submit or cite in support of a registration application (1).

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[1]Registration Manager; Director, Product Registration; and Manager, Federal and State Registration Affairs, Monsanto Company, St. Louis, MO.

With today's finalized EPA registration guidelines, 15 to 20 million dollars are required to register a new pesticide, and this process involves five or more years to complete the required pesticide data requirement studies. Since millions of dollars, many years of research, and protection and State Registration Affairs, Monsanto Company, St. Louis, MO.
of man and the environment are involved, it is very important that a potential registrant develop an accurate, complete registration data package as efficiently as possible. Also one does not know if a pesticide is acceptable for commercialization until the end of the five-year plus study when reviews become available.

Applications for new pesticide registrations contain supporting data that are required by 40 CFR Part 158. Specific data requirements cover several different types of materials: typical end-use product (TEP), manufacturing-use product (MP) and technical grade of the active ingredient (TGIA) or pure active ingredient, radiolabeled (PAIRA). Some studies depend on use patterns, physical properties and types of chemistry.

EPA has published Pesticide Assessment Guidelines for the various kinds of data required in 40 CFR Part 158. If a registrant wanted to register a new herbicide on corn, cotton, sorghum, soybeans and wheat, according to the EPA Pesticide Assessment Guidelines, the following data should be developed for submission to the EPA:

- Product Chemistry
- Environmental Fate
- Toxicology
- Reentry Protection
- Spray Drift
- Wildlife and Aquatic Organisms
- Nontarget Insect
- Residue Chemistry
- Product Performance

The time involved in developing these data and the final costs will depend on the specific chemical, the nature of metabolites, the magnitude of the residue levels, laboratory availability, personnel involved, time of year the study is requested, and the amount and duration of chemical exposure levels during application.

To support the desired pesticide registration for five crops (corn, cotton, soybeans, sorghum and wheat), the following registration data requirements would be needed and completion times (expressed in months to complete) would be expected.

Before I discuss the specific registration data requirements, please note that the timelines and costs that I will cover are those that we believe represent an industry average. Therefore, specific registration costs and timelines to complete certain studies may vary with each pesticide candidate.

Product Chemistry. Product Chemistry data is essentially information on product composition and specific chemical and physical characteristics (2). The specific Product Chemistry data requirements involve Product Identity and Composition, Enforcement Method Development, Certified Limits Development, Physical and Chemical Characteristics and Storage Stability. These studies are required on both the technical and end-use product. Most of these studies require 2-6 months to complete; however, the storage stability test completion time is 13 months (Table 1).

*Table 1. Product Chemistry Data Requirements and Completion Times (Months)

Date Requirements	Completion Time (Months)	
	Technical	End Use Product
· Product Identity and Composition	6-9	1
· Enforcement Method Development	2-6	1
· Certified Limits Development	1-3	1
· Physical and Chemical Characteristics	2-3	1
· Storage Stability	13	13
· Report Writing	1	1

Environmental Fate. Environmental Fate data requirements describe the degradation, metabolism, mobility, dissipation, and accumulation of pesticide chemicals in the environment (3). These data are used to identify and assess the potential hazards associated with the uses of a pesticide. The completion time for these studies varies from a low of 16 months (for degradation studies) to a high of 32 months (for accumulation studies). Table 2 contains the specific Environmental Fate Data requirements and completion times.

Table 2. Environmental Fate Data Requirements and Completion Times

Data Requirements	Completion Time (Months)
· Degradation	16
· Metabolism	18
· Mobility	18
· Dissipation	27
· Accumulation	32

Toxicology. A significant battery of toxicology data are required to support a pesticide registration. Specific tests evaluate the toxicity of pesticides to nonhuman organisms and for relating the results of these studies to human safety evaluation (4).

*In the following tables, completion time (months) does not include E.P.A. review time.

Many different kinds of toxicity tests are required, and they involve substantially different completion times and effort (Table 3). The acute toxicity and irritation studies require 3 to 9 months; the subchronic testing involves 8 to 16 months; the most time consuming studies are the chronic/oncogenicity studies that consume a minimum of 24 to 36 months; the reproductive/teratogenicity studies take 11 to 26 months to complete; and the mutagenicity studies require about 6 months for completion.

Table 3. Toxicology Data Requirements and Completion Times

Data Requirements	Completion Time (Months)
· Acute Toxicity and Irritation Studies	3 to 9
· Subchronic Testing	8 to 16
· Chronic/Oncogenicity	24 to 36
· Reproductive/Teratogenicity Studies	11 to 26
· Mutagenicity Studies	6

The acute toxicity, subchronic and chronic/oncogenicity studies are done sequentially; therefore, the completion of these total toxicology test requirements requires a much longer period of time than one might expect looking at individual study timelines alone. This total timeline will be discussed later.

Reentry. This data requirement is concerned with the determination of the interval between the time of application of a pesticide to a specified site and the time when a person can safely reenter such a site (5). Calculation of this time interval is based on the development and analysis of data on: amounts of pesticide remaining in the treated site; data on toxicity of the pesticide; and data on the expected human exposure to the residual pesticide from ordinary work practices that would take place at such a site.

For each formulated pesticide whose use and toxicity falls within the reentry guideline requirements, reentry data requirements include foliar dissipation, soil dissipation, dermal exposure, and inhalation exposure. The inhalation exposure study takes three to four months to complete, and the other three studies each require 12 to 18 months for completion (Table 4).

Table 4. Reentry Protection Data Requirements and Completion Time

Data Requirements	Completion Time (Months)
· Foliar Dissipation	14 to 16
· Soil Dissipation	14 to 16
· Dermal Exposure	12 to 18
· Inhalation Exposure	3 to 4

Spray Drift. These studies are required when aerial applications and mist blower or other methods of ground application are proposed, and it is estimated that the detrimental effect level of those nontarget organisms expected to be present would be exceeded. Droplet size spectrum and field evaluation of spray drift information is required (10).

Wildlife and Aquatic Organisms. Data are required concerning the effects of pesticides on wildlife and aquatic organisms. The toxicity tests have been grouped into two broad areas: tests for pesticidal effects on birds and mammals; and tests for pesticidal effects on fish and aquatic invertebrates (6).

The avian and mammalian testing takes 5 to 11 months, and the aquatic organisms testing takes 3 to 11 months of complete (Table 5).

Table 5. Wildlife and Aquatic Organisms Data Requirements and Completion Times

Data Requirements	Completion Time (Months)
· Avian and Mammalian Testing	5 to 11
· Aquatic Organism Testing	3 to 11

Nontarget Insect. Honey Bees are the primary insects involved. Acute toxicity studies are conducted with the active ingredient; and for the end-use product, toxicity studies of residues on foliage and field testing for pollinators are required (7). These data are required only when certain circumstances are present, such as when the proposed use will result in honey bee exposure (1). The completion times, for each of the three studies, involves four to five months (Table 6).

Table 6. Nontarget Insect Data Requirements and Completion Times

Data Requirements	Completion Time (Months)
· Honey Bee Acute Contact	4 to 5
· Honey Bee Toxicity of Foliage Residue	4 to 5
· Field Testing for Pollinators	4 to 5

Residue Chemistry. Residue Chemistry data are needed for pesticide uses that may result in residues in food or feed. These data are used to estimate the exposure of the general population to residues in food and to establish enforceable limits and tolerances for pesticide residues in food or feed (8).

Three different areas of testing are required, and they are completed sequentially. First the Nature of the Residue must be determined (parent material and any metabolites identified in crops and livestock). Then, an Analytical Method needs to be developed for identification of the residue components in appropriate matrices. Lastly, the Magnitude of the Residues is determined by analyzing raw agricultural commodities for residues (these include the crop residue samples that many of you have helped collect over the years) of the pesticide chemical after treatment corresponding to the uses proposed by the registrant (8).

These three areas of testing each involve approximately 12 to 18 months completion time and, since they are conducted sequentially to each other, this Residue Chemistry requirement is one of the two most time consuming data requirement areas (Table 7).

Table 7. Residue Chemistry Data Requirements And Completion Times

Data Requirements	Completion Time (Months)
· Nature of the Residue	14 to 16
· Analytical Methods	16 to 34
· Magnitude of the Residue	12 to 18

Product Performance. EPA's pesticide registration data requirements for efficacy data for pesticide products are listed in the Pesticide Assessment Guideline, Subdivision G (9). With the exception of vertebrate control products intended for the control of pests that directly or indirectly transmit diseases to humans, submission of efficacy data can be waived by the EPA under the provisions of 3(c)5 of FIFRA as amended. However, the states, as California does, may still require submission of efficacy data.

Even though the submission of efficacy data may be waived by the EPA, efficacy data still need to be developed by registrants to comply with EPA Product Performance Guidelines. This is done because the Agency still has the right to require registrants to submit efficacy data whenever requested; and for business reasons, the registrant must ensure the effectiveness of their product. Development of the product performance data occurs over many years (Table 8) and involves numerous professionals in universities, USDA, and private industry. Many of you have been involved with developing the necessary data that helped determine whether pesticides are efficacious; and we in the pesticide business appreciate your efforts, and your results and recommendations have been instrumental in how various pesticides have been developed and registered.

Table 8. Pesticide Registration Requirement Summary Completion Times

Data Requirements	Completion Time (Months)
· Environmental Fate	24 to 30
· Fish and Wildlife	30 to 36
· Nontarget Insect	4 to 6
· Product Performance	60+
· Product Chemistry	16 to 24
· Reentry	30+
· Residue Chemistry	42 to 50
· Toxicity	54 to 60

Pesticide Registration Requirement Summary. The various EPA data requirement tests and approximate times required to complete these tests involve many years and millions of dollars. Table 8 lists the approximate completion times for each of the data requirements. The range in completion times is very large. The Nontarget Insect tests can be done in four to six months; however, the Residue Chemistry and Toxicity studies require 42 to 50 months and 54 to 60 months, respectively. Plus, these completion times do not include EPA's review time after the pesticide is submitted to the EPA. The EPA review process may involve an additional 18 to 24 months for a new pesticide.

Based on current costs, it is estimated that over sixteen million dollars are needed to complete the necessary data requirements studies that are used to support a pesticide registration on corn, cotton, soybeans, sorghum and wheat (Table 9). Additional registrant costs such as registration fees, management costs and formulation development require another 1 1/1 to 2 million dollars (Table 10). (A significant increase in registration fees are being considered by both EPA and the states.)

Table 9. Pesticide Registration Data Requirements and Costs

Data Requirements	Completion Time Dollars
• Environmental Fate	2,000,000
• Fish and Wildlife	125,000
• Nontarget Insect	500
• Product Chemistry	275,000
• Reentry	825,000
• Residues	6,200,000
• Toxicology	3,250,000
• Product Performance	4,000,000
	$16,675,500

Table 10. Other Pesticide Registration Costs

Other Costs	Dollars
• Registration Fees	86,200
• Management Costs	1,100,000
• Formulation Development	500,000
	$1,686,200

Conclusion

Greater than $18,000,000 are required to obtain a pesticide registration today, and it will take a minimum of five or more years to develop the required data necessary for petition submission to the EPA. The registration process is complicated, costly and time consuming but better defined today versus five years ago. Hopefully, this information has provided you with a better understanding of the pesticide registration process, why it costs millions of dollars to develop a pesticide, and why it takes approximately seven or more years to obtain a new pesticide registration in the United States.

While costly and time consuming it is all done for one purpose; that being, to attempt to determine if a pesticide when used as directed will not cause any unreasonable adverse effects to man or the environment. Hopefully, this process is able to answer that question.

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AERIAL DRIFT CONTROL AND SWATH PATTERN ANALYSIS

Jim Greil[1]

There are not many new technologies currently available to reduce drift. Many laboratory or controlled experiments demonstrate potential drift reduction, but in the field they are neither practical nor economical.

On the other hand, there is some equipment available to improve swath patterns and to determine most effective swath widths and control wingtip vortices and other drift causing phenomena. An added benefit of these systems is reduced drift through increased operator awareness as well as actual drift retardation with such things as better nozzle placement, better nozzle orientation and shorter boom width.

Before I discuss this equipment, I would like to review some basic information concerning drift control. The following conflicting statements are all true: (1) do not spray when it is windy, (2) if the wind is ten miles per hour or less, it is a good time to spray to minimize drift, (3) avoid drift at all costs, and (4) we need a little drift to increase efficacy. By not spraying when it is windy, we can eliminate downwind movement of product, but if there is no wind there may be an inversion layer which can move very small droplets many miles off target. Statement three would be an ideal situation which is difficult to achieve but necessary when spraying immediately adjacent to highly susceptible crops. In number 4 above, a little drift increases the toxicity of a contact insecticide application by effecting more thorough distribution of the material on the leaves, for instance.

Drift is no accident; we know what causes it. Among these are the following: the type of equipment, the application techniques, operator skill, chemical formulations and various meteorologic factors.

The type of equipment primarily influences droplet size. This is affected by the type of nozzles such as the conventional hydraulic nozzles or the controlled droplet applicators. Also pressure influences drift since under high pressure there is more atomization than under low pressure.

If possible, all droplets should be at least 100 microns in size to reduce drift. For example, a 5 micron non-evaporating droplet in still air requires 5-1/2 hours to fall fifty feet while a 100 micron droplet under the same conditions falls in 55 seconds.

The application technique can also influence off target movement of pesticide. A poor pilot with inadequately maintained shut offs, or with improperly placed nozzles, can cause problems. Also flying in the wrong weather conditions (i.e., inversions, high wind) can cause undue drift. Good pilots and good ground crews including flaggers should always be used.

Chemical formulations and the choice between different formulations of the same chemical can also adversely affect pesticide movement off target. Use the lowest volatility formulation available while still maintaining efficacy. Use such things as 2,4-D amine formulations instead of volatile esters for instance, or use a dry granular form instead of a liquid if available.

Finally, temperature, wind, air stability (instability) and humidity all have an effect on drift. In hot, dry conditions, drift and volatility

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may be very high. Also in air inversion situations, much material in small droplets (less than 100 microns) may stay suspended for many hours, moving at will with the breezes. The most ideal conditions, then, might be in cool, damp conditions with a slight wind such as on a night with no inversion.

There are three swath pattern analysis methods currently available. The old standby involves stretching adding machine tape or spot cards in a line perpendicular to the flight path and spraying with a dye. The resultant visual observation can be very enlightening albeit confusing. This method can be enhanced by video graphics and processing the images with a microprocessor. Also the chemistry based approach has given some good results but is hard to duplicate and is very cumbersome. Here petri dishes are placed perpendicularly to the flight path and a metal tracer is sprayed by the aircraft. The concentrations are then measured and plotted giving a distribution. The fluorometric analysis developed at Oklahoma State University with a grant from NASA is the most advantageous system, in my opinion.

This system collects spray pattern data and other related information as an aircraft flies over the collector. The collector is a 1 mm diameter cotton string suspended near the ground. A fluorescent dye is the tracer material. In addition, wind speed, wind directions, aircraft speed and ambient air temperature are automatically recorded by the equipment. In addition, a picture is taken of the aircraft to determine altitude of the aircraft during the pass.

The analysis and graphics system consists of a computer controlled string drive system running the sprayed string through a filter fluorometer to read the spray deposition. The data is then analyzed and presented on the screen of an Apple IIC computer system and an HP 7470 X-Y plotter to present data similar to that in Figure 1.

The advantages of this system include its ease of operation, its use of three passes as composite sample and its ability to model.

It is a relatively simple system to operate and therefore lends itself well to field situations. The system uses three passes as illustrated in Figure 1 and then gives a composite average of all three on the screen. The information given includes deposition and optimum swatch width. With this information, the system can then be queried to determine what the deposition/pattern would look like with a different swath width. As a result, the modeling characteristics are limitless.

The use of systems such as the one described will enhance our ability to meet the new, more stringent regulations facing the pesticide application industry. An example of these new restrictions comes from Wisconsin which prohibits pesticide overspray and considers the applicator totally at fault for overspray under any conditions. We must face the realities of public scrutiny and meet the challenge head on with systems such as the one I have described.

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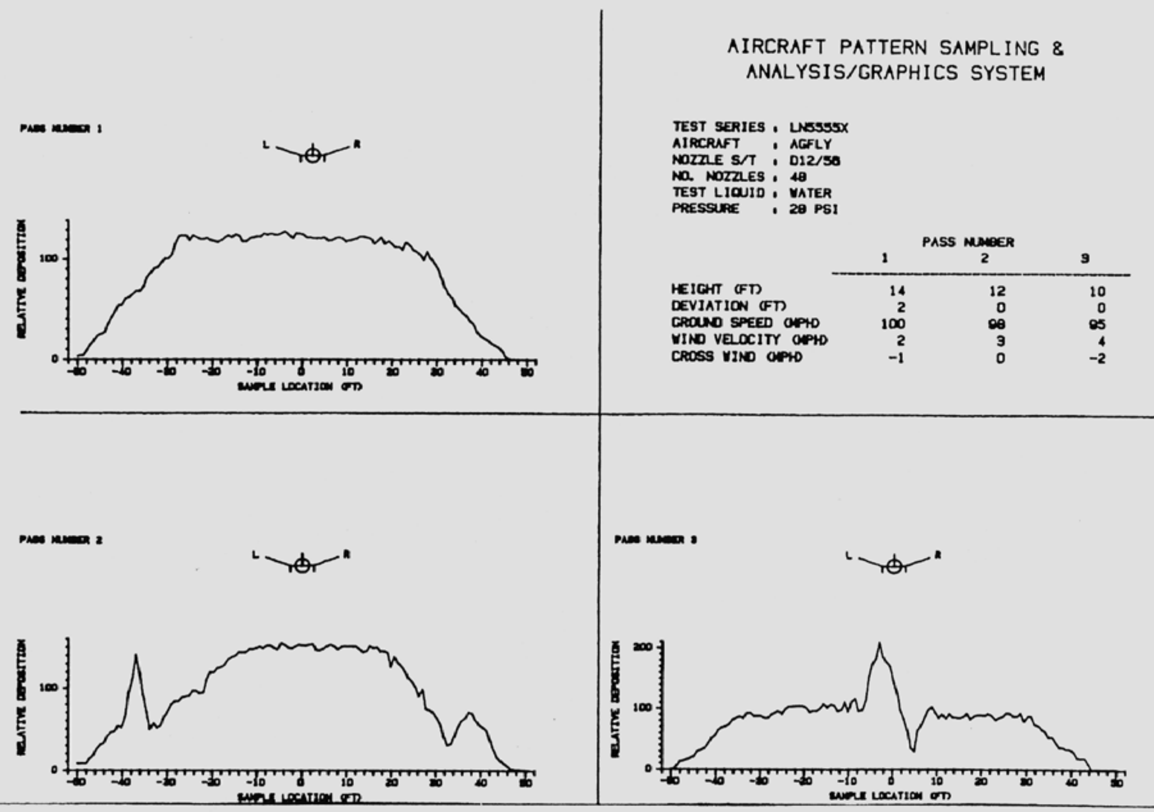

Figure 1. Three passes which comprise 1 run for Swath Pattern Analysis.
Pass 1, excellent pattern; Pass 2, vortex problems; Pass 3, propwash problems.

A CHEMOSYSTEMATIC STUDY OF THE EUPHORBIA ESULA L. COMPLEX (EUPHORBIACEAE)

James M. Torell[1], John O. Evans[2], and Stephen A. Clark[3]

Introduction

Taxonomy of Leafy Spurge. The *Euphorbia esula* L. complex, a group of plants known as leafy spurge in North America, has been variously treated by different taxonomists. (This group of plants is characterized by intergrading forms and a lack of dependable taxonomic characters.) Species, putative hybrids and intraspecific taxa have been proposed on the basis of morphology (2, 3, 6). Leafy spurge accessions have exhibited differential responses to herbicides and to biological control agents (1, 4). It has been suggested that the differential behavior is related to a high degree of genetic variability within the *E. esula* complex. Thus, the determination of taxonomic affinities within the complex and their underlying genetic basis is a prerequisite to implementation of effective control measures. Biochemical and cytological evidence may allow determination of taxonomic affinities that are not discernable on the basis of morphology.

Pyrolysis Mass Spectrometry. Mass spectrometry has long been recognized as a powerful tool for determining the identity of organic structures. Recently, pyrolysis mass spectrometry (PyMS) has been developed as a method for rapid analysis of complex biological materials and the determination of overall patterns of chemical variation (9). PyMS has been employed in taxonomic studies of several microorganisms that lack dependable morphological characters (5, 7, 8). Windig et al. (8) used PyMS to study the relationship of resistance to the black grass bug in forage grass lines to biochemical factors. Differences in pyrolysis mass spectra determined by discriminant analysis correspond very well with genetic differences determined by genetic analysis of cytological data.

Analysis by PyMS involves the application of the sample to a curie-point wire, pyrolysis, generation of a mass spectrum and analysis of mass spectral patterns through factor analysis, discriminant analysis and graphical rotation. These methods allow one to study overall patterns of biochemical variation within the study group and provide tentative identification of chemical components that account for differences between groups of replicated spectra.

The objectives of this study were: 1) determine overall patterns of biochemical variation within the *Euphorbia esula* L. complex; 2) evaluate pyrolysis mass spectrometry as an analytical tool in plant systematics; 3) determine taxonomic affinities within the *Euphorbia esula* L. complex.

Materials and Methods

Experiments were conducted in 1983 and 1984. Samples for the 1983 experiments were collected from a botanical garden at Fargo, North Dakota,

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and a field at Richmond, Utah, while samples for the 1984 experiment were collected at Bozeman, Montana. Samples of foliar material (leaves and stems) were ground and suspended in spectrograde methanol while latex was dissolved in spectrograde carbon disulfide. Five microliter drops were added to curie-point wires, and the wires were placed in the pyrolysis unit. Pyrolysis mass spectra were generated and analyzed by factor analysis, discriminant analysis and graphical rotation.

Factor analysis is a statistical procedure that finds orthogonal linear combinations (factors) of the data that account for variation in the data. The first factor accounts for the greatest proportion of variation, and each succeeding factor accounts for a progressively lower proportion of the variance; discriminant analysis is a statistical procedure that finds the factors that best discriminate between groups of replicated spectra; and graphical rotation is the rotation of the factor axes to coincide with an axis associated with a particular chemical component.

Results

Preliminary studies showed the presence of several component patterns with an isoprenoid pattern being particularly prominent in the latex spectra. Reproducibility of spectra with replicated runs on the same sample was highest for latex followed by stems and leaves. Factor analysis indicated a clustering the three accessions and the presence of one noticeably different accession (Figure 1). In the second experiment, a plot of group centroids of the first three discriminant functions showed a good separation of the groups in three dimensional space (Figure 2). Latex projection onto component axes (graphical rotation) indicated differences in terms of polyisoprenoid and phenolic compounds (Figure 1a, 2c). Factor and discriminant analysis of leaf and latex samples indicated similar patterns of variation.

Discussion

These studies indicate that pyrolysis mass spectrometry is a useful tool for elucidating overall patterns of chemical variation in systematic studies. Leafy spurge accessions are shown to vary in terms of triterpenoid and phenolic constituents. Differences in triterpenoid profiles between North American leafy spurge accessions have been reported by Davis et al. 1984. Further studies of the *Euphorbia esula* complex by pyrolysis mass spectrometry will aid in the determination of overall biochemical affinities within this group and provide information relative to classes of chemical constituents that should be studied by more detailed analytical separations.

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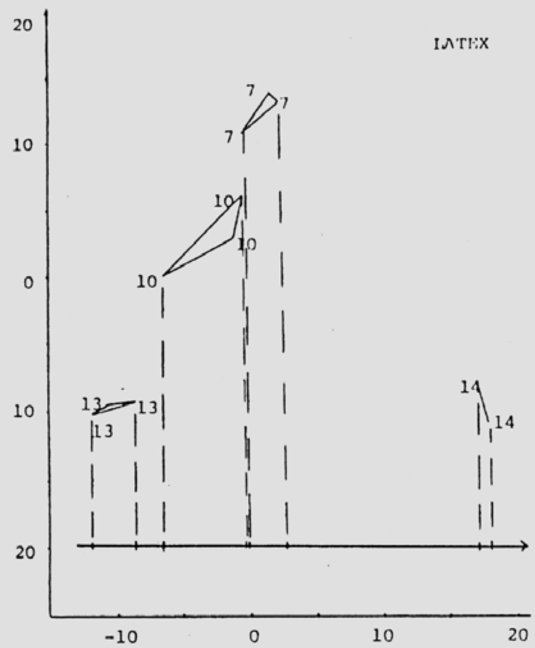

Figure 1. Factor score plots for latex of biotypes 7, 10, 13 and 14.

Collection Site

biotype 7: Franklin, Manitoba
biotype 10: Krems, Austria
biotype 13: Kalkaska, Michigan
biotype 14: Baker, Oregon

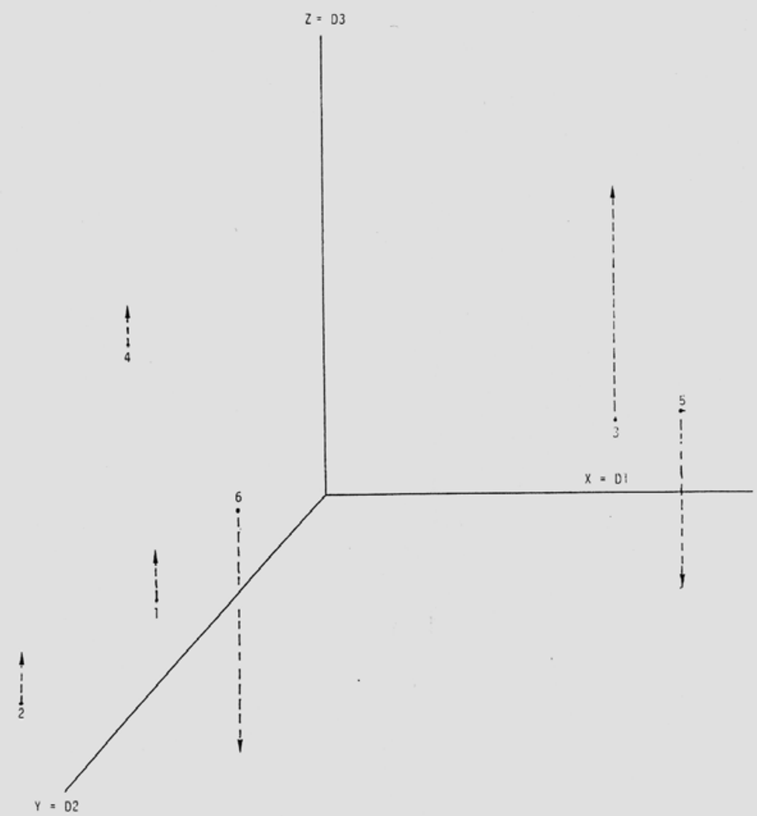

Figure 2. Latex from leafy spurge. Plot of the first three discriminant functions.

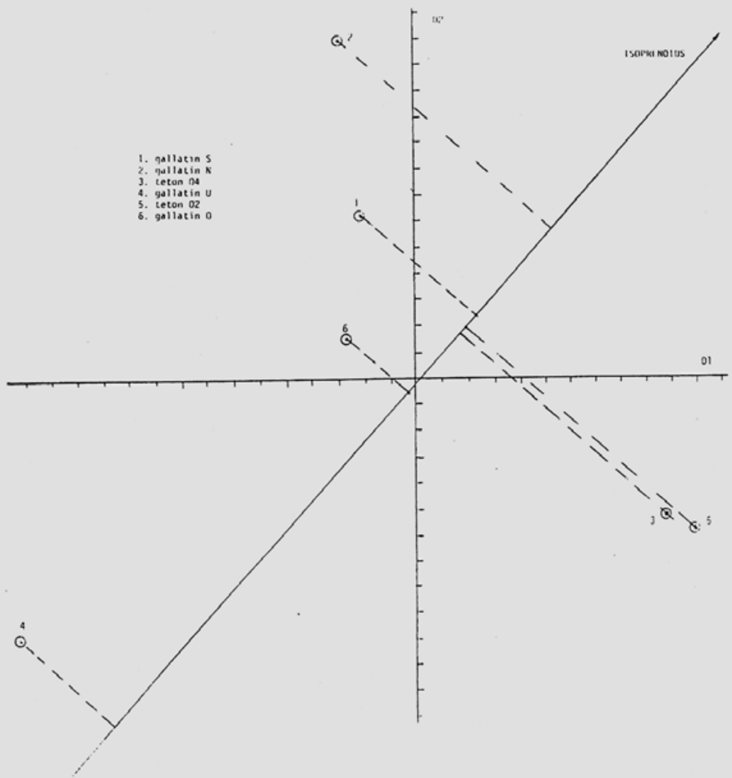

Figure 3. Latex projections onto isoprenoid component axis (D1 vs D2).

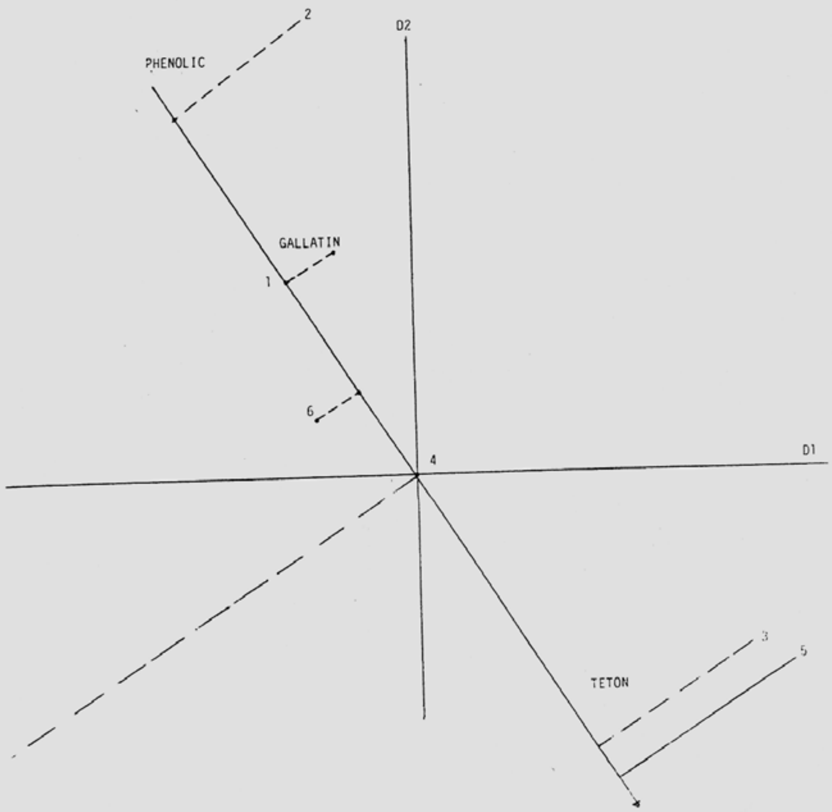

Figure 4. Latex projection onto phenolic component axis (D1 vs D2)

IN THE BEGINNING

Lambert C. Erickson[1]

"In the beginning," if you don't recognize that phrase, you should. If you then absorbed the remainder of Genesis as fact, you could omit cluttering your brain with all the scientific discoveries from the beginning, including the recent voyager closeup at 50,000 miles of Uranus.

Timmons (20) in 1970 did a great job in summarizing weeds from the beginning. "Adam was promised thorns and thistles." The only additional reference I can find is "tares" in Mat. 13.

In speaking to the Idaho State Weed Control Conference some years ago, I presented the following version (8).

"When man first on this Earth arrived, he had some food
 but he had no bride.
This was resolved by a piece of his rib.
Soon trouble arose, there were too many kids.
They hunted for food from the day they were born.
And slept in caves from dusk to dawn.
His stick he wielded with great precision
nigh to the point of his own extinction.

A surprisingly good reference is, "A History of Agriculture in Europe and America" by N.S.B. Gras. (10) Professor of Economic History, University of Minnesota 1925. It refers to weeds 13 different times. To make the book more credible, it was edited by Dr. Andrew Boss, Director of the Minnesota Agricultural Experiment Station and a leading agricultural authority of that era. I do note, however, that Gras said nothing about the perennial sowthistle (Sonchus arvensis L.) which solidly infested northern Minnesota at that time and caused cereal grains to yield six to ten bushels per acre. We can only guess, be it time or place, as to the first domestication of plants.

Was it on the banks of the Nile, on the banks of the Euphrates, in China? Or was it in one of the ancient and extinct civilizations of Mexico? The latter have been mentioned only since 1926.

We do know that the Latins and the Greeks had no word for weeds. Consequently, we have no "ology" for Weed Science. I had a personal experience when I worked in Greece some 15 plus years ago, explaining why we had no scientific name for Weed Science. The reason being that the Greeks had no words for weeds. The Greek co-workers said, "oh yes we do," --and gave me a Greek word. "What does it mean?" The word was very inclusive--it could mean cloudy weather, etc. Mostly it meant "Bad" and obviously not sufficiently specific for our purpose.

We do know that since ancient times, humans like all animal species grouped together for mutual protection. We know that, as time progressed, the land surrounding these collectives was frequently cropped and tilled. The tilling was done by hand, hand hoes, hand hooks, whatever the primitive implement, it was hand powered, and this continued for century upon century in various locations on this planet Earth. Sixteen hundred years BC the Jews were pastoral nomads (10).

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[1]University of Idaho, Retired, Moscow, ID

Then came Jethro Tull, (1674-1741), with his "Horse Hoeing Husbandry." His contemporary Charles Townsend (1654-1739), to whom we seldom refer, is only horse cultivated he also "marled" his land (10).

By 1600 our forefathers had invaded this continent. Eventually they brought all the weeds of Europe, Asia and Africa, including the dandelion for green salad! These alien species now comprise over 95 percent of our weed problem.

The Prevention Era. In 1898 Henderson (12) wrote a bulletin "The 12 Worst Weeds of Idaho." The herbarium burned soon thereafter but a mount was sent to Cornell University. There I had the pleasure of inspecting it in 1982. All our weeds had come as seeds. Consequently, the Connecticut Seed Laws of 1821, the Michigan Act 1871 and the California, Illinois, Missouri and Nebraska Acts were established before 1900. In 1907, persons testing seed met and organized what was to become the Association of official Seed Analysts. By 1940 only Florida remained without a seed law.

The "Federal Seed Act of 1939" changed the entire seed trade industry. It essentially required "truth in labeling" of seeds in interstate commerce.

In 1939 I was a student seed analyst majoring in Agricultural Botany (Weed Science) at the University of Minnesota. I mention this because my professor was A.H. Larson (22), the greatest brain I have ever encountered. No, he did not have a Ph.D. He said, "If that damn fool can get a doctorate, I don't want one."

Dr. R. B. Harvey (11), Department Head, was doing peculiar things, kind of crazy like Ph.D.'s should--. So he patented the ripening of bananas with ethylene gas, while attempting to kill all living plants with the thiocyanates.

It becomes necessary to go back "in time" a bit. The stock market crash of 1929 was the beginning of what history records as "The Great Depression." It was a catastrophe! "Two cars had been promised for every garage and a chicken in the pot," became two chickens in the garage and nothing in the pot.

As a consequence of the Great Farm Depression, President Franklin D. Roosevelt asked the U.S. Chamber of Commerce to determine "the single greatest loss in American Agriculture." Their studied reply was, "WEEDS."

One of the results was the Field Bindweed Research Appropriation of 1935 which placed L.M. Stahler (22) at Lamberton, MN, F.L. Timons (20) at Hays, KA., A.L. Bakke (3) at Ames, Iowa and C.I. Seeley (19), Moscow, Idaho. The latter coordinated a joint project by the Universities of Idaho and Washington State.

Recall that this was the twin eras of Prevention (the State and Federal Seed Laboratories) and Eradication (sodium chlorate, carbon bisulfide, borax, yes, and even common salt). The selectives were used experimentally (iron, copper, sulfates, etc.), but they were not accepted by the farmers or the public. Bolley (5) in 1908 said "....the acceptance by farmers would bring greater returns than any other single investigation...."

In 1941 I started the Wyoming State Seed Laboratory located at the University of Wyoming. In addition to being the State Seed Analyst, I was also advisor to the County Weed Control Units. This placed me in direct contact with the ongoing weed control efforts in the entire state.

One day in 1943 a peculiar colored alfalfa seed sample arrived for analysis. I was writing my Master's Thesis on, "The value of size and color on quality of alfalfa seed." In brief, the sample was screenings dusted with powdered sulphur. The era of erroneously labeled seed shipped in interstate commerce was past!

Other developments were in progress. The first Multi-State Weed Control Society was organized at Denver, June 16, 1938. Some of those present were Walter Ball of California, Bruce Thornton of Colorado, Harry Spence of Idaho. R.B. (Bob) Balcom, BLM Washington D.C. and others of which I have no record. I do want to impress on your minds that Walter Ball (1989-1975) was the secretary and "the wheel" in starting this Western Society of Weed Science.

The Present Era. In December 1944, 2,4-D was announced to the world via radio and newspapers. Recall that World War II was still in progress. And suddenly all State Agricultural Experiment Stations wanted one or more weed scientists, but there were few so trained.

Remember that to this point the prime herbicides were sodium chlorate, carbon bisulfide and borax. Instantly everybody wanted 2,4-D regardless of formulation. Thus, it became our job to teach safety, volatility, drift, decomposition, nondecomposition, residues, penetrants, etc., etc., etc. Companies preferred to manufacture the dramatic esters, methyl, ethyl, butyl, etc. They were fast acting and so were the gardeners and the housewives who had sensitive plants in the vicinity of these applications. Soon red flags and white dish towels become the display of the day as roadside weed spraying rigs came into sight.

In the summer of 1945 my lawn in Moscow, Idaho, became a dandelion control experimental area and every weekend became a "Field Day," people coming hundreds of miles to view the results. During the week and often weekends, I was down state treating plots e.g., powdered 2,4-D solubilized in Carbowax, then diluted in water to treat one square rod plots at 0, 1/2, 1, 1 1/2 and 2 lbs., per acre.

These were exciting times. World War II came to a sudden stop! Let's review why we were in a position to make somewhat reasonable use of this revolutionary material.

Bolley (5) had not been without co-workers. There were Korsmo (14) of Norway with many, many publications and Rademacher (18) of Germany yielding no less than 319 papers from 1927 to 1972, and Brenchley (6) of England. Here in the United States we had, just to mention a few, Arney (1), Ashlander (2), Bakke et al. (3), Ball, Madson, and Robbins (4), Brenchley (6), Harvey (11), Kennedy and Crafts (13), Morgan (16), Willard (21), and Wilson et al. (22).

In our immediate area we had Pavlychenko and Herrington (17) giving us a better insight on plant competition. Let us not omit Ada Georgia who first completed the textbook "Weeds" (9) nor Korsmos et al. (15), Ugras Plansjer. Let us not waste our time drawing weed plants already drawn correctly under Korsmos supervision.

I have purposely selected references from the beginning because I am a product of the end of that beginning. The bomb fell! We were in a new era.

Finally, I want to memorialize an act or action of the United States Department of Agriculture in 1935, A.L.Bakke, C.I. Seeley, L.M. Stahler, and F.L. Timmons into the field of weed research. The pioneer of all of these was A.L. Bakke 1886-1992. He had about 20 years experience in Weed Science when 2,4-D arrived on the scene. This, then equalled a total of at least 30 years experience for the remaining three. All society is indebted to them for their words of caution in those early days of the 2,4-D revolution and its expansion since that time.

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THE WEED SCHOOL: A COMPREHENSIVE, HANDS-ON LEADER TRAINING EXPERIENCE FOR COUNTY EXTENSION AGENTS AND AGRIBUSINESS PROFESSIONALS

J.E. Nelson[1]

Agricultural technology is changing rapidly. To keep abreast of new developments is a continuing challenge for county extension agents and ag chemical distributors and dealers. As one example, the rapid changes in tillage practices and subsequent changes in pesticide and fertilizer use are making it necessary for the distributor, the dealer and his employees to acquire new information. They are expected to translate research data into practical and profitable farming procedures. With accelerating technological advances, it is apparent that the agent, distributor or dealer of the future will be cast in the role of advisor and consultant to an even greater extent than ever before. And their role in influencing change will be even more dramatic than in the past. The role can be fulfilled, however, only if these people are equipped to provide leadership--only if they have the necessary knowledge and experience. Our objective was to develop a training program to meet the weed science educational needs of county extension agents and ag chemical dealerships in Montana and to reaffirm Montana State University as a leader in innovative extension education programs.

Materials and Methods

The Weed School was a 1 1/2 day field-classroom training program offered by the Montana State University Cooperative Extension Service that included hands-on training in herbicide technology, identification of seedling weeds, sprayer trouble-shooting, technical analysis of field problems and preparing for complaint investigations. Two Weed School

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[1]Cooperative Extension Service, Montana State University, Bozeman, MT.

seminars were offered, one to county extension agents and one to ag chemical distributor or dealer agronomist representatives. Participation was limited to 25 persons for each seminar. Unlike many seminars, a major emphasis was placed on training in the field. Motel and Montana State University Experiment Station facilities were used for the lecture and field portions of the program, respectively. The program combined field and classroom experiences both of which utilized lecture and hands-on training. Subjects were introduced in detail in the classroom and reinforced by a field experience. The subjects covered in the Weed School were as follows:

A. Weed Management
   1. Weed biology
      Weed control methods
   2. Factors influencing soil-applied herbicides
      Factors influencing foliar-applied herbicides
      Classification of herbicides by mode of action
      Herbicide toxicity (or injury) symptoms and selectivity
   3. Identification of seedling and mature grasses and broadleaf weeds

B. Herbicide Application
   1. Sprayer trouble-shooting
      The physical and biological aspects of herbicide application
   2. Sprayer calibration

C. Trouble Shooting
   1. Technical analysis of field problems
      Preparing for complaint investigations
         -Interactive analysis (people skills)
         -Goof plots
         -Role playing
      The hands-on training activities employed are as follows:
      a. Live plants
         1) Weed seedlings for use in the classroom during seedling identification section.
         2) Outdoor weed nursery and seedling box
            a) Fifty (50) species
            b) Mature and seedling stages
      b. Multi-crop and weed screen
         1) Eight crops and eight weed species included in crop screen
         2) Observe control spectrum, crop tolerance and injury symptoms caused by various herbicides
      c. Miscellaneous demonstration plots that reinforce an understanding of weed science principles and herbicide properties
      d. Goof plots and role playing
         1) Planned mistakes that demonstrate what can happen when something is done incorrectly
         2) Interactive role playing to demonstrate personality types, people skills and recognition of agronomic problems which requires that the problem be identified and a solution recommended as to what the producer can do this year to cope with the problem

and what he should do next year to eliminate a reoccurrence

3) An open discussion and critique of role players occurs following each situation.

Results

Response to the program was as good as we had hoped. Participants approved of the small group size, the opportunity for more personalized training, the indepth coverage, the opportunity to have questions answered, the hand-on training (particularly the field experience), and the notebook which contained materials tailored to each seminar presentation. Pre- and post-training testing showed that participants improved their weed identification skills 150% on the average.

Participant evaluations will be used to reshape the Weed School program for next year. Generally, it was felt the program should be longer, less hurried and more time should be spent with hands-on activities. We plan to incorporate many of these suggestions into the three to four weed schools that will be held next summer.

NORFLURAZON FOR WEED CONTROL IN ALFALFA

L.J. Russo and W.S. Belles[1]

Abstract. Field trials have been established over the past several seasons in Arizona, California, Oregon and Washington to evaluate weed control and crop tolerance in alfalfa. Replicated trials were placed in fields where alfalfa had been established for a least one season. Applications were made from fall to early spring, with rates of norflurazon (4-chloro-5-(methylamino)-2-(3-(trifluoromethyl)phenyl)-3(2H)-pyridazinone) ranging from 1.11 to 8.89 kg ai/ha. Effective use rates for norflurazon range from 1.79 to 3.33 kg ai/ha. Annual grasses controlled at an excellent level (90 to 100%) included annual bluegrass (*Poa annua* L.), Italian ryegrass (*Lolium multiflorum* Lam.), downy brome (*Bromus tectorum* L.), barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.], and yellow foxtail [*Setaria glauca* (L.), Beauv.]. Broadleaf weeds controlled effectively (85 to 100%) by norflurazon in these trials included london rocket (*Sisymbrium irio* L.) shepherdspurse [*Capsella bursa-pastoris* (L.) Medik], flixweed [*Descurania sophia* (L.) Webb], and common chick weed (*Stellaria media* L.). Weeds suppressed or not controlled included common groundsel (*Senecio vulgaris* L.), henbit (*Lamium amplexicaule* L.,) and hairy vetch (*Vicia villosa* Roth.). At normal use rates, slight chlorosis (less than 10%) was observed in several locations, but this disappeared prior to the first cutting. Yields were not adversely affected by norflurazon.

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[1]Zoecon Corporation, Palo Alto, California

VINEYARD WEED CONTROL WITH NORFLURAZON

W.S. Belles, L.J. Russo, B. Bauer and L. Stivison[1]

Abstract. Norflurazon (4-chloro-5-(methylamino)-2-(3-trifluoromethyl)-phenyl)-3(2H)-pyridazinone), a substituted pyridazinone herbicide, inhibits the biosynthesis of chlorophyll protecting carotenoids which results in partial to total whitening of susceptible plant species. Norflurazon is now registered for use on sandy loam and finger textured soils in all areas of the United States except specific areas in California and Florida. Ninety percent or better control of downy brome (*Bromus tectorum*), barnyardgrass (*Echinochloa crus-galli*), common chickweed (*Stellaria media*), flixweed (*Descurania sophia*), tumble mustard (*Sisymbrium altissimum*), and shephard's purse (*Capsella bursapastoris*) has been obtained in field trials conducted in the West. Species not readily controlled include curly dock (*Rumex crispus*), common dandelion (*Taraxacum officinale*) and field bindweed (*Convolvulus arvensis*). Grape injury has not occurred in registered soil types and areas. Effective rates vary from 2.2 kg/ha in sandy loam soils to 4.4 kg/ha in fine textured soils. Field studies were conducted in the western United States in 1985 in vineyards in areas and on soil types where norflurazon is currently not registered. Rates of 1.1 to 1.6 kg/ha resulted in good crop safety but somewhat erratic weed control. Combination treatments of norflurazon at low rates with Oryzalin and Oxyflurofen resulted in good to excellent weed control and crop safety.

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[1]Zoecon Corporation, Palo Alto, CA.

POSTEMERGENCE CONTROL OF PERENNIAL BINDWEED JOHNSONGRASS AND BERMUDAGRASS WITH TRANSLOCATED HERBICIDES

F.K. Lange and A.H. Lange[1]

Abstract. Although the development of glyphosate (*N*-(phosphonomethyl)-glycine) has been a major breakthrough in the battle to control perennial weeds, it has given more temporary control than lasting "eradication." Much work has gone into rate, spray volume, timing, methods and additive studies all aimed at improving the lasting control of perennial weeds. Several recent field studies on well-established stands of perennial weeds have indicated improved control of perennial bindweed (*Convolvulus arvensis* L.) when glyphosate was applied about a week prior to dicamba (3,6-dichloro-2-methoxybenzoic acid) or 2,4-D (2,4-dichlorophenoxy)acetic acid). Added surface acting agents did not appear to improve the long-term control of perennial bindweed with glyphosate.

On the other hand, the addition of some surface active agents did improve the activity of glyphosate on johnsongrass (*Sorghum halepense* (L.)

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[1]Herbicide Research Institute, Reedley, CA.

Pers.). In other tests repeated applications of fluazifop-butyl ((±)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid) at higher than recommended rates gave long-lasting bermudagrass control.

INTEGRATED PEST MANAGEMENT - FACT OR FICTION?

Susan G. Colwell[1]

Abstract. Integrated Pest Management is broadly defined as crop production systems that incorporate the optimum balance of cultural, physical, biological, and chemical practices to cost effectively obtain the best yields and to increase or maintain land productivity. The negative side effects of a previously heavy reliance on chemical fertilizers and pesticides in crop production has caused the mergence of the Integrated Pest Management supposition. Much allegiance has been paid to the notion of integrated pest management, but is it more than academic theory? Is it applicable to field situations? A group of scientists from six disciplines is currently working together on a federal four-year program to investigate management strategies that will increase pea yields in northeast Oregon and southeast Washington. The major limiting factor for pea production in these areas is the cumulative effect of three pathogens: *Fusarium solani* f. sp. *pisi*, *pythium ultimum*, and *Rhizoctonia solani*. A vigorous crop is necessary to tolerate attack by these pathogens. Therefore, reducing all stress factors on the pea crop becomes critical. Weeds, insects, fertility, tillage, etc.., all need to be managed to maximize the strength of the pea crop. Certain studies are designed to probe the interaction of tillage practices on pathogen, weed, and insect populations. Other experiments will determine the effect of tillage practice on soil fertility. The project is going into its second season with the optimism that Integrated Pest Management can be fact and not fiction.

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GRASS AND BROADLEAF WEED CONTROL IN CEREALS WITH TANK-MIXES OF DICLOFOP, BROMOXYNIL AND MCPA ESTER

Monte D. Anderson, Kevin J. Staska and Paul G. Mayland[1]

Abstract. Postemergent applications of diclofop ((±)(2-[4-(2,4-dichlorophenoxy)phenoxy]propanoic acid) effectively control wild oat (*Avena fatua*), foxtail species (*Setaria* spp.), and other annual grasses in wheat, durum and barley. Tank-mixing bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) with

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diclofop provides control of both annual grass and broadleaf weeds; however, the timing of the application is not always optimum for both compounds. Some broadleaf weeds, especially those in the mustard family, are hard to control with bromoxynil; therefore, the addition of a phenoxy compound would be desirable. At recommended use rates MCPA ((4-chloro-2O-methylphenoxy)-acetic acid) and 2,4-D ((2,4-dichlorophenoxy)acetic acid) antagonize diclofop's activity on grassy weeds. To prevent reduced wild oat and foxtail control when tank-mixing diclofop and MCPA, very low rates of MCPA are required.

In order to define a rate of MCPA ester that will not be antagonistic and still provide some broadleaf activity, various ratios of diclofop, bromoxynil and MCPA ester were tank-mixed to evaluate their efficacy on both grassy and broadleaf weeds. During the 1985 growing season, tests were conducted in North Dakota, Minnesota, Montana, Idaho and Washington on spring wheat, barley and winter wheat. Rates of diclofop and MCPA ester ranged from 0.80 to 1.12 kg/ha and 0.034 to 0.168 kg/ha, respectively. The bromoxynil rate was held at a constant 0.28 kg/ha. All treatments were applied at the one- to three-leaf stage of either the wild oat or foxtails.

In 1984, tank-mixes of diclofop, bromoxynil and MCPA ester reduced wild oat control at some locations when the rate of MCPA ester was greater than 0.112 kg/ha. In 1985 across seven locations, all treatments gave 82 to 90% wild oat control. Similarly, green and yellow foxtail control was greater than 85% with most treatments. Control of wild mustard (Sinapsis arvensis) and wild buckwheat (Polygonum convolvulus) was excellent (greater than 90%) with all tank-mix ratios, indicating that the addition of MCPA ester did not provide increased control over the bromoxynil alone. Tansy mustard (Descurainia pinnata) control ranged from 78 to 85% with all treatments, again indicating that MCPA ester was not required for effective control. However, control of field pennycress (Thlaspi arvense) increased as the rate of MCPA ester increased. Diclofop plus bromoxynil provided an average of 68% field pennycress control, while additions of MCPA ester increased control 5 to 19% with rates of 0.034 to 0.168 kg/ha, respectively. Yields were not different between treatments, regardless of the crop involved; however, all treatments resulted in yield increases over the untreated control. The degree of the yield increase was related to weed infestations.

CONTROL OF BLACK NIGHTSHADE IN CALIFORNIA COTTON WHEN RAINFALL DOES NOT OCCUR

Harold M. Kempen and Peter Belluomini[1]

Abstract. For a decade, nightshades have been an increasingly widespread problem in San Joaquin Valley cotton production areas. Herbicides, such as fluometuron (N,N-dimethyl-N'-[3-(trifluoromethyl)phenyl]urea) cyanazine (2-[[4-chloro-6-(ethylamino)-1,3,5-triazin-2-yl]amino]-2-methylpropanenitrile), diuron (N'-(3,4-dichlorophenyl)-N,N-dimethylurea) or prometryn ((N,N'-bis(1-methylethyl)-6-(methylthio)-1,3,5-triazine-2,4-diamine) do well in the west

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just as they do in rainbelt areas if rainfall occurs after planting. But *more than half the time rainfall does not occur, or it is too little or too* late. When these same herbicides are incorporated into soils before planting, control is also inadequate when no rainfall occurs after planting.

Research in the 1970's had shown that MSMA (monosodium salt of MAA) and DSMA (disodium salt of MAA) suppressed black nightshade (*Solanum nigrum* L.) and American black nightshade (*S. Americanum* mill.) that emerged with cotton when nutsedge research was being done. However, over-the-top sprays were not adequate to give the high degree of control needed at this stage of cotton development. Post-directed spray equipment technology had not come to the San Joaquin Valley then, and still has not, but because of the present high cost of cleaning up nightshades in cotton (up to $150.00 per acre), we now feel that there is now enough incentive to growers to use this widely used Southern Belt technology. Additionally, growers now know how to set up spray equipment so acceptance of an OT (over-the-top) plus PDS (post-directed spray) sequence is feasible.

Our research in 1984 and 1985 attempted to confirm earlier observation that this system would work under farm management conditions. Two situations were evaluated: one in 1984 on depauperate two-leaf cotton growing under very wet and cool growing conditions, and a second one on later planted cotton which grew off fast. Under both situations, we were able to show that an OT spray would stunt black nightshade for about three weeks, thereby allowing a well-controlled PDS application which finished off the nightshade. Where cotton grew off fast, dirting over the stunted nightshade might substitute for the PDS applications. Concurrently, our grower cooperator confirmed that the system would work because he had used MSMA by air OT for yellow nutsedge, and after seeing our plots, used a PDS application of MSMA plus prometryn to finish off a heavy stand of black nightshade of 160 acres. Studies in 1985 were equally effective but primarily because cotton emergence and growth was faster than black nightshade on 160 acres. Studies in 1985 were equally effective but primarily because cotton emergence and growth was faster than black nightshade, so that a PDS application alone controlled nightshade.

Evaluation of equipment from the southern cotton belt showed that the "Dickey Fender" unit was ore effective for PDS application to 5-6" cotton than were Alloway spray shields and S & N Model 5581 slide units. A shop-made sled-shoe, which growers could fabricate, was simpler and equally effective as the Dickey Fender commercial unit.

The challenge to us in Extension is to convince growers that this system should be adopted. The cost is low, the results are good, but the PDS equipment has not been used here. Therefore, we expect some inertia in getting the technique accepted.

EFFECT OF BLOOM APPLICATION OF METSULFURON ON SEED SIZE, VIABILITY AND SEEDLING VIGOR OF FIELD BINDWEED (CONVOLVULUS ARVENSIS L)

Hamid R. Mashhadi and John O Evans[1]

Introduction

Sulfonyl urea is a new family of herbicides that is known to inhibit mitosis in susceptible species of plants. Previous studies have shown that bloom applications of metsulfuron and chlorsulfuron inhibited viable seed formation in dyer's woad (*Isatis tinctoria* L.).

Field bindweed, (*Convolvulus arvensis* L.), a perennial noxious weed, is a prolific seed producer. The seeds are known to remain viable in the soil for decades. Such a property makes its management extremely difficult. This study was designed to investigate the effects of three rates of metsulfuron on seed size, viability and seedling vigor of field bindweed.

Materials and Methods

A field uniformly infested with field bindweed was selected in Cache Valley, Utah. Metsulfuron at three rates (23, 47 and 70 g ai/ha) was applied to 2.4 x 6.1 m plots arranged in a complete randomized block design with a hand held sprayer calibrated to deliver 94 L/ha at 30 psi. At application, field bindweed was in full bloom. Fifty seed capsules were randomly sampled from each plot. Capsules were weighed, opened to count the number of seeds per capsule and the seeds were weighed and evaluated with regard to shrunken seed. The seeds were then soaked in concentrated sulfuric acid for one hour and water rinsed for 15 minutes. Scarified seeds were germinated in petri dishes at 20 C in 100 ppm ceresan in water. After 5 days, the number of seeds germinated and seedling radicle length was measured.

Results and Discussion

Results indicate that metsulfuron treatments significantly decreased seed and capsule weight of field bindweed. No statistical significance was observed between metsulfuron dosages. Most seeds from treated plots appeared to contain a seed coat only and could easily be shattered with slight pressure. No differences were observed between treatments in number of bindweed seeds per capsule. Percentage of shrunken seeds were significantly higher in treated plots than in controls. Germination varied from 4.5 percent in the highest rate to 8.5 percent in the lowest rate compared to 70.5 percent in the control. Seeds from treated plots with higher percentage of shrunken seeds germinated less. However it was observed that many normal looking seeds from treated plots did not germinate. Five days after germination, seedlings from treated plots were significantly less vigorous than those of the control. This was indicated by average radicle length of 8, 4 and 2.8 mm in 23, 47 and 70 g/ha metsulfuron treatments respectively to 25 mm for the control.

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[1]Utah State University, Logan, UT.

Although detailed anatomical studies were not conducted, it is speculated that reduced seed size, weight and germination could be attributed to lack of mitotic activity of both embryo and endosperm. Since bindweed is an indeterminate flowering plant, the fertilized eggs and endosperms that had already undergone sufficient cell division before metsulfuron treatment were able to germinate while seeds with undeveloped embryo and endosperm failed. Existence of shrunken seed without normal embryos as well as non-shrunken (normal appearing) seed without normal embryos in metsulfuron treated plots may be attributed to the ovular developmental stage at treatment. Plants with well developed ovules but rudimentary embryos and endosperms appear normal but they do not develop normal embryos and viable seeds. Smaller food reserves in the endosperm of germinated seeds from metsulfuron treated plots may have contributed to less vigorous seedlings.

Table 1. Effect of Bloom Application of Metsulfuron on Seed Set and Seed Size of Field Bindweed (Convolvulus arvensis L.)

Treatment[2]	Wt. of capsule with seed (mg)[3]	Weight/ seed (mg)	Ave. # of seed per capsule	Shrunken seed % of total
Control	41.1 a	7.7 a	3.2 a	7.6 a
metsulfuron 23 g/ha	26.4 b	3.4 b	3.0 a	28.3 b
metsulfuron 47 g/ha	21.9 b	2.9 b	2.9 a	40.5 b
metsulfuron 70 g/ha	23.2 b	3.3 b	3.3 a	46.8 b

[1]Numbers in a column followed by the same letter are not significantly different at 5% level.
[2]All metsulfuron treatments included .25% v/v wk surfactant.
[3]Average of 20 capsules per treatment in each of four replications.

Table 2. Effect of Bloom Application of Metsulfuron on Seed Viability and Seedling Vigor of Field Bindweed (Convolvulus arvensis L.)[1]

Ave. radicle Treatment[2]	Germination length (mm)[3]	Germination %	% of Control
Control	25.0 a	70.5 a	100.0 a
metsulfuron 23 g/ha	8.0 b	8.5 b	12.0 b
metsulfuron 47 g/ha	4.0 b	5.0 b	7.0 b
metsulfuron 70 g/ha	2.8 b	4.5 b	6.4 b

[1]Numbers in a column followed by the same letter are not significantly different at 5% level.
[2]All metsulfuron treatments included .25% v/v wk surfactant.
[3]Average of 50 seeds germinated in each 4 replications.

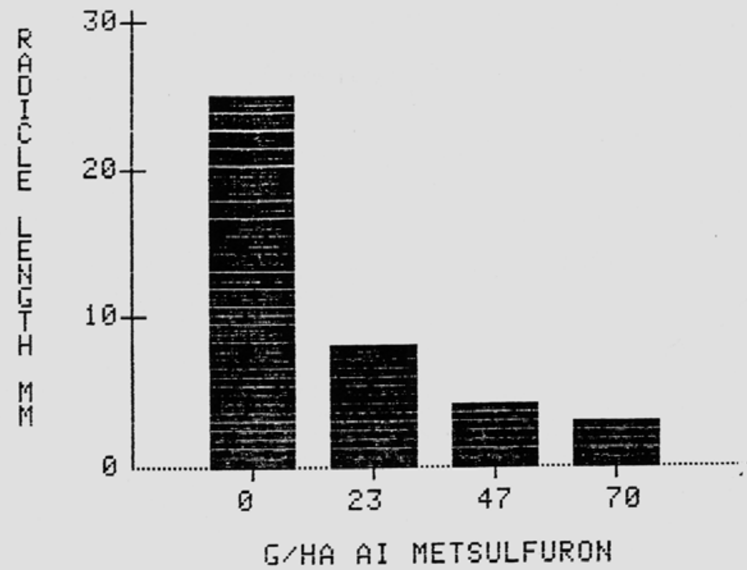

Figure 1. Effect of metsulfuron applied at full bloom on radicle length of field bindweed seedling, five days after germination.

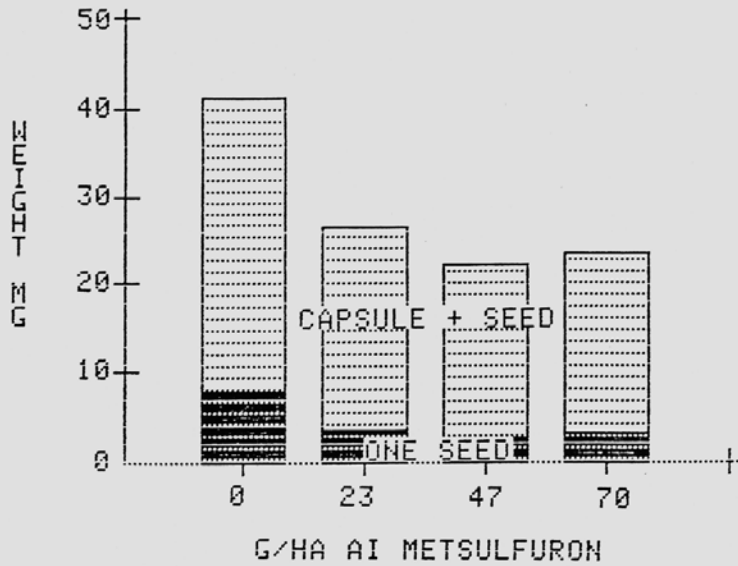

Figure 2. Effect of metsulfuron applied at full bloom on seed and capsule weight of field bindweed.

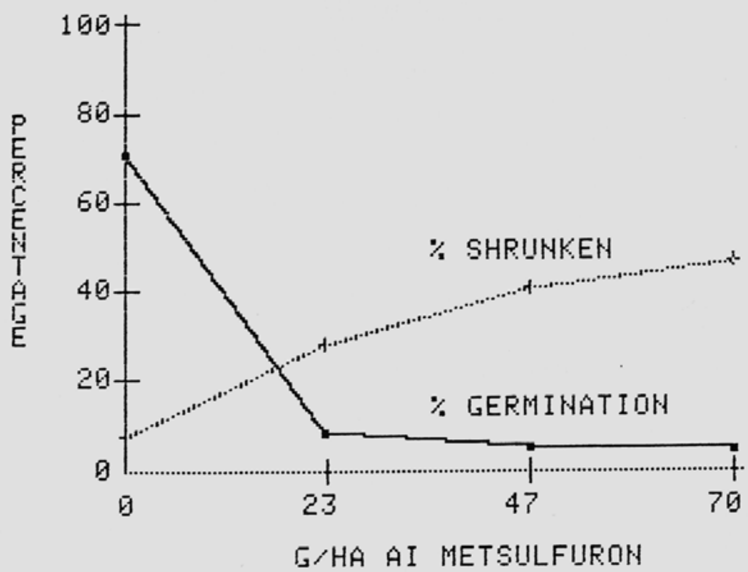

Figure 3. Effect of metsulfuron applied at full bloom on seed viability and seed plumpness of field bindweed.

POSTEMERGENCE BLACK NIGHTSHADE (SOLANUM NIGRUM L.) CONTROL WITH ACIFLUORFEN IN CANNING TOMATOES

Jack Orr, Robert Mullen and Larry Clement[1]

Introduction

Black nightshade (Solanum nigrum L.) is the number one weed pest in California's canning tomato industry fields causing severe yield losses and high hoeing bills amounting to $68 million dollars.

In 1985 and 1984, fifteen canning tomato cultivars in the 1-2 true leaf stage were treated postemergence with 0.125 lbs/A a.i. acifluorfen (5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoic acid) to determine if there was any interaction between the herbicide and varieties. This study consisted of large plots 100 feet in length, replicated and harvested with a commercial tomato harvester.

A second rate study consisted of acifluorfen applied postemergence to tomatoes in the 1-2 true leaf stage. Single applications at 0.031 and 0.062 lbs/A a.i. were made at the first true leaf followed one week later by the next higher increment of 0.062 and 0.125 lbs/A a.i. Black nightshade was in the cotyledon to first true leaf stage. Plots were hand harvested to determine yield differences.

A third rate study over a three-year period looked at time of day and temperature in relation to acifluorfen application. Postemergence applications of acifluorfen at rates of 0.031 to 0.37 lbs/A a.i. were applied at 9 a.m. vs 3 p.m. to tomatoes in the 2-4 true leaf stage; morning temperatures averaged 66° F followed by afternoon temperatures of 91° F at application time.

Research Results

The herbicide, tomato variety interaction study resulted in no interaction between acifluorfen and the 15 cultivars tested (Table 1).

Rate and timing studies showed a significant difference in yield between single rates of application. The 0.125 lb/A a.i. rate was significantly higher yielding than 0.031 lbs/A a.i., but not the 0.062 lb/A a.i. rate.

Double applications of split treatments resulted in significantly higher yields than single treatments. The 0.062 + 0.125 yielded 27.2 tons/A versus 24.4 tons/A of a single 0.062 lb/A a.i. rate (Table 2).

The 0.25 lb/A a.i. rate seemed to be the breaking point for yield reduction with the single application rate. A combination rate of 0.062 + 0.25 lb/A a.i. resulted in very significant yield reductions.

All but the 0.37 lb/A a.i. rate resulted in a significant yield increase over the hoed control. Black nightshade control was increased significantly through split applications.

[1]University of California, Davis, CA.

Time of day, temperature and rate studies showed that applications in the afternoon when temperatures were in the 90's resulted in significant yield reductions. The 0.125 lb/A a.i. rate yielded 27.6 tons/A versus 20.3 tons/A for the same rate applied at 3 p.m. Black nightshade control increased from 48 percent in the morning to 63 percent in the afternoon (Table 3).

Conclusion

Acifluorfen applied either as a single or split application will give fair to good control of black nightshade when the tomatoes are in the first to second true leaf stage and the nightshade is in the cotyledon to first true leaf (Table 4). Use rates should be between 0.062 and 0.125 lb/A a.i. It is critical not to apply acifluorfen during periods of high temperature, above 90° F.

Table 1. 1985 Tomato Variety/acifluorfen Interaction Study

Canning Tomato Variety	Canning Tomato Variety
CXD 100	ADVANTAGE
HYB 898	DIEGO
HYB 33790	49'er HYB
C1518	PETO 343
UC82B	UC204C
E6203	HYB 9889
H2152	JOAQUIN
DEL ORO	

No interaction between varieties and acifluorfen (0.125 lb/A a.i.) at the 5% level

Table 2. Time and Rate of acifluorfen on Processing Tomatoes for the Control of Black Nightshade

Treatment	lbs/AC a.i.	Yield1/4/ T/A	Weed Control2/ Rating	Average Crop3/ Vigor Reduction
acifluorfen 2E	0.031	22.4	2.25	1.75
acifluorfen	0.062	24.4	4.00	2.50
acifluorfen	0.125	25.3	5.75	3.00
acifluorfen	0.25	21.2	6.50	4.25
acifluorfen	0.37	20.1	8.00	6.00
acifluorfen	0.031 + 0.062	24.6	3.50	2.50
acifluorfen	0.031 + 0.125	26.4	4.75	2.75
acifluorfen	0.031 + 0.25	24.5	5.25	4.25
acifluorfen	0.062 + 0.062	26.9	6.00	2.50
acifluorfen	0.062 + 0.125	27.2	6.75	3.75
acifluorfen	0.062 + 0.25	23.4	7.75	5.25
Treated check (hoed)		18.9	0.40	0.20

LSD 5% Level 1.6 T/A
LSD 5% Level 0.92
LSD 5% Level 1.91
4 reps

Table 3. Influence of Application Time on Black Nightshade Control with acifluorfen on Processing Tomatoes.

Treatment	lb/A a.i.	Yield1/ T/A	Crop Vigor2/ Reduction	Weed Control3/ Rating
acifluorfen A.M.	0.031	24.7	1.2	2.3
acifluorfen A.M.	0.062	26.6	1.5	2.8
acifluorfen A.M.	0.125	27.6	1.7	4.8
acifluorfen A.M.	0.25	22.9	2.7	6.8
acifluorfen A.M.	0.37	23.4	4.0	7.5
acifluorfen P.M.	0.031	23.0	1.7	3.5
acifluorfen P.M.	0.062	21.8	2.2	4.3
acifluorfen P.M.	0.125	20.3	3.3	6.3
acifluorfen P.M.	0.25	18.2	5.2	7.8
acifluorfen P.M.	0.37	17.1	5.8	9.3
1 (hoed) A.M.	---	22.6	0.4	0.1
1 (hoed) P.M.	---	22.5	0.9	0.4

LSD 5% Level = 1.9
LSD 5% Level = 0.7
LSD 5% Level = 0.1

Table 4. Postemergence Weed Control Trial in Processing Tomatoes

Treatment	Rate lb/AC	Weed Control1/ Black nightshade 5/7	Weed Control1/ Black nightshade 5/14	Crop Phyto1/ 5/7	Crop Phyto1/ 5/14
acifluorfen	0.031	7.9	6.6	0.8	0.6
acifluorfen	0.062	8.8	7.6	1.2	0.8
acifluorfen	0.125	9.4	8.5	1.7	1.1
acifluorfen	0.031 + 0.062	*7.9	7.4	*0.8	0.7
acifluorfen	0.062 + 0.125	*8.7	8.8	*1.2	0.9
Control	-	0.0	0.0	0.4	0.4

1/ Average of four replications
0 = no weed control; no crop damage
10 = complete weed control; crop dead
*evaluation after one application

THE USE OF DIRECT PHOTOSYNTHETIC MEASUREMENT IN HERBICIDE RESEARCH

Hamid Mashhadi, Bruce Bugbee, and John O. Evans[1]

Introduction

Although the mode of action of many herbicides is known, few studies on the short and long-term effects of herbicides on whole plant photosynthesis, respiration and transpiration have been conducted. These measurements are necessary to determine stomatal apertures, translocation effects and rapid physiological changes. The quantity of phloem-mobile herbicide translocated to metabolic sinks (e.g. root and shoot meristems) almost always determines herbicide efficacy. Since carbon assimilation promotes rapid translocation, measurement of photosynthetic activity following herbicide treatment can indicate rate and distance of herbicide translocation.

This research was conducted to design and build a system to measure photosynthetic characteristics in whole plants. The system was tested using field bindweed (*Convolvulus arvensis* L.) which was sprayed with different concentrations of the phloem-mobile herbicide, metsulfuron.

Materials and Methods

Gas Exchange System. An open gas exchange system was designed and built to continuously measure photosynthesis, transpiration and night-time respiration of whole plants (Figure 1). The plants were enclosed in six, 35-liter, plexiglass cylinders, which were placed inside a growth chamber. Air was collected six meters above the building and passed through three, 155-liter tanks to buffer and stabilize the carbon dioxide (CO_2) concentration. Flow rate into the chambers was measured with rotometers that were calibrated volumetrically. A small fan was placed inside each chamber to insure complete mixing of the internal air. The cylinders were operated at a positive pressure of 25 cm water column, which corresponds to the pressure at which the rotometers were calibrated. This positive pressure insures that no external gas can leak into the system and because this is an open system, gas leaks from the cylinders to the external environment have no effect on system accuracy.

The mole fraction of water vapor was determined with a dew point hygrometer. Mole fraction of CO_2 was determined with an infrared gas analyzer (IRGA), which was used in the differential mode. Operation of the IRGA in the differential mode was preferred for this system because it gives more precise measurement of CO_2 concentration and adjusts for gradual changes in CO_2 concentration. Six, normally closed, solenoid valves were cycled so that measurements could be made in each chamber for seven minutes every hour. The remaining 18 minutes of each hour were used to calibrate the IRGA and to determine the dew point of incoming air.

Temperature and Humidity Control. A thermocouple was placed inside each plexiglass cylinder to monitor air temperature. Desired air temperature was obtained by changing the temperature setting of the growth chamber. Because of greenhouse effects, cylinder air temperatures were

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always 5-7° C warmer than chamber air temperatures during the light period. Desired relative humidity was obtained by adjusting the flow rates through cylinders.

Construction Materials. Materials that do not absorb or transmit CO_2 and water vapor were used throughout the system. Tubing in the system was made of high density polypropylene (Bev-A-Line). Solenoids and manifolds were made from either stainless steel or nickel-plated aluminum. These precautions greatly enhanced system response time and accuracy. Prior to plant measurements, the system was tested without plants to insure that no changes in CO_2 concentration or dew point temperatures occurred in the chambers. This test helps to establish that all changes in CO_2 and water vapor in subsequent plant studies are only from photosynthesis and transpiration.

Plant Culture. Bindweed seeds were scarified for one hour in 16 molar sulfuric acid, rinsed with tap water for 15 minutes and planted in vermiculite. One-month-old plants were then transferred to half-strength, modified Hoagland nutrient solution and grown in a greenhouse under 16-hour photoperiod and 25°C temperature. Eighty-day-old plants were transferred to the plexiglass analysis cylinders in a growth chamber and grown under a 16-hour photoperiod with a photosynthetic photon flux (PPF) of 430 umoles m^{-2} s^{-1} and 24/21°C day/night temperature. A closed-cell foam plug separated the root and shoot environments. This plug prevented root-zone gas transfer into the shoot environment.

Herbicide Application. After determining the pretreatment photosynthesis and transpiration rates of each plant for six days, they were removed from the cylinders and sprayed to the drip with five metsulfuron concentrations, .05, .21, .84, 3.36, 13.44 mmol/l (20, 80, 320, 1280, 5120 ppm). The control plant was sprayed with tap water. All treatments contained .25% v/v WK surfactant. Plants were then placed back into the analysis cylinders, and their photosynthesis and transpiration rates were monitored until photosynthesis in treated plants had stopped.

Results

Ambient Carbon Dioxide Stability. Unstable ambient CO_2 concentrations made it difficult to obtain a steady measurement of photosynthesis. To minimize this problem, the following modifications were made to the system:

a. The air intake was raised six meters above the single-level building to avoid getting exhaust air into the system.

b. Three, 155-liter tanks were connected in series after the blower to buffer and stabilize the CO_2 concentration. Buffering capacity of these tanks was dependent on the flow rates through the cylinders.

c. An additional 4-liter buffering chamber was added to the pre-analysis line before it went to the IRGA. This made pre- and post-chamber buffering capacities more identical.

Air Circulation. Air circulation inside cylinder was found to be important in stabilizing the CO_2 concentration when input flow rates were low. Two miniature fans (Micronel, U.S.*) with capacities of 1,100 and 500 l/min were tested. The larger fan caused excessive shaking of leaves, while the latter resulted in gentle leaf flutter and more desirable air circulation.

Plant Response. Photosynthesis and transpiration rates of field bindweed plants showed a day-time fluctuation. They were at their highest rate in the first few hours after the light period began and at their lowest rate in the final hours before the dark period. However, both photosynthesis and transpiration were relatively steady during the middle 8-10 hours of the light period (Figure 2).

Plants showed a sudden decline in photosynthesis and transpiration rate after treatment, but the rates gradually increased during the next three days. Rates then gradually declined for about two weeks until death (Figure 3). An unexpected finding was that the different herbicide concentrations reduced photosynthesis and transpiration at about the same rate (Figures 3 and 4).

Conclusions

1. Photosynthetic rate of field bindweed shows a large day-time fluctuation decreasing about 25% during a 16-hour light period. The transpiration rate decreases about 40% over the same period.

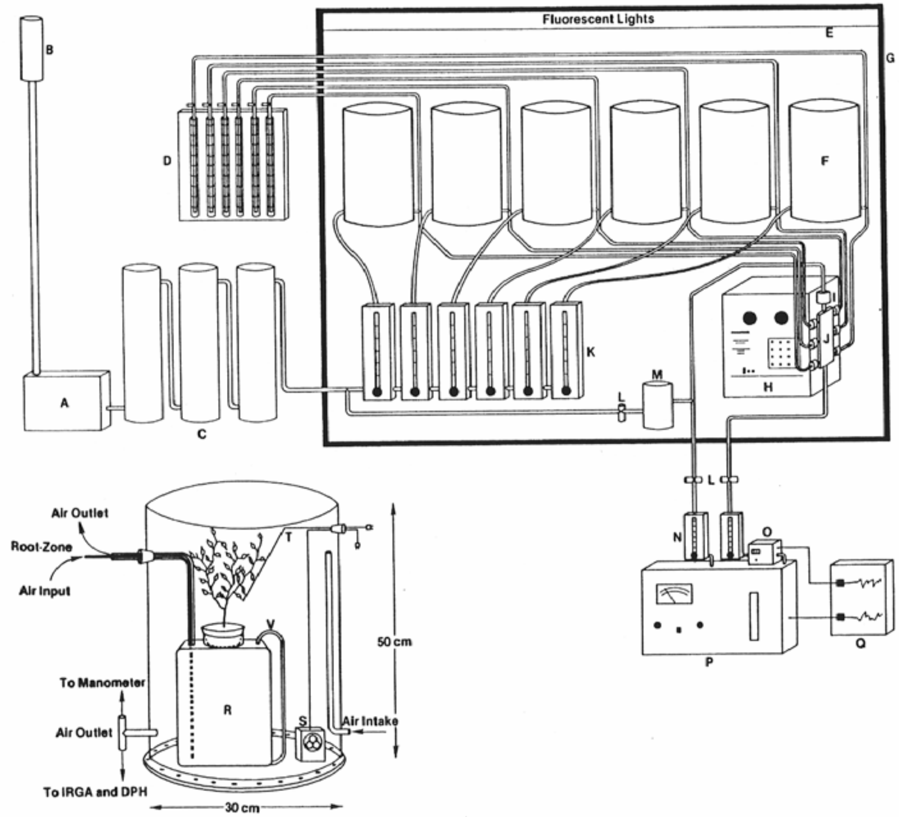
2. Metsulfuron causes an immediate reduction in photosynthesis followed by partial recovery.

3. Metsulfuron stopped photosynthesis of bindweed after two weeks. This effect appears to occur regardless of concentration.

4. Whole plant photosynthetic measurements can be a very useful tool in herbicide research.

*Brand names are mentioned only to provide construction details and do not imply that other, similar products would not be equally suitable.

Diagram of the Open Gas Exchange System



A Rotary Vane Blower
B Filtered Air Intake (6 meters above building)
C 3 155-liter Buffering Tanks (for stabilizing carbon dioxide concentration)
D Manometers
E Plexiglass Barrier Below Lamps
F Plexiglas Cylinders (see detailed diagram)
G Growth Chamber
H Lawn Sprinkler Timer (Buckner model MT12)* (to cycle solenoid valves)
I Normally Open Valve
J Normally Closed Valves
K 0-50 l/min Rotometers (Dwyer Inst. Inc.)*
L 5 Micron Filters
M Additional 5-liter Buffering Chamber
N 0-1 l/min Rotometers
O Dew Point Hygrometer
P Infrared Gas Analyzer (differential mode)
Q Double Pen Chart Recorder
R 2-liter Amber Bottle
S Circulation Fan
T Thermocouple
U Closed Cell Foam Plug
V Solution Level Indicator

FIGURE 1

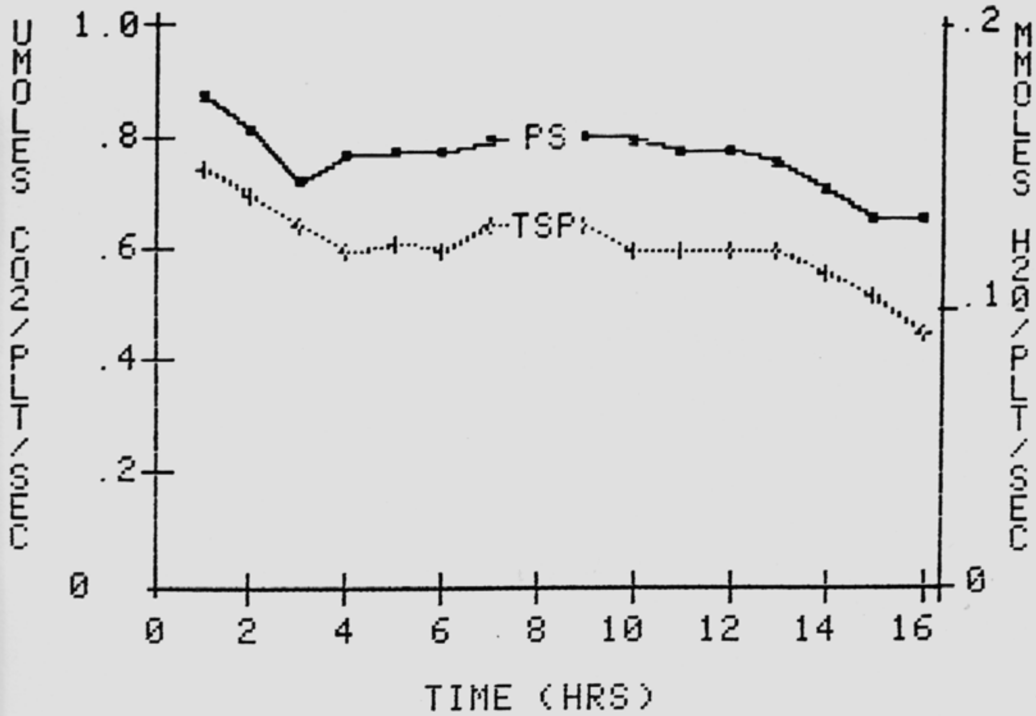


Figure 2. Typical daytime changes in photosynthesis and transpiration of field bindweed grown in hydroponic culture. Units for photosynthesis are µmol plant^{-1} s^{-1}, for transpiration mmol plant^{-1} s^{-1}.

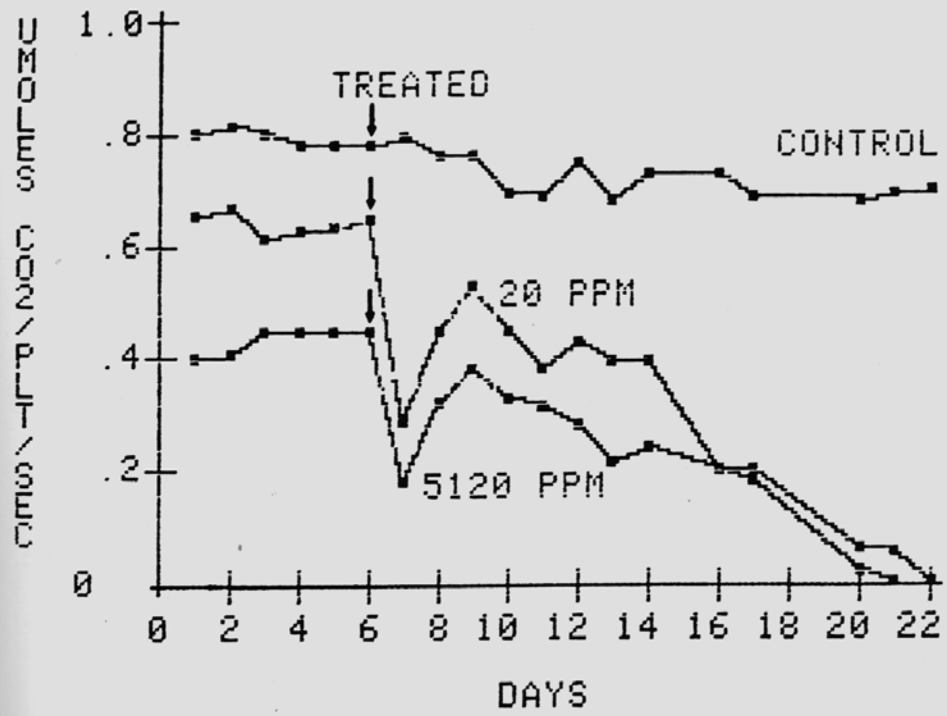


Figure 3. The effect of metsulfuron on photosynthesis of field bindweed. Note the sharp drop and gradual recovery after spraying. Note also that initial rates were not equal because of different plant sizes.

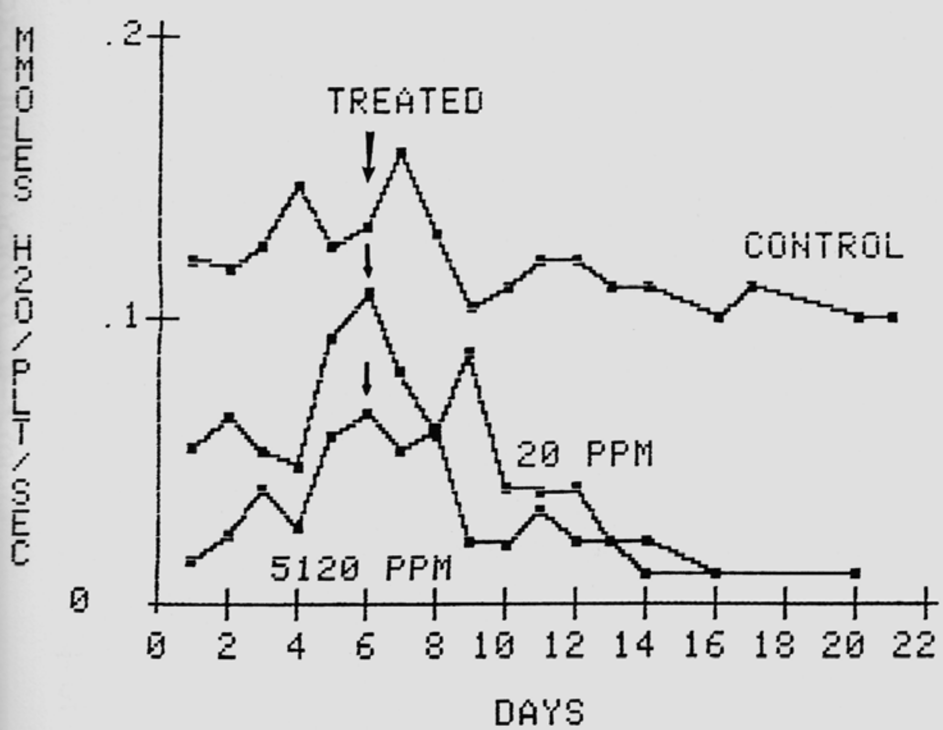


Figure 4. The effect of metsulfuron on transpiration of bindweed. Note the initial rates were not equal because of different plant sizes.

IMPROVING CHEMICAL APPLICATIONS STATEWIDE: AN ON-GOING PROGRAM CONDUCTED BY THE MONTANA COOPERATIVE EXTENSION SERVICE TO IMPROVE CHEMICAL APPLICATIONS AT THE FIELD LEVEL

H.S. Howard and J.E. Nelson[1]

The objectives of the **SPRAY CHEK** program are to demonstrate that proper sprayer calibration at the field level is needed and that a statewide program is economically beneficial and cost effective to initiate. In the past four years, university and private research nationwide has published numerous accounts of substantial misapplication of chemicals at the field level. Misapplication caused by inadequate calibration has been documented with air and ground spraying equipment. This severe problem exists at all levels of the industry from agricultural to industrial pest control. In response to research and a publication entitled: The Billion Dollar Blunder, (University of Nebraska research published in Successful Farming magazine 1982), the Montana Extension Service embarked on a venture known as "Operation Spray Check." Since that time, the Montana Extension Service has instituted an on-going statewide program designed to educate chemical applicators and "tune up" actual field spraying equipment in the process. The process and equipment called **SPRAY CHEK** was developed by and is a trademark of Accu Tech Associates, Inc., Bozeman, Montana.

Methods and Materials

Participating county agents were informed of the program's objectives and trained in the methods of accurate data collection, pattern testing and use of the computer program during a training course conducted in March, 1983 at the MSU campus. **SPRAY CHEK** spray tables and computer software were purchased by each of the four area Extension offices to be used by county agents who elected to conduct sprayer clinics for their region. Ten counties elected to purchase additional **SPRAY CHEK** equipment to facilitate the program. The **SPRAY CHEK** software program is a prescriptive program designed to ensure proper calibration of field sprayers. A sample "printout" from the computer program is presented below. Sample sprayer evaluation from a clinic conducted in 1985.

DATA INPUTS

DATE: 5-1-85
LOCATION: WHITE SULPHUR SPRINGS, MT
SPRAYER TYPE: SKID MOUNT (ROADSIDE APPLIC)
APPLICATOR ID: MEAGHER COUNTY WEED DISTRICT
TRACK LENGTH: 200
1ST TRAVEL TIME (SEC): 22
2ND TRAVEL TIME (SEC): 20
VELOCITY (MPH): 6.5
BOOM PRESSURE: 20 PSI
BOOM HEIGHT (INCHES): 30

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[1]Accu. Tech Associates and Montana State University, Bozeman, MT.

DATA INPUTS (CONT.)

SWATH WIDTH (FEET): 13.3
TANK CAPACITY (GALLONS): 500
EXPECTED APPLICATION RATE (GPA): 5
ACRES TO SPRAY: 500
SECONDS TO COLLECT OUTPUT: 15
NUMBER OF NOZZLES: 10
NOZZLE ID NUMBER: 80025
NOZZLE SPACING (INCHES): 20
NOZZLE OUTPUT UNITS: MIL

NOZZLE EVALUATION

COLLECTED NOZZLE OUTPUT IN MIL

NOZZLE 1 (155)
NOZZLE 2 (163)
NOZZLE 3 (160)
NOZZLE 4 (160)
NOZZLE 5 (152)
NOZZLE 6 (158)
NOZZLE 7 (180)
NOZZLE 8 (158)
NOZZLE 9 (160)
NOZZLE 10 (160)

COLLECTED NOZZLE % DEVIATION FROM MEAN:

```
                                   -          |          +
NOZZLE 1:   -3.49                          ***|
NOZZLE 2:    1.49                             |
NOZZLE 3:   - .37                             |
NOZZLE 4:   - .37                             |
NOZZLE 5:   -5.35                        *****|
NOZZLE 6:   -1.62                            *|
NOZZLE 7:   12.08                             |*************
NOZZLE 8:   -1.62                            *|
NOZZLE 9:   - .37                             |
NOZZLE 10:  - .37                             |
```

INDIVIDUAL PRODUCT COST:

PRODUCT 1 - BANVEL

EXPRESSED AS AMOUNT OF PRODUCT PER ACRE
COST IS $45 FOR 1 (GALLON)
RATE/ACRE IS 1 (PINT)
EXPECTED PRODUCT GALLONS/TANK: 15
EXPECTED PRODUCT COST PER TANK: $675.00
EXPECTED PRODUCT COST PER ACRE: $5.64
EXPECTED PRODUCT COST PER APPLICATION: $2815

ACTUAL PRODUCT COST PER ACRE: $8.74
ACTUAL PRODUCT COST PER APPLICATION: $4370

OVERALL SPRAYER EVALUATION:

VELOCITY (MILES/HRS): 6.5
AVE. NOZZLE FLOW RATE (GAL/MIN/NOZ): .17
BOOM FLOW RATE (GAL/MIN): 1.7
EXPECTED APPLICATION RATE (GAL/ACRE): 5
ACTUAL APPLICATION RATE (GAL/ACRE): 7.77

EXPECTED ACRES TREATED PER TANK: 120
ACTUAL ACRES TREATED PER TANK: 77.25
ACTUAL ACRES TREATED PER HOUR: 13.11
AVERAGE % NOZZLE ERROR: 2.71
AVERAGE % OVERALL APPLICATION ERROR: 55.34
$$ WASTED PER ACRES: $3.12
TOTAL WASTED PER APPLICATION: $1560

RECOMMENDATIONS:

ANY ONE OF THE FOLLOWING CHANGES WILL IMPROVE YOUR SPRAY OPERATION:

1. NEW PRESSURE: 8.29 PRESSURE BELOW 25 MAY CAUSE LOSS OF PATTERN INTEGRITY UNLESS YOU ARE USING LOW PRESSURE NOZZLES.

2. NEW SPEED: 10.08 (MPH)
THAT IS 13.53 SECOND/TRACK DISTANCE

3. NEW FLOW RATE: .11 GALLONS/MIN/NOZ
COLLECTED FLOW RATE OF 113.55 MIL PER 15 SECONDS

end of "printout"

SUMMARY OF DATA: A total of 61 sprayer clinics were conducted by 39 counties during 1983-1985. The results are summarized below:

Sprayers evaluated (private and commercial)	**804**
Average acreage sprayed by equipment evaluated	**1,232**
Total acreage sprayed by equipment evaluated	**991, 072**
Average applicator error: (based on expected vs. actual GPA)	**23%**
% of sprayers that were within 10% application error (based on expected vs. actual GPA)	**60%**
Average nozzle error (under application)	**13%**
Average nozzle error (over application)	**18%**
Average spread of nozzle error (under and over)	**31%**

ECONOMIC EVALUATION

Inadequate calibration of sprayers in Montana has resulted in over and under applications of pesticides causing (damaged) crops, wasted chemicals, poor pest control and/or reduced yields). These misapplications cause average **losses of $5.00 to $12.00 per acre.**

804 sprayers accurately calibrated

804 applicators methods evaluated and improved
$5.00 per acre is a conservative estimate of the amount saved by participating applicators per **991,072** acres sprayed following the calibration clinics.
Savings to participating applicators **$4,955,000.**
Nearly 5 million dollars saved in three years

CONCLUSION: With a modest investment for equipment and training, the Cooperative Extension Service's **SPRAY CHEK** program is well established, working cost effectively and is expanding into the mainstream of Montana's agricultural and non-crop pest control activities via the private sector.

In addition, the on-going data base is offering important statistics documenting applicator methods, sprayer component evaluation and the economic relationship to the state of Montana.

EXPLOITATION OF EXCIPLEX CHEMISTRY FOR DEVELOPMENT OF POTENTIAL NEW POSTEMERGENT HERBICIDE TECHNOLOGY

M.E. Hogan[1] and G.L. Orr[2]

Abstract. Based on photochemistry *in vitro* between β-carotene (β-car) and lipophilic nitrodiphenyl ether (nitroDPE) herbicides, we suggest

$$^{1}\beta\text{-car} + {}^{1}\text{nitroDPE} \xrightarrow{\text{UV-A}} {}^{1}\beta\text{-car} + {}^{1}\text{nitroDPE}^{*} \longrightarrow$$

$$^{1}({}^{1}\beta\text{-car} + {}^{1}\text{nitroDPE}^{*}) \longrightarrow {}^{1}(\beta\text{-car}/\text{nitroDPE}^{*}) \longrightarrow$$

$$^{1}(\beta\text{-car}^{+}/\text{nitroDPE}^{-}) \longrightarrow {}^{1}(\beta\text{-car}^{\dot{+}} + \text{nitroDPE}^{\dot{-}}) \longrightarrow$$

$$\beta\text{-car}^{\dot{+}} + \text{nitroDPE}^{\dot{-}} \xrightarrow{O_2} \beta\text{-car}^{\dot{+}} + {}^{1}\text{nitroDPE} + O_2^{\dot{-}} \longrightarrow$$

$$\longrightarrow \beta\text{-car-}O_2$$

[photooxygenation products (e.g., dioxetanes) via electron transfer],

exploitation of exciplex chemistry[1] with β-carotene and other *in vivo* photosensitizers (e.g., riboflavin) or xenobiotics for development of potential new postemergent herbicide technology. β-carotene and nitroDPEs (or riboflavin) show no interaction in the ground state. However, in the excited state, complexes are formed due to increase in electron donor-acceptor properties of the reactants. These complexes are stabilized by both exciton resonance and charge transfer. Subsequent to absorption of a photon of UV-A radiation, nitroDPEs in the excited singlet state interact with ground state β-carotene to yield an exciplex by first forming an

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[1]Weller, A., 1982 Z. Phys. Chem. (Frankfurt am Main) 130:129
[2]Colorado State Univ., Fort Collins, CO.

encounter complex with the solvated reactants. The exciplex is stabilized by formation of a charge transfer complex which then gives rise to a geminate radical pair. Solvation of the radical pair permits interaction with secondary electron acceptors. Thus, reduction of oxygen to generate superoxide and ground state nitroDPE ensues. Photooxygenation of the - carotene cation radical via electron transfer with superoxide results in formation of dioxetanes of -carotene. Toxicity due to perversion of phytophotochemistry is incurred (because of induction of uncontrolled lipophilic free radicals by toxic oxygen species) when oxyradical scavenging systems *in vivo* are unduly burdened. Mechanisms for herbicide safening, based on manipulation *in situ* of radical scavenging systems are proposed.

SETHOXDIM FOR GRASS WEED CONTROL IN ALFALFA

Gary C. Cramer[1]

Alfalfa (*Medicago sativa*) is grown in millions of a cres in the U.S. Approximately 1-2 million acres are grown in the far western states, Arizona and California. The alfalfa hay in this area is almost always grown under irrigation. The alfalfa varieties (often nondormant or semi-dormant types) are high yielding especially under abundant moisture conditions and year-round growing season.

Yields in Arizona and Southern California, for instance, are commonly one ton/acre per cutting. There are approximately 8-12 cuttings per year and stands are maintained for three to four years.

Weed pressure is often the reason for renovating the alfalfa crop. Even in areas where disease or insect pressures have weakened or thinned the crop, it is the resulting weed pressure that necessitates renovation.

BWC market development representatives and university researchers in the far western states have conducted numerous sethoxydim/alfalfa trials in 1982-1984. In general, these tests were rate studies testing sethoxydim (2-[1-ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one) at .1, .2, .3, .4, .5,# AI/AC. Some of these tests also compared total spray volumes of 5.10 and 20 GPA.

Grasses tested include yellow foxtail (*Setaria lutescens*), wild oat (*Avena fatua*), Italian rye (*Lolium multiflorum*), winter wheat, sandbur (*Cenchurs incertus*), and bermudagrass (*Cynodon dactylon*).

Results

The annual grasses tested were controlled 90% or better with .3# AI/AC, the exception being sandbur (76%). Some annual species (e.g. sandbur) that had been cut repeatedly and/or overwintered in the frost-free desert areas needed a second application of .3# AI/AC on regrowth.

The perennial, bermudagrass, was controlled 90% or more by sethoxydim at .5# AI/AC. Bermuda regrowth almost always requires a second application within 21-30 DAT. A second application of .3# AI/AC is sufficient to control the weak regrowth.

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[1]BASF Corporation, Tucson, AZ.

Table 1. Alfalfa/Annual Grass (% Control)

Sethoxydim Rates	GPA	13-28 Days after Treatment Y.F.	W.O.	I.R.	WH.	S.B.
.1	10-20	--	30	85	51	--
.2	5-20	76	70	90	78	--
.3	5-10	--	90	95	95	81
.4	5-20	83	95	99	95	92
.5	5-10	--	--	--	--	96

[1]First evaluation; [2]Averages of 1-4 trials; [3]Y.F. = yellow foxtail; W.O. = wild oat; I.R. = Italian rye; WH. = wheat; S.B. = sandbur.

Table 2. Alfalfa/Annual Grass (% Control)

Sethoxydim Rates	GPA	30-177 Days after Treatment Y.F.	W.O.	I.R.	WH.	S.B.
.1	10-20	--	25	85	40	--
.2	5-20	82	75	90	87	--
.3	5-10	--	90	95	95	76
.4	5-20	92	95	99	87	81
.5	5-10	--	--	--	--	88

[1]Second evaluation; [2]Averages of 1-4 trials; [3]Y.F. = yellow foxtail (*Setaria lutescens*); W.O. = wild oat *Avena fatua*); I.R. = Italian rye (*Lolium multiflorum*); WH. = wheat; S.B. = sandbur (*Cenchrus incertus*)

FISILADE 2000 (PP005): A NEW POSTEMERGENCE HERBICIDE FOR THE CONTROL OF GRASS WEEDS

Charles Doty, Henry Buckwalter and Robert Munson[1]

Abstract. FUSILADE 2000 (PPoo5) is the commercial name for fluazifop-P-butyl. The chemical name is butyl (R)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxyl]propanoate. FUSILADE 2000 1E contains 1 pound (+) isomer (fluazifop-P-butyl) per gallon.

FUSILADE 2000 effectively controls a broad spectrum of both perennial and annual grasses in broadleaf crops. Current EPA labels include cotton, soybeans, noncrop, nonfood, and ornamentals.

FUSILADE 2000 rapidly enters the plant via the leaves. It moves in both the xylem and phloem. The first visible symptom of activity is cessation of growth in 24 to 48 hours. Meristematic tissue becomes necrotic and young leaves show chlorosis. Actively growing young grasses show symptoms much quicker than older grasses or those under stress from such factors as drought or very high temperatures. Either a non-ionic surfactant or crop oil concentrate should be added to the spray solution at 1/4% v/v or 1% v/v, respectively. Extensive testing in the western U.S. has shown fusilade 2000 to be 1 1/2 to 2 times as active as the original FUSILADE 4E. New labels anticipated for 1986 include carrots, peanuts, onions and garlic.

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[1]ICI Americas Inc., Wilmington DE.

THE BRITTLEBUSH PROBLEM AND POTENTIAL CONTROL MEASURES IN BUFFELGRASS PASTURES IN SONORA, MEXICO

Fernando A. Ibarra, Martha H. Martin, L. Ricardo Torres, Martin F. Silva[1], Howard L. Morton, and Jerry R. Cox[2]

Abstract. More than 300,000 hectares (ha) of rangelands have been seeded to bufflegrass (*Cenchurus ciliarus* Link.) in Sonora, Mexico. There are an additional three million ha which could be seeded. Buffelgrass pastures produce more than eight times as much forage as native pastures. Stocking rates on native pastures are from 30 to 40 ha/Animal Unit Year (AUY); whereas, on buffelgrass pastures stocking rates are from 3 to 4 ha/AUY. Brittlebush (*Encelia farinosa* Gray) has invaded buffelgrass seedings as well as native pastures. Brittlebush densities as high as 30,000 mature plants/ha occur in seeded pastures and seedling densities often exceed 48,000 plants/ha. Biomass of mature brittlebush plants on these areas average 20 tons Dry Matter (DM)/ha. Brittlebush seed production can

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[1]Centro de Investigaciones Pecuarias del Estado de Sonora (CIPES), Hermosillo, Sonora, Mexico.
[2]U.S. Dept. Agric., Agric. Res. Serv., Aridland Watershed Manage. Res. Unit, Tucson, AZ.

vary from several grams to over 60 kg Pure Live Seed (PLS)/ha/year. Several studies were conducted to determine the effectiveness of mechanical and chemical brush control methods on plant mortality. Mowing killed few plants and temporarily reduced growth. Hand removal resulted in 100% mortality, but seedlings rapidly reinvaded and densities were equal to pretreatment levels after three months. Soil applied pelleted tebuthiuron at 0.5 and 1.0 kg active ingredient (ai)/ha killed 73 and 98% of the plants respectively, during the first year; while soil applied pelleted picloram at 0.5 and 1.0 kg acid equivalent (ae)/ha killed 93 and 99% of the plants, respectively. A single, hot summer burn killed 32% of the mature plants and 60% of the seedlings. Burning in two consecutive years killed 70% of the mature plants and 90% of the seedlings. High intensity livestock grazing reduced brittlebush growth, but caused no significant changes in brittlebush density after three years.

Introduction

There is no doubt that shrub species, primarily the ones not preferred by grazing animals, are increasing on rangelands (2, 3, 6). Mechanical brush control practices such as cabling, mowing, railing and disk plowing generally provide temporary control (7,9). Foliar herbicides such as 2,4-D [(2,4-dichlorophenoxy)acetic acid]; 2,4,5-T[(2,4,5-Trichlorophenoxy)acetic acid]; picloram (4-amino-3,5,6-Trichloropicolinic acid); and dicamba (3,6-dichloro-o-anisic acid) have controlled only a limited number of shrubby species (5, 8). Soil applied herbicides such as tebuthiuron (N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N,N^1-dimethylurea) and picloram control many woody species that are resistant to foliar applied herbicides (12, 13), while fire effectively controls some non-sprouting brush species (4,16).

The increase of brittlebush in the Sonoran Desert has been documented. Densities of the species have almost doubled in 30 years near Tucson, Arizona (14). In Sonora, Mexico, brittlebush densities increased on mechanically disturbed areas seeded to buffelgrass, abandoned farmlands, and on overgrazed rangelands. At least 50% of the 300,000 ha of buffelgrass pastures established in the State of Sonora have been invaded by brittlebush (Figure 1); and more than 60% of the 3 million ha suitable for buffelgrass seeding have varying amounts of brittlebush.

Young and mature brittlebush plants are shrubs with dense hemispheric canopies, reaching 80 cm in diameter and frequently over 1 m in height. Leaves are gray-green and densely hairy; 2 to 5 cm long and 1.5 to 2.5 cm wide. Disc flowers of some plants are yellow or purple. Brittlebush is very abundant on dry rocky slopes up to 950 m in elevation. In the United States it is distributed in southern California, southern Nevada, southwestern Utah and southern and western Arizona. In Mexico it is distributed in Baja, California, Sonora and Sinaloa (Figure 1) (1, 10, 11).

Literature pertaining to brittlebush control does not exist. The objectives of this study were: 1) To determine the infestation potential and the amount of competition between buffelgrass and brittlebush, 2) to evaluate the effectiveness of herbicides and mechanical treatments, fire and grazing practices on brittlebush control, and 3) to develop effective and economical practices to reduce brittlebush densities in buffelgrass pasture.

Materials and Methods

A series of experiments were conducted to evaluate the response of buffelgrass to several brush control methods at two sites in Sonora, Mexico. Rancho Maria de Lourdes is located 28 km north of Hermosillo along the Hermosillo-Nogales Highway. Elevation is 260 m and precipitation averages 309 mm annually, with 70% falling in the summer and 30% during the winter. Mean monthly temperature is 24.2° C. Soils are deep loams and pH is 6.7. Two nine-year-old buffelgrass pastures were selected; one in good condition and moderate brittlebush infestation and the other in poor condition and highly infested with brittlebush. Other brushy species at the site were: palo verde (Cercidium spp), ironwood (Olneya tesota A. Gray), mesquite (Prosopis julifora (Swartz) D.C.), kidneywood (Eysenhardtia orthocarpa S. Wats) and torchwood (Bursera spp).

Treatments were: 1) hand removal of brittlebush, 2) hand removal and fertilizer (80 kg/ha of nitrogen as urea (+) 40 kg/ha of phosphorus as triple superphosphate), 3) burning, broadcast application of 20% pellets of tebuthiuron at 4) 0.5 and 5) 1.0 kg ai/ha, and broadcast application of 10% pellets of picloram at 6) 0.5 and 7) 1.0 kg ae/ha. Treatments were applied in both pastures on May 1985, replicated three times and arranged in randomized complete block design.

Brittlebush density was estimated before and after treatment application in three randomly selected 30 m^2 quadrats per plot. Forage production was estimated at the end of the summer growing season by clipping ten 1 m^2 quadrats randomly placed in each plot. Forage was dried at 40° C for 72 h. Brittlebush biomass was estimated by removing and weighing all plants present within 15 by 30 m plot. To determine the effect of each treatment on reproductive capacity, buffelgrass seed production was estimated by harvesting seed randomly on twenty 1 m^2 quadrats in each plot.

The second site is at Centro de Investigaciones Pecuarias del Estado de Sonora (CIPES): located 72 km north of Hermosillo along the Hermosillo-Nogales Highway. Elevation is 450 m and annual precipitation is 328 mm; 70% falls in summer and 30% in winter. Mean monthly temperature is 21.9° C. Soils are deep, sandy loams and pH is 6.8.

Your studies were placed on four 7-year-old buffelgrass pastures with dense stands of buffelgrass and highly infested with brittlebush.

Study one. Mowing was applied before the summer growing season of 1983 in half of a 40 ha pasture. The remaining half was left as an untreated quadrats each. Brush mortality was calculated from densities on treated and untreated plots. Forage production (standing biomass) was estimated at the end of the growing season of 1984 and 1985 by clipping 80 randomly placed 1 m^2 quadrats.

Study two. In the summer of 1982, two-thirds of a 70 ha pasture was burned and in summer of 1983 half of the area previously burned in 1982 was reburned to determine the effect of a single burn and of two burns. Brittlebush density was estimated from the number of plants in 40 randomly placed 45 m^2 quadrats in plots burned once, twice and on the untreated check.

Study three. Grazing studies were started in 1983. Treatments applied were light, moderate and intensive continuous grazing with stocking rates of 4, 3, and 2 ha/AUY, respectively. Brittlebush density was estimated from 30 randomly placed 45 m^2 quadrats on each of the grazed pastures and on an ungrazed excluded area.

Study four. Foliar sprays were applied in the summer of 1985. Foliar herbicides applied were: dimethylamine salt of 2,4-D, isooctyl ester of 2,4-D, potassium salt of picloram, dimethylamine salt of dicamba, dimethyl amine salt of 2,4-D (+) potassium salt of picloram, triethylamine salt of 2,4,5-T (+) triethylamine salt of picloram and potassium salt of picloram (+) dimethylamine salt of dicamba each at rates of 0.5 and 1.0 kg ae/ha. Each treatment was triplicated in a 15 by 30 m plot and arranged in a randomized complete block design. Brittlebush density was estimated before and after treatment application in three randomly selected 30 m^2 quadrats per plot.

Data collected were subjected to analyses of variance and when significant ($P<0.05$) differences were detected, means were separated by Duncan's Multiple Range Test (15). In the mowing, burning and grazing studies we used variability within plots for our statistical comparisons because a limited number of pastures prevented replication.

Results

Precipitation in both summer and winter of 1982 was near the ten-year average, above average during summer and winter of 1983 and 1984 and below average in summer and winter of 1985 at the two study sites.

Rancho Maria de Lourdes. Brittlebush density and biomass were significantly different among pastures (Table 1). Density of young and mature brittlebush plants was almost four times greater and biomass almost three times greater in the poor condition pasture compared with the good condition pasture. Plants on the good condition pasture were 0.190 kg heavier than plants on the poor condition pasture.

Table 1. Brittlebush density and biomass at two 9-year-old buffelgrass pastures at Rancho Maria de Lourdes, Hermosillo, Sonora, Mexico in 1985.

Pasture Condition	Plants		Density	Biomass
			(Plants/ha)	(kg DM/ha)
Good	Mature		6,790	7,747
	Young		7,440	997
		Total	14,330	8,744
Poor	Mature		27,800	21,628
	Young		29,300	2,432
		Total	57,100	24,060

The highest brittlebush mortality was obtained with soil applied herbicides (Table 2). Apparently range condition and brush density do not influence herbicide effectiveness. Hand removal of brittlebush initially killed all plants in both pastures. However, brittlebush seedlings rapidly

Table 2. Brittlebush mortality (%) five months after the application of several brush control methods on two buffelgrass pastures with different range conditions at Rancho Maria de Lourdes, Hermosillo, Sonora, Mexico in 1985.

Treatments	Pasture Condition	
	Good	Poor
	---(% Mortality)---	
Hand removal	60 bc[a]	43 c
Hand removal (+)		
Fertilizer[b]	52 c	35 c
Burning[c]	71 b	44 c
Tebuthiuron (ai/ha)		
0.5 kg	73 b	78 b
1.0 kg	98 a	90 a
Picloram (ae/ha)		
0.5 kg	93 a	86 ab
1.0 kg	99 a	96 a

[a]Means within columns followed by the same letter are not significantly different (P>0.05) according to Duncan's Multiple Range Test.
[b]80 kg/ha of nitrogen as urea (+) 40 kg/ha of phosphorus as triple superphosphate.
[c]Burned before the summer rains.

reinvaded and densities were almost equal to pretreatment levels after three months. Tardy and reduced summer rainfall had a considerable effect on brittlebush seedling densities. Seedling mortality at five months was 60 and 43% in the good and poor condition pastures, respectively. Fertilizer application did not affect seedling density, but plants appeared greener and more succulent.

Forage production increased from 10 to 70% after treatment and was significantly greater than in the untreated checks at the good condition site (Table 3). Forage production was greatest after fire, followed by the hand removal (+) fertilizer and the high application rates of both herbicides.

Table 3. Forage production of buffelgrass (kg DM/ha) five months after application of several brush control methods at Rancho Maria de Lourdes, Hermosillo, Sonora, Mexico in 1985.

	Good Condition Site		Poor Condition Site	
Treatments	Forage Production	Increase	Forage Production	Increase
	(kg/ha)	(%)	(kg/ha)	(%)
Hand removal	1531 c[a]	14	365 b	44
Hand removal (+)				
Fertilizer[b]	1952 b	49	421 a	65
Burning[c]	2286 a	70	363 b	43
Tebuthiuron (ai/ha)				
0.5 kg	1508 c	12	361 b	47
1.0 kg	1773 bc	31	278 c	10
Picloram (ae/ha)				
0.5 kg	1463 c	10	382 b	51
1.0 kg	1851 bc	38	416 a	64
Check	1345 d	--	253 c	--

[a]Means within columns followed by the same letter are not significantly different ($P>0.05$) according to Duncan's Multiple Range Test.
[b]80 kg/ha of nitrogen as urea (+) 40 kg/ha of phosphorus as triple superphosphate.
[c]Burned before the summer rains.

Forage production increased from 43 to 65% after treatment at the poor condition site and was significantly greater than the untreated checks following all treatments except the high rate of tebuthiuron. Forage production was greatest following hand removal (+) fertilizer and the high rate of picloram.

The greater forage production on the hand removed (+) fertilizer indicates that buffelgrass responds to range fertilization, and forage production increases can be expected in good condition pastures.

Buffelgrass forage production in the untreated checks in the good condition pasture was more than five times greater than the checks in the poor condition pasture (Table 3), while brittlebush biomass in the poor condition pasture was almost three times greater than in the good condition pasture (Table 1). These differences were due to management, because both pastures were seeded on the same date and in contiguous pastures.

Buffelgrass seed production was greatest after hand removal with or without fertilizer, burning and the low rate of picloram applied in the good condition pasture (Table 4). Seed production was greatest in hand removed (+) fertilized plots in the poor condition pasture.

Table 4. Buffelgrass seed production as affected by several brush control methods of Rancho Maria de Lourdes, Sonora, Mexico in 1985. Data was collected five months after treatment application.

	Good Condition Site	Poor Condition Site
Treatments	Seed Production	Seed Production
	(kg/ha)	(kg/ha)
Hand removal	20.9 a[a]	9.4 b
Hand removal (+)		
Fertilizer[b]	21.2 a	12.5 a
Burning[c]	20.1 a	9.5 b
Tebuthiuron (ai/ha)		
0.5 kg	18.3 b	9.1 b
1.0 kg	10.9 d	5.4 d
Picloram (ae/ha)		
0.5 kg	19.1 ab	8.9 bc
1.0 kg	14.4 c	8.8 bc
Check	13.9 c	7.6 c

[a]Means within columns followed by the same letter are not significantly different (P>0.05) according to Duncan's Multiple Range Test.
[b]80 kg/ha of nitrogen as urea (+) 40 kg/ha of phosphorus as triple superphosphate.
[c]Burned before the summer rains.

CIPES. Mowing did not reduce brittlebush densities. Mowed plants grew back to pretreatment sizes within three years and mowing had no effect on forage production.

A single, hot summer burn in 1982 killed 32% of mature plants and 60% of seedlings. Remaining plants sprouted vigorously during the next year. Burning in two consecutive years killed 70% of mature plants and 90% of seedlings. Remaining plants were injured and have not recovered.

Cattle were observed grazing leaves and tips of stems of brittlebush plants; however, grazing intensity did not appear to affect brittlebush densities. Brittle bush size was less under heavy grazing than under moderate and light. It was not possible to determine if plant damage was due to grazing or trampling since botanical composition of diets in grazing animals were not determined. foliar applied herbicides had no effect on brittlebush populations.

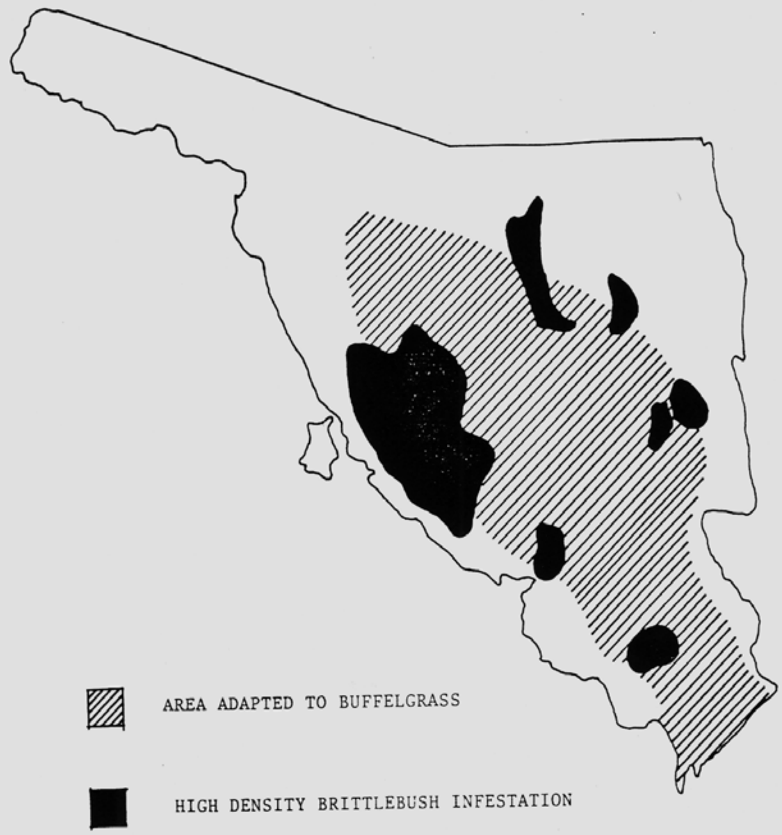

FIGURE 1.- THE AREA SEEDED OR WHERE BUFFELGRASS COULD POTENTIALY BE SEEDED TO IMPROVE RANGELAND PRODUCTION, AND AREAS WHERE BRITTLEBUSH IS THE DOMINANT SPECIES IN SONORA, MEXICO.

Figure 1. The area seeded or where buffelgrass could potentially be seeded to improve rangeland production and areas where brittlebush is the dominant species in Sonora, Mexico.

Conclusions

Preliminary data suggest that brittlebush reduces forage production and is a strong competitor with buffelgrass. The soil applied herbicides tebuthiuron and picloram, and prescribed burning seem to adequately control brittlebush. Brittlebush reinfestation appears to be related to range management practices. Large number of small brittlebush plants were found after hand removal. Rainfall, drought and other environmental factors will determine the longevity of brittlebush control measures.

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BRUSH CONTROL AND FORAGE PRODUCTION ON SOUTHEASTERN ARIZONA RANGELANDS

Howard L. Morton and Jerry R. Cox[1]

Abstract. We aerially applied tebuthiuron [N-(5-[1,1-dimethylethyl]-1,3,4-thiadiazol-2-yl)-N, N'-dimethylurea] at rates ranging from 0.27 to 1.65 kg ai/ha to reduce competition of creosotebush (*Larrea tridentata* [DC] Coville), whitethorn acacia (*Acacia constricta* Benth.), desert zinnia (*Zinnia pumila* Gray), tarbush (*Florensia cernua* DC) and associated half-shrubs at three sites. Plant mortality was greatest on shallow, coarse-textured soils and least on deep, fine-textured soils. Creosotebush mortalities ranged from 32 to 100%, whitethorn acacia from 31 to 100%, tarbush from 87 to 100% and desert zinnia from 88 to 100%. Shrub mortalities increased as herbicide rate increased. Perennial grass forage production across all herbicide rates increased from 50 to 478 kg/ha between one and three years at two sites; and varied from 376 to 914 kg/ha between two and seven years at the third site. Forage production increased as

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herbicide rate increased (shrub competition declined) and was from three to five times greater on treated than on untreated areas.

Introduction

Woody plants have invaded the semidesert grasslands in the western United States (1, 17). As woody plant densities increased, perennial grass densities and forage production declined (7). Often it is desirable to reduce woody plant competition and stimulate perennial grass growth in order to reduce runoff and erosion, increase infiltration and provide forage and cover for livestock and wildlife (2, 6, 11).

Mechanical tillage and seeding perennial grasses have been used to reduce shrub competition and restore grassland productivity for the past 90 years (3). The probability of establishing perennial grasses in semiarid areas of the southwest occurs in only one of ten years (4). Therefore, a less destructive approach which will reduce shrub competition without destroying existing native grasses is needed (10).

Tebuthiuron, a soil applied herbicide, effectively reduces woody plant competition and at low rates has a minimal effect on existing perennial grasses (8, 9, 10, 12, 13). In this study we aerially applied tebuthiuron to reduce shrub competition and determine forage production in subsequent years.

Materials and Methods

Site Descriptions. Three sites were selected in southeastern Arizona. Sites were located: 1) 80 km southeast of Tucson at Fairbanks, 2) 100 km southeast of Tucson at Hereford, and 3) 40 km south of Tucson at the Santa Rita Experimental Range (SRER). Elevation varied from 1000 m at SRER to 1300 m at Hereford. Creosotebush [*Larrea tridentata* (DC) Cov.], whitethorn acacia (*Acacia constricta* Gray), burroweed [*Haplopoppus tenuisectus* (Green) Blake], Mariola (*Parthenium incanum* H.B.K.), tarbush (*Flourensia cernua* DC.), broom snakeweed [*Xanthocephalum sarothrae* (Pursh) Shinners] and desert zinnia (*Zinnia pumila* Gray) were the dominant woody plants, while the predominant grasses were bushmuhly (*Muhlenbergia poteri* Scribn.), spike dropseed (*Setaria macrostachya* H.B.K.), fluffgrass [*Tridens pulchellus* (H.B.K.) Hitchc.] and threeawns (*Aristida* spp.).

At Fairbanks soils were loamy, mixed, thermic, shallow typic Palerothid and Pectrocalcic calciustoll (15). At Hereford they were fine, mixed, thermic Typic Paleargid and Ustolic Haplargid. At SRER they were coarse, loamy, mixed, calcareous, thermic Typic torrifluvents and loamy, mixed thermic shallow Typic Palerothids (14). Soils at the three sites were mixed and formed complex associations. All soils were well drained.

The Fairbanks site was fenced to exclude domestic livestock grazing in 1979. Livestock were removed and no grazing by livestock occurred at the Hereford site after treatments were applied in 1978. The SRER site was grazed by domestic livestock from the time of treatment in 1976 until 1981 when livestock was excluded. Livestock grazing on the treated plots was essentially nil (utilization of forage plants less than 5%) in 1976, 1977, and 1978. However, grazing in 1979 and 1980 was moderate but heavy enough to preclude accurate forage production estimates.

Chemical treatments. Tebuthiuron pellets containing 20% active ingredient (ai) were aerially applied at SRER on July 15, 1976 with a slotted metering plate and spreader at rates of 0.35, 0.46 and 1.20 kg ai/ha. The herbicide was aerially applied at Fairbanks and Hereford on June 19, 1978 at rates of 0.27, 0.64, and 1.25 kg ai/ha at rates of 0.55, 1.10 and 1.65 kg ai/ha. At SRER and Hereford plots were 100 by 800 m and those at Fairbanks were 100 by 460 m. SRER and Hereford had 100 m wide check plots.

Plant mortality. Plots were evaluated 39 months after treatment by determining dead plants within each plot. Six to 10, 100-plant groups were counted on each plot.

Forage production. We estimated forage production (standing above-ground biomass) on each plot by the double-sampling technique of Wilm et al. (16). Weight of each plant species in a 0.89 m^2 quadrat was estimated, and plants in each tenth quadrat were clipped and weighed. After drying at 40° C for 48 h, regression equations for each species were calculated and corrections between estimated and clipped weights applied to the estimated dry weights. Ten quadrats made up a sample unit, and we used from 7 to 23 sampling units (70 to 230 quadrats) in each plot.

At Hereford and SRER, slope, aspect, botanic composition and soil differences affected responses of forage plants. At these two sites forage production means on treated plots and adjacent untreated check plots are presented. Forage production was evaluated after the 2nd, 3rd, 4th and 6th growing seasons after treatment at Fairbanks and Hereford and after the 3rd, 6th, and 8th growing season after treatment at SRER.

Results and Discussion

Brush mortality. All rates of tebuthiuron gave excellent control of all brush species at Fairbanks (Table 1). The shallow, course-textured soils at this site probably account for the high mortality rates. Mortalities were not as high at Hereford as at Fairbanks, but control of at least 54% was attained for all species except for honey mesquite (Table 2). Untreated desert zinnia and whitethorn acacia mortality rates of 4 and 5% were recorded at Hereford, Low temperatures in January 1979 caused extensive stem damage to nearly all plants of these two species but nearly all plants has resprouted in 1981.

Table 1. Mortality of shrubs treated with three rates of tebuthiuron at Fairbanks[a].

	Application rates (kg/ha)		
Plant Species	0.27	0.64	1.25
	(% dead)		
Creosotebush	78	81	100
Whitethorn acacia	91	93	100
Tarbush	87	90	100
Mariola	100	100	100
Desert zinnia	100	100	100

[a]Applied June 19, 1978 and evaluated September 1981.

Table 2. Mortality of shrubs treated with three rates of tebuthiuron at Hereford[a].

	Application rates (kg/ha)		
Plant Species	0.55	1.10	1.65
	-----------(% dead)-----------		
Whitethorn acacia	64	98	98
Desert zinnia	88	100	100
Broom snakeweed	69	65	95
Burroweed	54	71	90
Honey mesquite	38	71	69

[a]Applied June 19, 1978 and evaluated September 1981.

The two lowest rates of tebuthiuron killed about one-third of the creosotebush and whitethorn acacia plants, and the highest rate killed 90% or more of both species at SRER (Table 3). Desert zinnia was the most susceptible species to tebuthiuron and mesquite the least.

Forage production. Forage production on untreated areas at Fairbanks was essentially nil in 1979 (Table 4). Forage production increased each subsequent year and was highest in 1983. This reflects protection from livestock grazing as the plot area was fenced in 1979. Forage production on the 0.27 kg/ha rate peaked during the 1980 growing season and remained essentially unchanged during the next three years. Forage production on the 0.63 and 1.25 kg/ha rates were lower in 1979 than on the 0.27 kg/ha, suggesting that at these rates tebuthiuron was inhibitory to the forage plants. Some of the plants on these plots showed chlorosis and other symptoms of tebuthiuron toxicity in 1979. Forage production increased in 1980 and 1981 on plots treated at 0.63 and 1.25 kg/ha rates with highest production occurring at both rates in 1981.

Forage production increased between two and four fold on plots treated with tebuthiuron when compared with untreated check plots at the Hereford site (Table 5). Forage production at the SRER site was always higher in all years on the plots treated with tebuthiuron than on adjacent untreated plots (Table 6). Highest brush mortality and forage production occurred on the plot treated at 1.20 kg/ha rate. This study shows that forage production improves after brush competition is reduced or removed with tebuthiuron.

Table 3. Mortality of shrubs treated with three rates of tebuthiuron at SRER[a].

	Application rates (kg/ha)		
Plant Species	0.35	0.46	1.20
	-----------(% dead)----------		
Creosotebush	36	32	90
Desert zinnia	32	76	100
Whitethorn acacia	31	35	94
Mesquite	17	27	92

[a]Applied July 15, 1976 and evaluated October 1979.

Table 4. Forage production in plots treated with tebuthiuron in 1978 at Fairbanks.

Tebuthiuron	Year of Evaluation			
rates	1979	1980	1981	1983
(kg ai/ha)	------------(kg DM/ha)---------			
0.00	2	32	45	103
0.27	201	379	311	269
0.63	113	457	490	316
1.25	45	530	605	504

Table 5. Forage production on plots treated with tebuthiuron in 1978 at Hereford.

Tebuthiuron rates	Year of Evaluation 1979	1980	1981	1983	Average
(kg ai/ha)	-----------(kg DM/ha----------				
0.55	699	466	603	342	528
0.00	64	267	109	58	124
1.10	174	210	230	390	251
0.00	128	50	97	94	92
1.65	418	310	624	607	490
0.00	264	257	370	334	306

Table 6. Forage production on plots treated with tebuthiuron in 1976 and untreated plots at SRER.

Tebuthiuron rates	Year of Evaluation 1978	1981	1983	Rate Average
(kg ai/ha)	-------(kg DM/ha)-------			
0.35	403	337	734	491
0.00	81	121	193	132
0.46	376	482	822	560
0.00	104	151	223	159
1.20	528	653	914	698
0.00	146	158	230	178

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SPATIAL DISTRIBUTION OF TEBUTHIURON IN SOIL FOLLOWING APPLICATION OF PELLETS

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Abstract. Tebuthiuron (N-[5-(1,1 dimethylethyl)-1,3,4-thiadiazol-2-yl]-N,N'-dimethylurea) pellets containing 40% active ingredient (ai) were placed on the surface of three soils in Utah. Soil collections were made at four or five post-application dates from 20 to 370 days and at 12 combinations of depth and distance from the point of pellet placement to evaluate the spatial distribution of tebuthiuron in the soil following application of tebuthiuron pellets. Soil samples were analyzed for tebuthiuron resides using High Performance Liquid Chromatograph (HPLC) with an ultraviolet detector. Movement and persistence were influenced by precipitation, clay content and organic matter content of the soil. Surface-soil residuals were 1,843 ppm 37 days after treatment at one of the three sites. However, this concentration was present in only a small area under each pellet. Data indicate that an application of 40% tebuthiuron pellets at 1.1 kg ai/ha would leave a residue on 17 to 38% of the treated area, depending on the soil organic matter content. Movement of tebuthiuron was less in high organic matter soils compared to low organic matter soils.

Introduction

Aerial applications of tebuthiuron pellets are reportedly effective for control of mountain big sagebrush (*Artemisia tridentata* spp. *vaseyana* #3 ARTTR) (Clary et al. 1985a), Utah juniper (*Juniperus osteosperma*) (Clary et al. 1985a), and Gambel oak (*Quercus gambelii*) (Clary et al. 1985b). Efficacy and persistance of soil-applied herbicides are functions of application rate, timeliness and extent of post-application rainfall, soil organic matter and clay content. Previous lab (Chang and Stritzke 1977) and greenhouse (Duncan and Scifres 1983) studies indicated tebuthiuron is relatively immobile in the soil and may be quite persistent. Field observations of tebuthiuron treated rangeland indicate that significant residues may persist in soils for two to four years.

Pelleted herbicides have several advantages compared to foliar-active sprays for rangeland use. Most important among these advantages are reduced drift potential, negligible volatilization hazard and a longer application season. Soil-active herbicides such as tebuthiuron depend on rainfall for transport into the root zone. Activity of a soil-active herbicide is regulated by leaching, chemical degradation, microbial decomposition and/or adsorption onto the soil colloids (Kearney and Kaufman 1969). Since these processes reduce the amount of herbicide available for uptake by plants, an understanding of soil-herbicide interactions is of practical importance to range resource managers, especially as they influence decisions concerning herbicide application rate. Persistence and activity of tebuthiuron in soils has important implications in areas to be reseeded following application.

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[3]Letters following this symbol are a WSSA approved computer code from Important Weeds of the World, 3rd Ed., 1983.

Several reports (Hance 1965, Dubey and Freeman 1969, Kearney and Kaufman 1969) have indicated organic matter to be the single most important soil characteristic in adsorption of substituted-urea herbicides. Chang and Stritzke (1977) reported tebuthiuron mobility to be greater in soils with low organic matter and clay contents. They found 40% of the tebuthiuron was adsorbed when applied to a soil with 4.8% organic matter. Bovey et al. (1982) determined that tebuthiuron residues at 30 cm persisted for more than two years in a fine sandy loam soil in Texas.

However, Harris and Warren (1964) indicated that organic matter may be responsible for more adsorption of herbicides by some soils and clay more important in others, since soil compositions vary so greatly. Sheets (1958) and Geissbuhler et al. (1963) reported varying amounts and types of clay minerals could influence adsorption of phenylurea herbicides, particularly in soils with relatively low organic matter.

Bovey et al. (1982) using wheat bioassays of treated soil stated that the long residual life and effectiveness of tebuthiuron on certain weed and brush species make it a highly successful herbicide. However, these same attributes may inhibit the growth of desirable vegetation, especially if seeding or vegetative propagation is attempted too soon after treatment.

Materials and Methods

Tebuthiuron formulated as 40% extruded pellets (206 ± 1 mg) was placed on loam soils at two field locations in randomized complete block designs near Emphraim and Tintic Utah.[4] Pellet placement locations were permanently marked; enabling future soil sampling under and around the point of pellet placement. These studies were initiated to investigate the movement and dissipation of tebuthiuron from the immediate location of pellets.

Soil collections were made from 12 combinations of depth and distance from the point of pellet placement. Soil samples were collected from three depths (0 to 3, 3 to 12 and 12 to 30 cm) and at four distances (0, 10, 20, and 30 cm). Duplicate subsamples were combined to produce each of the samples to be analyzed in the lab.

Soil samples were placed in polyethylene bags and frozen until laboratory extractions and analyses were conducted. Prior to freezing, soil samples were air-dried and ground to pass through a 2 mm sieve. The entire soil sample, at least 50 g, was thoroughly mixed prior to extraction.

Emphraim Study Area. Tebuthiuron pellets were applied to the interspaces of a Utah juniper community on April 13, 1984. The soil under the juniper trees, with its presumably higher organic matter content, was avoided at this study area. Soil collections were made on May 3, May 23, June 12, July 2, October 10, 1984 and May 4, 1985.

Tintic Study Area. The Tintic study area is a basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) site where the sagebrush plants were removed at the soil surface. Tebuthiuron pellets of each formulation were placed on the soil under the former sagebrush canopy and in the interspaces, on May 5, 1984. The soil under the sagebrush canopies has a much higher surface soil organic matter content (Table 1) than the soil in the interspaces, providing an excellent opportunity for comparing tebuthiuron

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[4]The authors acknowledge the assistance of the Utah Division of Wildlife Resources and the Range Science Department at Utah State University. Their assistance in locating study areas and in providing precipitation data is

movement and persistence under identical soil texture and precipitation conditions. The sagebrush plants were removed at ground level so precipitation amount and intensity would be similar on the tebuthiuron pellets placed on both soils. Soil collections were made on May 25, June 12, July 22, October 30, 1984; and May 5, 1985.

Laboratory Analysis. Tebuthiuron was sequentially extracted from the soil with a mixture of water and methanol, followed by boiling 3N HCl. An aliquot of the extract was purified by liquid-liquid partitioning and alumina column chromatography. The purified extracts were concentrated for measurement by comparison with a standard solution using HPLC and an ultra-violet absorbance detector at a 254 nm wavelength (West and Burger 1981).

Statistical Analysis. Based on recovery samples fortified with 0.1 to 5,000 ppmw of technical tebuthiuron, average recovery was 91.3 4.1% and sensitivity was 0.1 ppm. Tebuthiuron residue concentrations from the soil samples at all sampling dates, distances and depths within each combination of study area and pellet formulation were subjected to analysis of variance. Mean separation was conducted using Duncan's new multiple range test. Tebuthiuron concentrations (ppm) in the surface 3 cm of soil under the pellet and at each soil were subjected to linear and quadratic regression. Tebuthiuron concentration was used as the dependent variable; cumulative precipitation and the number of days after pellet application were used (in separate equations) as the independent variable.

Results

The tebuthiuron pellets lost their original structure by the first sampling date as a result of rainfall, but were visible on the soil surface at both study areas. Precipitation from the application date to the first sampling date was 7.16 cm at the Emphraim study area and 4.98 cm at the Tintic study area (Table 2). Total precipitation over the 350 to 370 day period was quite similar, varying from 46 to 50 cm (Table 2).

At the Emphraim study area, the highest tebuthiuron residues 20 days after treatment, were within 2 cm of the pellet and in the surface 3 cm of soil. Tebuthiuron resides were 1,254 ppm under the pellets (Table 3). Data from the Emphraim location indicate little lateral movement of tebuthiuron into the 30 cm area, except at the 12- to 30-cm depth (Table 3). Significant tebuthiuron residues did not appear at this depth-distance combinations for at least six months after treatment.

At the Ephraim location, downward movement of tebuthiuron was evident at 20 and 40 days at the 3- to 12-cm and 12- to 30-cm depths, respectively (Table 3). The tebuthiuron appeared to move down and slightly outward. At the lowest soil layer collected, tebuthiuron residues were often greater at the 10 to 20 cm distances than directly under the pellet.

At the Tintic study area, the highest tebuthiuron residues occurred within 2 cm of the pellet and in the surface 3 cm of soil 37 days after treatment. Tebuthiuron residues in the low organic matter soil were 1,843 ppm (Table 4). In the high organic matter soil the tebuthiuron residues were 1,652 ppm under the pellets (Table 5). Lateral movement of tebuthiuron residues was generally reduced on the high organic matter soils compared to the low organic matter soils. Downward movement of tebuthiuron residues increased with low soil organic matter and more concentrated pellet formulations.

Attempts at describing tebuthiuron disappearance in the surface 3 cm of soil using linear regression were unsuccessful. Coefficients of correlation ranged from 0.44 to 0.78. However, negative exponential regression provided a more reliable description of tebuthiuron disappearance in this study. Cumulative precipitation proved to be a less precise independent variable for predicting tebuthiuron disappearance than the number of "days" between application and soil collection." All regression equations in this report use "days" as the independent variable. Equations fitting data from each of the three soils and overall equations are found in Table 6.

Tebuthiuron disappearance in the surface 3 cm of soil under 40% pellets, in all three soils, was best explained by the exponential regression equation: $\mathbf{Y} = \mathbf{bX^a}$, where **Y** is the tebuthiuron concentration in ppmw and **X** is time (days) after pellet placement, **b** is 1.43 X 10^6, and **a** is -1.964 (r^2=0.92). Negative exponential regression equations describing tebuthiuron disappearance in the surface 3 cm of soil under the pellet were developed for each soil (Table 6).

Tebuthiuron disappearance immediately under the pellet was more rapid in high organic matter soils than in low organic matter soils (Figure 1). This more rapid disappearance occurred despite the reduced movement of tebuthiuron in soils with higher organic matter contents. An examination of the slopes derived from tebuthiuron disappearance data reveals steeper slopes on the high organic matter soils (Table 6). This more rapid disappearance of tebuthiuron in soils with higher organic matter contents may be due to increased microbial activity in those soils (Hurle and Walker 1980).

The influence of soil type on herbicide persistence is poorly understood. Because soil microorganisms are usually involved in degradation of tebuthiuron (Chang and Stritzke 1977), soil organic matter might be expected to have some influence since microbial activity is usually higher in soils with more organic matter (Hurle and Walker 1980). However, adsorption of most herbicides increases with increasing organic matter and since adsorption reduces the herbicide concentration in the soil solution, it could potentially reduce degradation. For these reasons, Hamaker (1972) suggested that an increase in organic matter might increase degradation rates in mineral soils up to a limiting value, above which the rate of loss would be retarded. Many of the tebuthiuron residues reported in this study are probably too high for adsorption to play a significant role in limiting degradation rates. However, as concentrations are reduced over time, adsorption of tebuthiuron to clay particles and organic matter may reduce the rate of tebuthiuron degradation. For this reason, regression equations predicting residue concentrations beyond the time period of the data in this study, would be subject to additional and unknown error.

Conclusions

Vertical and lateral movement and persistence were influenced by precipitation, clay content and organic matter content of the soil. Movement of tebuthiuron was less on high organic matter soils compared to low organic matter soils.

Tebuthiuron residues reported in this study are considerably higher than those reported by other investigators (Garcia and Gontarek 1975, Bovey et al. 1978, Emmerich et al. 1984, Ibarra and Morton 1984). This is probably because the other studies reported tebuthiuron concentrations of random soil samples collected in an area which had received broadcast applications of pellets. These samples undoubtedly included soil immediately under pellets as well as soil from between pellets. The area between pellets would vary with pellet formulation (ai), pellet size, and application rate. This mixture of treated and untreated soil would have lower tebuthiuron residues than soil immediately under pellets. This study reports tebuthiuron residues immediately under and around tebuthiuron pellets. The different sampling approaches, soil characteristics and climatic conditions of the various studies probably account for much of the variation in tebuthiuron concentrations between this and other studies. The sampling approach used in this study should give a more reliable indicator of the amount and distribution of tebuthiuron in soils following application of pelleted material.

Tebuthiuron application rates for big sagebrush control range from 1.1 to 1.6 kg ai/ha, depending on soil texture. An application of 40% tebuthiuron pellets (206 mg each) would represent one pellet per 0.74 m^2 and 0.49 m^2 at 1.1 kg/ha and 1.6 kg ai/ha, respectively. Data indicate that 40% tebuthiuron pellets influence approximately 20 to 30 cm around each pellet, depending on soil organic matter and clay content. Calculating the area influenced by each pellet and expressing that as a percentage of the soil surface area per pellet yields an approximation of the percent of the soil surface containing tebuthiuron residues. On the Tintic soil containing high soil organic matter, approximately 1,257 cm^2 of soil surface was affected around each pellet. This means that about 17 and 26% of the soil surface was affected by tebuthiuron residues following applications of 1.1 and 1.6 kg ai/ha, respectively. Soils with lower organic matter contents would have a larger percentage of the area affected. Tebuthiuron residues, one year after application, were probably sufficient, based on data from other studies (Bovey et al. 1982, Masters and Scifres 1984), to significantly influence establishment of seeded species. Plants growing outside these treated areas may not be influenced by tebuthiuron residues, unless their root systems grow into the treated zone and receive sufficient tebuthiuron to result in growth reduction or death.

At present (with data covering only one year) this data has limited the ability to predict the length of time tebuthiuron residues would be present in the soil. Extrapolation, in time, beyond the present data set is not advisable because of the many variables which can influence the rate of tebuthiuron degradation. However, this data should provide sufficient information to enable resource managers to predict the spatial distribution of tebuthiuron in a variety of soils, following application of pelleted formulations of tebuthiuron. With an understanding of critical minimum residues of tebuthiuron, in a variety of soils and on a variety of plant species, resource managers should be able to more accurately access the potential for problems in seeding efforts following tebuthiuron applications.

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Table 1. Chemical and physical characteristics of soils in which tebuthiuron movement and persistence was monitored near Tintic and Ephraim, Utah, during 1984 and 1985.

Location	Depth (cm)	Textural components Sand (%)	Silt (%)	Clay (%)	Organic matter (%)	pH
Ephraim	0 to 3	39.6	32.9	27.5	1.8	8.2
	3 to 12	32.9	30.8	36.3	1.9	8.2
	12 to 30	34.1	30.0	35.9	1.1	8.4
Tintic						
Low organic matter	0 to 3	35.2	44.9	19.9	1.7	7.8
	3 to 12	27.9	43.9	28.2	1.7	7.8
	12 to 30	28.1	42.4	29.5	1.4	7.8
High organic matter	0 to 3	35.2	45.1	19.7	4.7	7.6
	3 to 12	27.3	44.3	28.4	1.8	7.8
	12 to 30	28.5	42.4	29.1	1.6	7.8

Table 2. Cumulative precipitation totals from the application date to the date of soil collection, at the Ephraim and Tintic, Utah, study areas.

Study area	Days after application	Cumulative precipitation (cm)
Ephraim	20	7.16
	40	16.46
	78	16.51
	189	26.62
	370	50.17
Tintic	37	4.98
	80	8.26
	173	27.08
	350	46.81

Table 3. Average concentrations (ppmw) of tebuthiuron residue in soil at various depths, at four distances from the initial pellet placement and at various times after application of 40% pellets, on April 13, 1984, to soil near Ephraim, Utah[1].

Soil depth (cm)	Time after pellet placement (days)	Distance from tebuthiuron pellet 0 (cm)	10 (cm)	20 (cm)	30 (cm)
0 to 3	20	1,254.1 a	25.4 e	0.4 ij	0.0 j
	40	982.1 b	22.3 e	0.0 j	0.0 j
	78	328.2 c	17.7 ef	0.0 j	0.0 j
	189	29.1 e	4.2 g	0.0 j	0.0 j
	370	11.9 f	3.1 gh	0.0 j	0.0 j
3 to 12	20	31.3 e	2.6 gh	0.5 ij	0.0 j
	40	57.7 d	3.1 gh	0.0 j	0.0 j
	78	52.0 d	11.3 f	0.0 j	0.4 ij
	189	14.2 f	17.8 ef	4.9 g	0.5 ij
	370	1.7 h	1.7 h	1.4 hi	1.1 i
12 to 30	20	0.0 j	1.4 h	0.0 j	0.0 j
	40	1.3 h	6.0 fg	1.1 i	0.4 ij
	78	0.5 ij	11.2 f	2.6 gh	0.1 i
	189	0.3 j	11.4 f	10.1 f	9.8 f
	370	2.9 gh	0.2 j	8.9 f	5.4 g

[1]Means followed by the same letter are not significantly different at the 95% level according to Duncan's new multiple range test.

Table 4. Average concentrations (ppmw) of tebuthiuron residue in soil at various depths, at four distances from the initial pellet placement and at various times after application of 40% pellets, on May 5, 1984, to low organic matter soil near Tintic, Utah[1].

Soil depth (cm)	Time after pellet placement (days)	Distance from tebuthiuron pellet 0 (cm)	10 (cm)	20 (cm)	30 (cm)
0 to 3	37	1,843.1 a	93.0 cd	1.6 hi	0.4 ij
	80	383.5 b	38.9 e	5.2 g	2.2 h
	173	38.2 e	38.8 e	5.1 g	1.8 hi
	350	23.6 e	23.0 e	4.4 gh	1.0 i
3 to 12	37	70.4 d	23.9 e	5.6 g	0.3 j
	80	24.2 e	23.8 e	10.2 fg	2.1 h
	173	14.0 f	13.4 f	6.3 g	1.7 hi
	350	2.7 h	5.8 g	2.4 h	1.0 i
12 to 30	37	14.1 f	14.2 f	0.0 j	0.0 j
	80	12.1 f	10.2 fg	0.7 i	0.0 j
	173	6.9 g	7.0 g	5.1 g	2.3 h
	350	6.0 g	5.8 g	4.2 gh	3.1 h

[1]Means followed by the same letter are not significantly different at the 95% level according to Duncan's new multiple range test.

Table 5. Average concentrations (ppmw) of tebuthiuron residue in soil at various depths, at four distances from the initial pellet placement and at various times after application of 40% pellets, on May 5, 1984, to high organic matter soil near Tintic, Utah[1].

Soil depth (cm)	Time after pellet placement (days)	Distance from tebuthiuron pellet 0 (cm)	10 (cm)	20 (cm)	30 (cm)
0 to 3	37	1,652.1 a	865.3 c	6.2 jk	0.0 m
	80	691.4 b	238.3 e	5.1 k	0.0 m
	173	55.0 g	41.3 gh	2.6 kl	0.0 m
	350	8.1 j	8.9 j	1.1 l	0.0 m
3 to 12	37	343.1 d	249.2 e	20.2 i	0.0 m
	80	130.0 f	3.4 k	5.1 k	0.0 m
	173	43.3 gh	21.2 i	6.2 jk	0.0 m
	350	10.1 j	4.3 k	1.8 l	0.0 m
12 to 30	37	0.0 m	0.0 m	0.0 m	0.0 m
	80	0.4 lm	0.6 lm	1.1 l	0.0 m
	173	3.2 k	1.9 l	1.4 l	0.0 m
	350	0.9 l	0.4 lm	0.0 m	0.0 m

[1]Means followed by the same letter are not significantly different at the 95% level according to Duncan's new multiple range test.

Table 6. Exponential regression equations describing tebuthiuron (40% pellets) disappearance in the surface 3 cm of soil under the point of pellet placement at study areas near Ephraim and Tintic, Utah. All equations take the form of $Y=bX^a$, where Y is ppmw of tebuthiuron and X is days after pellet placement.

Location	b	a	r^2
Ephraim	4.07×10^5	-1.753	0.9507
Tintic			
Low organic matter	2.77×10^6	-2.056	0.9582
High organic matter	1.76×10^7	-2.456	0.9666
All sites combined	1.43×10^6	-1.964	0.9212

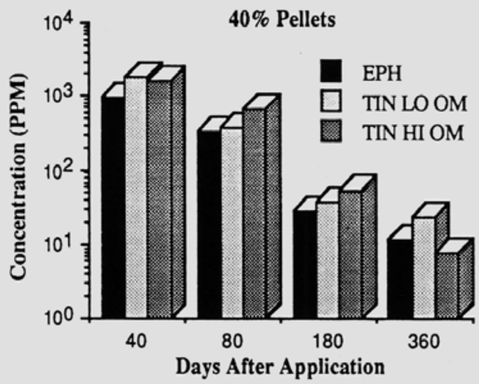

Figure 1. Tebuthiuron concentration in the surface 3 cm of soil under the pellet in the Ephraim (EPH), Tintic low organic matter (TIN LO OM) and Tintic high organic matter (TIN HI OM) soils.

SURVEY FOR PICLORAM IN WELLS AND STREAMS IN NORTH DAKOTA

Rodney G. Lym and Calvin G. Messersmith[1]

Abstract. Picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) is the most effective herbicide for leafy spurge (*Euphorbia esula* L.) control. Leafy spurge currently infests over one million acres in North Dakota in many environments such as grasslands, wooded areas, wetlands and arid regions. Picloram use has increased steadily since 1981. It is estimated that over 230,000 A of leafy spurge were treated in North Dakota in both 1984 and 1985. Generally, picloram plus 2,4-D (2,4-dichlorophenoxy)acetic acid) at 0.25 + 1.0 lb/A has been applied, but commonly small patches have been treated with picloram at the maximum labeled rate of 2.0 lb/A. Herbicide application has been by certified personnel, but accidental contamination of water or run-off from nearby application may have occurred. The purpose of this survey was to determine if picloram was present in North Dakota groundwater especially in areas with high picloram use for leafy spurge control.

Ten North Dakota counties and at least twelve wells per county were chosen for the survey; eight counties had applied picloram in an active leafy spurge control program and two counties with minimal picloram application were the control sites. Stark and Ward counties were emphasized because they included the Heart and Souris Rivers, respectively, and have conducted an active leafy spurge control program using picloram. The well locations were chosen based on the amount of picloram applied nearby, the well depth and whether the well was in an aquifer as mapped by the United States Geological Survey (U.S.G.S.). Shallow wells located near areas that had received repeated picloram applications were emphasized as representing a site most likely to be contaminated. A total of 144 wells were sampled three times; in early June prior to the spray season, in mid-July immediately after the general spray season and in September to detect possible changes in herbicide content with time. Also, stream samples from the Heart and Souris Rivers were collected in June and September from U.S.G.S. monitoring stations. Analysis was conducted using HPLC techniques with a detection limit of <0.1 ppb.

Picloram was present in five well in five counties and all were within one mile of an area treated for leafy spurge control. Picloram was present at trace to 12.4 ppb levels. The suggested no-adverse-response level (SNARL) is 1050 ppb picloram. The picloram concentration of 12.4 ppb is higher than would be expected if the well had been contaminated by leaching during a week control spraying program, and picloram was not found in nearby wells. Picloram concentrations ranging from a trace to a few ppb were found in the Des Lacs and Souris Rivers in Ward County. No picloram was found in the Heart River or in well samples from the control counties. A study to determine how picloram contamination occurred is in progress. Wells located near the contaminated well in each county but not originally surveyed will be sampled, a history of well use will be determined, and well construction will be evaluated. The picloram concentrations detected are not a health hazard but are a warning to those involved in the leafy spurge program to use more caution in applying picloram at high concentrations and/or in areas near streams or with high water tables.

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WHAT INFLUENCES CONTROL OF COASTAL DECIDUOUS BRUSH WITH GLYPHOSATE?

M. Newton[1], E.C. Cole and D. E. White

Introduction

Two experiments investigated the factors influencing efficacy of glyphosate on six woody species in the Oregon Coast Range. The main series evaluated control of five species appearing after harvest of an alder/spruce/hemlock forest with an understanding of salmonberry (*Rubus spectabilis*) and elderberry (*Sambucus racemosa*) and a seed bank containing much Himalaya blackberry (*R. procerus*) and evergreen blackberry (*R. laciniatus*). This experiment was executed three and one-half years after harvest and brushblading, at which time red alder (*Alnus rubra*) seedlings were dominant over seedlings and sprouts of the other species. Douglas-fir seedlings in their fourth growing season were present. The other experiment looked only at bigleaf maple (*Acer macrophyllum*) sprout clumps two years after clear cutting, and planting with three-year-old Douglas-fir (*Pseudotsuga menziesii*).

Treatments - five species plots. Plots were 15' x 29' (= .01 acre). Each was broadcast sprayed with a backpack sprayer with the waving wand technique, with timed delivery in one or two passes. Three plots received each treatment in a completely randomized layout.

Treatments included two formulations of glyphosate (N-phosphonomethyl)-glycine), Rodeo and Roundup, two seasons of treatment (July and August), two spray volume per acre (3, 10 gpa), presence or absence of added surfactant and rate of application (.5, 1.0, and 1.5 lbs/Ac, acid equivalent). These were applied in two nested complete factorial experiments as per Table 1.

Ten each of alder and salmonberry sprout clumps were tagged before or during treatment, if present. Variable numbers of elderberry, Himalaya and evergreen blackberry were encountered, leading to variable precision of estimation. Three Douglas-fir seedlings, 3-5 feet tall were tagged and covered with plastic bags as shielding. Others were left uncovered to show sensitivity to foliage activity.

Treatments - bigleaf maple. The bigleaf maple experiment had to be conducted separately because of the clump nature of second-year stump sprouts. Clumps were treated on an individual basis. Each clump was measured for height and average crown diameter to determine crown area and crown volume. Dosage was calculated on a per-acre basis by applying a measured volume of spray to each clump, based on its crown area. Experimental variables included rate per acre (2.4 pounds/Ac.) and concentration of Roundup product in the spray mixture (2, 7.5 and 30 percent). Thus, each rate was applied in a low, medium and high volume application. Nine clumps received each treatment in a randomized layout. All treatments were applied the same day, in late August, 1984. All results are given as of ten months after treatment (rating was in late June, 1985).

Evaluation. Rating of all species involved ocular estimation of percent loss of leaf area (net, after dieback and recovery in some instances), and total stem dieback. Bigleaf maple clumps were also evaluated dimensionally and crown volume reduction computed on a proportional and absolute basis.

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Results. Results provide some patterns useful for explaining some inconsistencies in efficacy. Alder, normally regarded moderately resistant to glyphosate, was poorly controlled in August, but control was better in July ($p<.01$) volume per acre strongly favored the 10-gallon rate, and there was a moderate season x surfactant interaction ($p<.01$) (Table 2).

Differences were observed in products containing surfactant versus no surfactant (Rodeo vs. Roundup) in analogous tests at low volume ($p<.10$) (Table 3). Both products showed improvement at 1/2 or 1 lb/Ac. When six percent surfactant was added in August ($p<.05$) and rate was highly significant ($p<.01$). Ten gallons per acre gave much more consistent results in both seasons than 3 gpa, ($p<.01$) with or without surfactant, but spotty good results with the low volume suggests that the application method was perhaps incapable of delivering uniform patterns at such a low volume. Surfactant had no statistically significant effect by itself, and the over-all arithmetic average with surfactant was poorer than without. There appears to be a weak season x surfactant interaction ($p<.10$), suggesting that such an adjuvant may prove more beneficial in later seasons. Stem kill was somewhat lower than crown kill but was still excellent in July treatments at 1 lb/Ac., or greater, in 10 gpa.

Salmonberry responded somewhat differently from alder. Crown reduction was significantly greater in August than July ($p<.01$). Again there were no differences between products with or without surfactant, but rate was important ($p<.05$), and the surfactant was associated with improvement of both products when applied at low volume (vol. x surf. interaction, $p<.05$). Addition of the surfactant did not affect performance at high volume (10 gpa), and there may be a season x surfactant interaction ($p<.10$). Normally considered very sensitive to glyphosate in September, salmonberry showed only intermediate sensitivity during July and August. There was increasing tendency for sprouts to display good color and vigor after July treatments, and we expect recovery to be at a maximum for any level of crown reduction. The low degrees of stem kill in the later season are coupled with low ability to elongate, hence competitive activity will be depressed for several years. As with alder, very low volumes were usually associated with poor or spotty control, especially at the lowest rate of application.

Elderberry seedlings were almost equal in sensitivity for the two seasons except for two anomalous sets, glyphosate gave consistently excellent control at 10 gpa (Table 6). Control was adequate but less consistent at 3 gpa. Added surfactant had no effect on results.

Himalaya and evergreen blackberries were not controlled effectively in any of these treatments. The range of crown reductions (0-30 percent) was not significantly different from the controls.

Bigleaf maple crown reduction varied between 60-85 percent, with no differences between rates, but decreasing efficacy with lower volumes ($p<.05$). A much larger range in volumes occurred in maple tests than for other species, and the importance of coverage was amply demonstrated, both in terms of percent crown kill and in residual competitive biomass. Douglas-fir was injured by all rates and conditions of application in July but not August. Even the high rates applied to bigleaf maple clumps did not cause important injury to trees sheltered by treated clumps.

Over-all, our results support the principle that glyphosate is most effective on all species in volumes of 10 gpa or more, although we acknowledge distribution weaknesses at the lowest volumes tested. For most species, August was the season of greater sensitivity, consistent with the traditional September use pattern. For alder, however, early July was superior to later application. Addition of surfactant did to produce an over-all increase in efficacy. There was a tendency to improve results at low rates, at low volumes, in August, suggesting that surfactant prescriptions across the board may be ill-advised.

There is a tendency for alder and conifers to be most sensitive in July and for the other species to be more sensitive later. This suggests that the principal uses on alder may be for site preparation in July. The other species may be treated in August or later to good effect, in 10 gpa or more. Either product is equally likely to produce satisfactory results without added surfactant during most of the time they are in a sensitive state. Coverage is especially important on maple clumps.

Table 1. Treatment hierarchy in the .01-Acre plot experiments.

			Gallons Per Acre			
			3		10	
			Season			
Glyphosate Product	Surf	Rate Lbs/A	July	Aug	July	Aug
Roundup®	No	½	X	X	X	X
		1	X	X	X	X
		1½	X	X	X	X
	Yes	½	X	X	X	X
		1	X	X	X	X
		1½	-	-	-	-
Rodeo®	No	½	-	X	-	-
		1	-	X	-	-
		1½	-	-	-	-
	Yes	½	-	X	-	-
		1	-	X	-	-
		1½	-	-	-	-

Table 2. Control of red alder by Roundup® at two volumes of application, two seasons, and three rates, with and without surfactant. Leaf area reduction/stem kill.

		Spray Volume, GPA			
		3		10	
Acid Equiv/Acre	Surf. Added Percent	July	Aug	July	Aug
		Defol/Stem Kill			
½	0	29/39	17/6	75/61	78/52
1		54/42	22/6	93/91	37/13
1½		62/54	61/54	93/92	60/36
½	6	39/17	26/13	36/20	20/7
1		28/15	48/41	60/50	71/61

Table 3. Control of red alder by Roundup® and Rodeo® herbicides at two rates, with and without added surfactant, when applied in August in 3 gpa total volume. Loss of leaf area/stem kill.

Product	Acid equiv Per Acre, Lbs	Surfactant Added 0	6%
		Defol/Stem Kill	
Roundup®	½	17/6	26/13
	1	22/6	48/41
Rodeo®	½	14/3	31/11
	1	44/37	76/51

Table 4. Control of salmonberry by Roundup® at two volumes of application, two seasons, and three rates, with and without added surfactant. Leaf area reduction/stem kill

Acid Equiv. Per Acre Lbs.	Surfactant Added Percent	Spray Volume, GPA 3		10	
		Season			
		July	August	July	August
		Defol/Stem Kill			
½	0	26/9	27/19	31/10	80/76
1		12/7	40/28	74/43	66/21
1½		45/34	85/48	78/70	69/48
½	6	33/22	59/41	11/4	42/21
1		20/8	68/36	45/16	84/52

Table 5. Control of Salmonberry by Roundup® and Rodeo herbicides at two rates. With and without added surfactant when applied in August at 3 gpa total volume. Loss of leaf area/stem kill.

Product	Acid Equiv. Per Acre Lbs.	Surfactant Added, percent 0	6
		Defol/Stem Kill	
Roundup®	½	27/19	59/41
	1	40/28	66/36
Rodeo®	½	17/10	57/28
	1	68/25	68/43

Table 6. Control of red elderberry by Roundup® at two volumes of application, two season and three rates, with and without surfactant. Leaf area reduction/stem kill.

Acid Equiv. Per Acre Lbs.	% Surf.	Spray Volume GPA 3		10	
		Season			
		July	Aug.	July	Aug.
		Defol/Stem Kill			
½	0	55/52	44/28	100/74	100/100
1		54/49	86/86	100/100	54/22[1]
1½		72/94	100/94	100/100	95/86
½	6	28/22	81/174	2/0[2]	60/60
1		88/72	100/100	100/100	99/99

[1]Bias introduced by small number of specimens, including plants much larger than general population. No statistical analysis.

[2]Only two specimens, both apparently protected by tall brush.

Table 7. Control of red elderberry by Roundup® and Rodeo® herbicides at two rates, with and without added surfactant, when applied in August is 3 gpa total volume. Loss of leaf area/stem kill.

Product	Acid Equiv. Lbs./Acre	Surfactant Added, Percent 0	6
		Defol/Stem Kill	
Roundup®	½	44/28	81/74
	1	86/86	100/100
Rodeo®	½	56/61	79/76
	1	100/82	91/78

Table 8. Crown reduction and stem kill by Roundup® in two-year-old bigleaf maple sprout clumps treated in late August. First year.

Acid equiv. per acre lbs	Product in spray mix percent	Gallons per acre	Product change in crown volume	Residual crown volume, 1985 cubic feet/tree
2	2.0	33	- 91 cd[1]	32 c
	7.5	9	- 72 bc	122 bc
	30.0	2	- 75 bc	91 bc
4	2.0	67	- 86 cd	36 c
	7.5	18	- 78 bc	112 bc
	30.0	4	- 60 b	186 b
Control	0	0	+136 a	1171 a

[1]Figures within columns followed by the same letter are not significantly different at $p < .05$, by Duncan's Multiple Range Test.

RESPONSE OF NORTHWESTERN HARDWOODS, SHRUBS, AND DOUGLAS-FIR TO ARSENAL AND ESCORT

Elizabeth C. Cole, Michael Newton, and Diane E. White[1]

AC 252, 925 (2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-pyridinecarboxylic acid; Arsenal), and DPX-T6376 (methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl] benzoate; Escort) are two new chemicals with potential for forestry applications. To determine their uses for site preparation and conifer release, three sites were selected for screening trial studies.

The first site was dominated by two-year-old bigleaf maple (*Acer macrophyllum*) sprouts. Planted Douglas-fir trees (*Pseudotsuga menziesii* var. *menziesii*) were two years old at the time of treatment.

The second site consisted of a sclerophyll brush community with a mixture of Pacific madrone (*Arbutus menziesii*) of sprout and seedling origin, seedling varnishleaf ceanothus (*Ceanothus velutinus* var. *laevigatus*), hairy manzanita (*Arctostaphylos columbiana*), and whiteleaf manzanita (*A. viscida*). The site is part of a 5000 acre wildfire in 1978. Douglas-fir was aerially seeded in 1978, and regeneration is a mixture of the seeded Douglas-fir and volunteer Ponderosa pine (*Pinus ponderosa*), grand fir (*Abies grandis*), and Douglas-fir, with most of the regeneration being volunteers.

The third site is a coastal deciduous community. Overstory Douglas-fir, western hemlock (*Tsuga heterophylla*), and red alder (*Alnus rubra*) had been logged three years prior to treatment. The site was scarified and invaded by seedling alder and salmonberry (*Rubus spectabilis*) in large numbers, with evergreen blackberry (*R. laciniatus*) and Himalaya blackberry (*R. procerus*) present in lesser quantities. Planted Douglas-fir were three-years-old at the time of treatment.

Treatment and Evaluation Procedures

Bigleaf maple site. Each herbicide was tested in a factorial experiment with three groups of three replications. Herbicides and dosage are shown in Table 1. Each bigleaf maple clump was measured for height, crown diameter and stump diameter. From the crown diameter, area of the clump was determined. The amount of herbicide each clump received was determined by considering what portion of an acre each clump occupied. Volume of spray for each clump was converted into seconds of spray time by calibrating the backpack sprayer for delivery rate. All treatments were applied at ten gallons per acre. Spraying was done on a single day in late August, 1984.

Shrubs were evaluated in late June, 1985. Each shrub was measured for current height and crown width in two directions. Percent crown volume reduction and percent stem reduction were ocularly estimated. Percent change in crown volume was calculated from the crown volume measurements. An analysis of variance was performed for each component--crown volume 1984, crown volume 1985, percent change in crown volume, ocularly estimated crown reduction and ocularly estimated stem reduction. Duncan's multiple range

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test was used to determine differences among treatment means. Conifers were also rated for damage.

Sclerophyll and coastal deciduous sites. Each herbicide was tested in a factorial experiment with three replications. Herbicides, dosage, and season of application are shown in Table 1. Each treatment included 1.3% added surfactant and was applied at ten gallons per acre. The 29 by 15 foot plots (0.01 acre) were sprayed with a backpack sprayer using a single adjustable Chapin nozzle and the "waving wand" technique. Before or immediately after treatment, ten of each major shrub species were tagged for evaluation, if present. At the coastal deciduous site, three Douglas-fir trees were covered with plastic bags during spraying to prevent foliage interception of the herbicides. Treatments were applied in mid-June and mid-July at the sclerophyll brush site and in early July and late August at the coastal deciduous site.

In March, 1985, ten Douglas-fir trees were planted in the high rate (1 and 2 pounds/acre AC 252, 925; 1 and 2 ounces/acre DPX-T6376) plots to determine if soil residues would affect tree growth.

Plots were evaluated in June, 1985, and each shrub was ocularly rated for crown and stem reduction. Both the conifers present at the time of treatment and those planted in March were rated for damage. Treatments were analyzed using a factorial analysis of variance, and differences among means were compared using Duncan's multiple range test.

Bigleaf maple site. All treatments resulted in significant changes in crown and stem reduction over the control (Tables 2a, 2b). Both rates of AC 252,925, 1 and 2 pounds/acre caused essentially 100% defoliation. New leaf formation was inhibited, and current foliage exhibited chlorosis and stunting similar to the "littleleaf disease" caused by glyphosate injury. Two pounds/acre resulted in significantly greater stem kill, 90% compared to 60%.

No differences were found among the 2 and 4 ounces/acre rates of DPX-T6376. Overall, crown reduction was 70 to 80% and stem kill 40 to 60%. Most shrubs had crown reduction as topkill, with the lower portions of the crown recovering and exhibiting no herbicide injury.

Both chemicals produced injury on Douglas-fir trees, primarily through foliar uptake. Top dieback and loss of lower crown foliage were observed, so that these chemicals would not be suitable for conifer release, in general. Douglas-fir beneath treated clumps received only minor soil uptake effects (AC 252,925 only), suggesting that carefully directed spot sprays would be effective.

Sclerophyll brush site. AC 252,925. On ceanothus, season of treatment is more important than rate with AC 252,925, with the highest rate (2 pounds/acre) in July not as effective as the lowest rate ().5 pound/acre) in June (Table 3a). In June, crown reduction varied from 85 to 95% and stem reduction 45 to 65% with the highest rate producing the greatest stem kill. In July, crown reduction varied from 10 to 60% and stem reduction 3 to 27%. The July treatments are causing growth inhibition so that no new foliage is being produced and no resprouting is occurring.

As with ceanothus, seasonal differences were significant on madrone, with the July treatments being less effective (Table 3a). Crown reduction was 35 to 50% and stem reduction 7 to 30% in July, while June treatments had 95% crown reduction and 60 to 90% stem reduction. For all treatments, either resprouting from the base or new growth was occurring.

Seasonal differences were not apparent with hairy or whiteleaf manzanita. Low rates were generally ineffective with crown reduction from

30 to 34% and stem reduction 14 to 17%. Higher rates had crown reduction from 70 to 80% and stem reduction from 50 to 65% (Table 3b). Growth inhibitory effects were noticed at the high rates, especially with the July treatments.

DPX-T6376. Rates and seasonal differences were significant in the DPX-T6376 treatments on ceanothus (Table 3a). For all rates in June and the high rates (1 and 2 ounces/acre) in July, crown reduction was 95 to 99% and stem reduction 90 to 95%. The 0.5 ounce/acre rate in July had significantly lower crown (57%) and stem (41%) reduction. Although defoliation and stem kill are high, shrubs are resprouting from below ground, especially at the low rate and the July treatments.

On madrone, the July 0.5 ounce/acre rate resulted in 30% crown reduction and 20% stem reduction. For other treatments, crown reduction varied from 80 to 90%, with no differences among rates or seasons. Stem reduction was slightly greater in June than in July; values ranged from 60% to 90% (Table 3a). Shrubs were resprouting and had healthy current foliage.

Crown reduction averaged 55 to 75% and stem reduction 50 to 70% for hairy manzanita, with the low values corresponding to the low rate (Table 3b). Except for the low rate (where the June treatment produced greater control), seasonal differences did not occur. Results on whiteleaf manzanita were similar for low rates, but 5 to 10% more effective at the higher rates (Table 3b).

Conifer Injury. Injury from both chemicals caused terminal dieback and some mortality of Douglas-fir and ponderosa pine that were present at the time of treatment. Trees planted in March 1985 averaged 97.5% survival for both chemicals. With DPX-T6376, the trees showed no major sings of herbicide injury. With DPX-T6376, the trees showed no major signs of herbicide injury. With AC 252,925, the trees exhibited infrequent but significant signs of injury, including chlorotic, small needles and some loss of lower crown needles, primarily at the 2 pounds/acre rate. Evidence of residual effects at 1 pound/care was minor.

Coastal deciduous site. AC 252,925. On red alder, AC 252,925 caused almost complete defoliation and significant amounts of stem kill (Table 4a, 4b). No differences among rates were found, but the July treatments caused significantly greater stem kill, 90 to 100% in July compared to 20 to 40% in August. Crown reduction was slightly better in July, 90 to 100% compared to 80 to 95% in August. Foliage on live alder exhibited "littleleaf disease" similar to that found from glyphosate injury. Considerable growth inhibition occurred even when crown reduction was low.

On salmonberry, control with the high rates of AC 252,925 were not statistically different, but the low rate (0.5 pound/acre) was significantly less than the 2 pounds/acre rate. Both crown and stem reduction ranged from 80 to 100% at the high rates and 55 to 70% at the low rate. Seasonal differences were not found. Some of the shrubs exhibited stunting and chlorosis of new foliage, and some growth inhibition was occurring.

For both Himalaya and evergreen blackberry, control was marginal, ranging from 0 to 30% crown reduction and 0 to 20% stem reduction (Table 4c). Vigorous current growth was present.

Overall, this product showed excellent prospects as a general herb and shrub control agent for coastal site preparation at approximately 1 pound/acre.

DPX-T6376. DPX-T6376 was generally ineffective on red alder, regardless of rate. Although the July treatments appeared better than the

August treatments, none was significantly different from the control (Tables 4a, 4b). Crown reduction was 5 to 20% and stem reduction 0 to 10%.

In contrast, DPX-T6376 was highly effective on the three Rubus species sampled (Tables 4a, 4c). On salmonberry, 100% kill resulted on all plots. Control on the blackberries ranged from 85 to 100%. Some of the shrubs with lower control were located under other vegetation so that the lower control may be due to canopy interception of the herbicide.

Conifer Injury. Injury to unbagged Douglas-fir trees was severe for both chemicals, including terminal dieback and some mortality. Bagged trees in the AC 252,925 plots exhibited stunting of foliage and terminal dieback, with more several injury occurring in July. Some uptake of the herbicide from the soil is apparently occurring, although little rain fell prior to the September after treatment. Bagged trees in the DPX-T6376 plots had only minor injury to foliage and slight terminal dieback. Soil uptake appeared minor, and injuries may have resulted from contamination from the bags or from exposed foliage during spraying.

Survival for the trees planted in March 1985 was 100% for both chemicals. Some chlorosis of needles, stunting and loss of lower crown foliage occurred in the AC 252,925 plots. In the DPX-T6376 plots, the only residue effects were minor chlorosis of needles at the 2 ounces/acre rate.

Summary

AC 252,925 produced the most complete and consistent control of bigleaf maple sprout clumps when applied in late summer. There was no recovery of leaf area and greater than 50% stem kill with the low rate.

In sclerophyll brush communities, early summer applications (June) produced greater control than mid-summer treatments. The June treatments reduced shrub cover to low levels for at least one growing season, but the July treatments were much less effective.

High rates of AC 252,925 produced good control for both red alder and salmonberry but were ineffective on blackberry.

On all shrubs (excluding madrone and the blackberries), some growth inhibition was occurring that decreased or prevented new foliage and stem growth. It is not certain if these effects will continue beyond the current growing season. If inhibition of leaf formation continues, these plants will be nearly defoliated and low in competitive ability.

Although DPX-T6376 reduced crown volume on bigleaf maple, recovery appears likely.

As with AC 252,925, the June DPX-T6376 treatments were more effective on sclerophyll brush than the July treatments. High rates generally produced greater stem kill, and the treatments reduced shrub cover for the current growing season.

With good coverage, DPX-T6376 killed the three Rubus species evaluated but was not effective on alder.

On all sites, shrubs that were not killed were recovering and producing healthy foliage on the DPX-T6376 plots.

Both chemicals produced severe injury to untreated Douglas-fir and would not be suitable for conifer release. However, both appear useful for site preparation with preference being a matter of local species composition.

Table 1. Herbicide treatments at three study sites. All sites had control (no herbicide application) plots.

Site	Herbicide	Rate/Acre	Season of Application
Bigleaf Maple	AC 252,925	1.0 lbs	late August
		2.0 lbs	late August
	DPX-T6376	2.0 oz	late August
		4.0 oz	late August
Sclerophyll Brush	AC 252,925	0.5 lb	mid-June, mid-July
		1.0 lb	mid-June, mid-July
		2.0 lbs	mid-June, mid-July
	DPX-T6376	0.5 oz	mid-June, mid-July
		1.0 oz	mid-June, mid-July
		2.0 oz	mid-June, mid-July
Coastal Deciduous	AC 252,925	0.5 lb	early July, late August
		1.0 lb	early July, late August
		2.0 lbs	early July, late August
	DPX-T6376	0.5 oz	early July, late August
		1.0 oz	early July, late August
		2.0 oz	early July, late August

Table 2a. Averages and standard errors for crown volume 1984, crown volume 1985, and change in crown volume of bigleaf maple. The same letter after an average indicates treatments not significantly different at the p=0.05 level of probability based on Duncan's multiple range test.

Herbicide	Rate /Acre	Crown Volume 1984 (ft^3)	Crown Volume 1985 (ft^3)	% Change in Crown Volume
AC 252,925	1 lb	528 (120)a	2 (4)b	-100 (0.4)b
AC 252,925	2 lb	358 (78)a	1 (1)b	-100 (0.2)b
DPX-T6376	2 oz	352 (84)a	92 (39)b	-77 (8.1)b
DPX-T6376	4 oz	480 (90)a	105 (45)b	-83 (6.6)b
Control		556 (128)a	1171 (219)a	+136 (36.7)a

Table 2b. Averages and standard errors for ocular estimates of crown and stem reduction of bigleaf maple. Means followed by the same letter are not significantly different at the p=0.05 level of probability based on Duncan's multiple range test.

Herbicide	Rate /Acre	% Crown Reduction	% Stem Reduction
AC 252,925	1 lb	99 (0.6) a	59 (10.1) bc
AC 252,925	2 lb	99 (0.6) a	91 (5.2) a
DPX-T6376	2 oz	77 (7.0) bc	54 (7.5) bcd
DPX-T6376	4 oz	66 (8.4) cd	37 (7.6) de
Control		0 (0) e	0 (0) f

Table 3a. Means and standard errors for varnishleaf ceanothus and Pacific madrone. Means followed by the same letter are not significantly different at the p=0.05 level of probability based on Duncan's multiple range test.

			Ceanothus		Madrone	
			% Crown	% Stem	% Crown	% Stem
Herbicide	Rate/Acre	Season	Reduction		Reduction	
AC 252,925	0.5 lb	June	84 b (2.7)	45 c (4.6)	95 a (1.9)	62 ab (6.1)
AC 252,925	1.0 lb	June	95 ab (1.3)	45 c (5.0)	94 a (2.5)	72 a (6.9)
AC 252,925	2.0 lb	June	96 ab (0.9)	66 b (3.5)	99 a (0.4)	89 a (4.0)
AC 252,925	0.5 lb	July	10 e (2.6)	3 e (1.5)	34 c (6.2)	7 c (2.6)
AC 252,925	1.0 lb	July	46 d (5.6)	15 de (3.0)	47 c (5.9)	22 c (5.6)
AC 252,925	2.0 lb	July	61 c (4.3)	27 cd (3.3)	53 bc (7.7)	30 bc (8.6)
DPX-T6376	0.5 oz	June	97 ab (1.0)	99 a (0.3)	85 a (4.0)	81 a (6.2)
DPX-T6376	1.0 oz	June	98 ab (1.3)	97 a (1.8)	80 ab (6.0)	61 ab (7.6)
DPX-T6376	2.0 oz	June	99 a (0.3)	99 a (0.5)	92 a (3.6)	89 a (5.0)
DPX-T6376	0.5 oz	July	57 cd (5.2)	41 c (5.7)	31 cd (15.1)	20 c (16.0)
DPX-T6376	1.0 oz	July	96 ab (2.5)	92 a (3.8)	87 a (4.6)	72 a (7.1)
DPX-T6376	2.0 oz	July	95 ab (2.6)	92 a (3.4)	90 a (4.4)	69 a (8.9)
Control			3 e (1.0)	1 e (0.5)	6 d (2.3)	0 c (0.1)

Table 3b. Comparisons among means for hairy and whiteleaf manzanita. Since the treatment*season interaction was not significant, data have been pooled over seasons. Means followed by the same letter are not significantly different at the p=0.05 level of probability based on Duncan's multiple range test.

Herbicide	Rate/Acre	Hairy % Crown Reduction	Hairy % Stem Reduction	Whiteleaf % Crown Reduction	Whiteleaf % Stem Reduction
AC 252,925	0.5 lb	34 c	17 c	31 bc	14 b
AC 252,925	1.0 lb	72 a	56 ab	82 a	64 a
AC 252,925	2.0 lb	72 a	62 ab	62 ab	53 a
DPX-T6376	0.5 oz	55 b	50 b	59 ab	53 a
DPX-T6376	1.0 oz	69 ab	59 ab	81 a	75 a
DPX-T6376	2.0 oz	77 a	70 a	83 a	80 a
Control		3 d	2 c	1 c	1 b

Table 4a. Comparisons among means for crown reduction in red alder, and crown and stem reduction in salmonberry. Since the treatment* season interaction was not significant, data have been pooled over seasons. Means followed by the same letter are not significantly different at the p=0.05 level of probability based on Duncan's multiple range test.

Herbicide	Rate/Acre	Red Alder % Crown Reduction	Salmonberry % Crown Reduction	Salmonberry % Stem Reduction
AC 252,925	0.5 lb	91 a	66 b	61 b
AC 252,925	1.0 lb	96 a	92 ab	83 ab
AC 252,925	2.0 lb	98 a	98 a	98 a
DPX-T6376	0.5 oz	8 b	100 a	100 a
DPX-T6376	1.0 oz	6 b	100 a	100 a
DPX-T6376	2.0 oz	19 b	100 a	100 a
Control		0 b	0 c	0 c

Table 4b. Comparisons among means for stem reduction in red alder. Means followed by the same letter are not significantly different at the p=0.05 level of probability based on Duncan's multiple range test.

Herbicide	Rate/Acre	Season	Red Alder % Stem Reduction
AC 252,925	0.5 lb	July	90 a
AC 252,925	1.0 lb	July	93 a
AC 252,925	2.0 lb	July	99 a
AC 252,925	0.5 lb	Aug	19 bc
AC 252,925	1.0 lb	Aug	44 b
AC 252,925	2.0 lb	Aug	43 b
DPX-T6376	0.5 oz	July	9 c
DPX-T6376	1.0 oz	July	3 c
DPX-T6376	2.0 oz	July	12 c
DPX-T6376	0.5 oz	Aug	0 c
DPX-T6376	1.0 oz	Aug	0 c
DPX-T6376	2.0 oz	Aug	1 c
Control			0 c

Table 4c. Comparisons among means for evergreen and Himalaya blackberry. Since the treatment*season interaction was not significant, data have been pooled over seasons. Means followed by the same letter are not significantly different at the p=0.05 level of probability based on Duncan's multiple range test.

Herbicide	Rate/Acre	Evergreen % Crown Reduction	Evergreen % Stem Reduction	Himalaya % Crown Reduction	Himalaya % Stem Reduction
AC 252,925	0.5 lb	12 bc	5 b	0 b	0 b
AC 252,925	1.0 lb	30 b	21 b	2 b	1 b
AC 252,925	2.0 lb	7 bc	1 b	21 b	10 b
DPX-T6376	0.5 oz	100 a	98 a	88 a	85 a
DPX-T6376	1.0 oz	100 a	83 a	100 a	99 a
DPX-T6376	2.0 oz	99 a	86 a	100 a	100 a
Control		0 c	0 b	0 b	0 b

ENHANCED HERBACEOUS WEED CONTROL IN CONIFERS WITH COMBINATIONS OF NITROGEN FERTILIZER FORMULATIONS AND HEXAZINONE

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Introduction

Christmas trees are a very important specialty crop in the Pacific Northwest. Weed control in young plantations is important in insuring survival and good growth in conifers. In addition, fertilization, typically with urea, is often carried out at least once in the six to nine year crop rotation, both to promote growth and to insure the dark green color of the foliage. A treatment that would combine weed control and fertilizer treatments into one operation would be cost-effective to the grower. Also if the effectiveness of the weed control could be enhanced, and the fertilizer could be released slowly, positive long-term responses in the conifers would be expected for a given level of investment. The objectives of this study then were: 1) to test the efficacy of hexazinone (3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione) herbicide on herbaceous weeds when applied at the same time as nitrogen fertilizer as urea or urea blended with slow release Nitrazine (triamino-so triazine) fertilizer, 2) to examine the effects of the herbicide-fertilizer applications on newly planted Douglas-fir and noble fir seedlings, 3) to determine whether efficacy of weed control is changed when the herbicide-nitrogen mixture is applied as dry co-granules or as a high-volume, co-liquid mixture, and 5) to determine whether the nitrogen form is important in the results achieved.

Materials and Methods

Study sites. The study was established in three locations to provide an array of environmental conditions. Specifically, the Valley site (3.5 miles south of Philomath, Oregon) is on a Christmas tree operation owned by Holiday Tree Farms. It is a heavy Bellpine or Jory soil, southerly 10 percent slope, with a 12-year history of Christmas tree production. During this period, an estimated 40lbs/acre/year of nitrogen have been removed during harvest, with no nitrogen additions. Lime, K_2O and P_2O^5 were added before the first crop was planted; the second crop, all Douglas-fir was just harvested. A light stand of bentgrass (*Agrostis tenuis*) and scattered trailing blackberry (*Rubus ursinus*) are the prevailing cover. During the past 12 years, annual weed control has been maintained at a bare soil level. Precipitation is about 50 inches per year, of which 87 percent occurs between October 1 and March 31.

The Five River site is on Newton Forests property about 35 miles west of the Valley site, in a coastal valley of the Oregon Coast Range. The land is a highly productive site that has been used for grain crops and pasturage. Soils are alluvial fine sandy loams to sandy loams with gradients less than 5 percent. Historically it has had exploitive treatment with low or negligible fertilization. Rainfall is 90 to 100 inches per year.

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Current cover consists of a heavy stand of bentgrass, intermingled with velvetgrass (Holcus lanatus), tansy ragwort (Senecio jacobea), several legumes, of which vetches (Vicia sp) are prominent and scattered bracken fern (Pteridium aquilinum). Seven-year-old Douglas fir (Pseudotsuga menziesii) is planted in the area with rows on a 16-foot spacing, permitting plots between rows.

The Camas Valley site is about 30 miles southwest of Roseburg, Oregon, in a relatively dry section of the Coast Range. The site is similar to the Valley site, a clay loam, nearly flat, that has been used for Christmas trees for 13 to 14 years. It is on the Wayman Schmidt property. In the history of the plantation, two crops of Douglas-fir have been removed, with a depletion of some 520 pounds per acre of nitrogen of which less than 200 pounds per acre have been restored by fertilization. Plant cover includes such catsear (Hypochaeris radicata) and St. Johnswort (Hypericum perforatum) with scattered bentgrass, ryegrass and trailing blackberry. The site has had annual applications of herbicides to remove herbs, and the community present is considered moderately resistant.

Treatments. The study was designed as a complete block factorial with three levels of nitrogen (0, 100, 200 lbs/acre) and four levels of hexazinone (0, 05., 1.0, 2.0 lbs/acre). The study was repeated three times, once using a separate application of prill fertilizer with urea nitrogen at 46 percent and hexazinone spray, once using a separate application of prill fertilizer made up of 55 percent nitrogen with 27.5 percent urea nitrogen and 27.5 percent Nitrazine nitrogen with a hexazinone spray, and once using a co-granule prill containing hexazinone, urea and Nitrazine with a total of 55 percent nitrogen. In addition, a partial series was established in which the co-granules described above were dispersed in 200 gallons of water per acre and applied as a slurry containing 200 lbs/acre of nitrogen plus the various rates of hexazinone.

Plot size was 10 feet by 43 feet on the Valley and Five Rivers sites and 10 feet by 50 feet at Camas Valley to accommodate tree spacing needs. Each plot was planted with at least ten each of 2-0 Douglas-fir and noble fir (Abies procera) seedlings at approximately 5-foot spacing.

Treatments were randomized among 31 plots at each site. Control plots were triplicated on each site.

Trees were hand planted during the third week of March, 1984. The Valley plots were treated March 28, Camas Valley March 30, and Five Rivers April 6, 1984. Planting was followed by a summer of below average temperatures and above average precipitation.

Liquid hexazinone was applied with a hand-held boom fed by a pressurized sprayer system. It was noted at the end of the Five Rivers (last) replication that the pressure regulator had malfunctioned to an unknown degree, causing a minor reduction in dosage on that site. Prill fertilizer/hexazinone materials were applied with a hand-held rotary dispenser operated so as to provide a 10-foot swath.

The co-liquid, high volume slurry was applied with a solo backpack sprayer equipped with a Cooper-Pegler wand with an in-line filter of about 30 mesh. Many passes were required to disperse the two gallons of liquid on the 1/100 acre plots, using a downward-directed nozzle, waved back and forth with the "waving wand" technique. Although distribution was undoubtedly good with this technique, the volume of 200 gpa was clearly excessive for operational use, and the solubility of the 55-0-0 was inadequate to put the Nitrazine urea base prill into solution.

In November, 1984, the treatments were evaluated. Visual estimates were made of percent bare ground, percent grass cover and percent forb cover on each plot. Each conifer was rated on a scale of A through E, where A= very vigorous, needles dark, green, B= vigorous, needles medium green, C= reduced vigor, needles chlorotic, D=low vigor, bud damage, needles chlorotic to necrotic, and E= dead.

Results and Discussion

Table 1 shows vegetation responses to 100 lbs/acre and 200 lbs/acre of nitrogen averaged over all formulations and hexazinone rates. Only forb cover is responsive to differences in nitrogen. Total cover, grass cover and conifers were not effected.

Table 1. Responses of all classes of vegetation to two levels of nitrogen, means over all formulations of nitrogen and rates of hexazinone[1].

Vegetation	Nitrogen Rate	
	100	200
Total ground cover	75.5[a]	65.1[a]
Grass cover	38.1[a]	41.7[a]
Forb cover	38.6[a]	24.4[b]
Healthy Douglas-fir	89.4[a]	83.9[a]
Healthy noble fir	46.4[a]	53.2[a]

[1]Means within rows followed by the same letter are not significantly different at the 0.05 level according to Tukey's HSD test.

Increasing rates of hexazinone result in significant decreases in total cover and grass cover (Table 2). Forb cover does not appear to be affect-- possibly the result of a community shift toward the resistant forb species. Douglas-fir was not responsive to hexazinone rate, but increasing levels of hexazinone, which corresponded to decreasing levels of competition, increased the percentage of healthy noble fir (Table 2).

Table 2. Responses of all classes of vegetation to different levels of hexazinone, means over all levels of nitrogen and formulations of nitrogen.[1]

Vegetation	Hexazinone Rate (lbs/A)			
	0	0.5	1.0	2.0
Total ground cover	92.5[a]	86.0[a]	68.7[b]	41.6[c]
Grass cover	64.2[a]	52.6[a]	37.0[b]	17.0[c]
Forb Cover	27.9[a]	33.1[a]	35.2[a]	25.2[a]
Healthy Douglas-fir	76.4[a]	86.4[a]	92.4[a]	85.8[a]
Healthy noble fir	18.3[a]	41.4[ab]	50.7[b]	76.7[c]

[1]Means within rows followed by the same letter are not significantly different at the 0.05 level according to Tukey's HSD test.

Total cover, grass cover and percentage of healthy noble fir all responded significantly to formulation of nitrogen. Weed control, except for forbs, was increased almost 100 percent with co-granule or co-liquid formulations. The percentage of healthy noble fir was twice as great in the co-granule and co-liquid treated plots as in those that received application of the other formulations (Table 3).

Table 3. Responses of all classes of vegetation to formulation of nitrogen. Means over all levels of hexazinone and both rates of applied nitrogen.[1]

Vegetation	Formulation[2]			
	1	2	3	4
Total ground cover	85.4[a]	80.6[a]	48.3[b]	41.7[b]
Grass cover	55.6[a]	52.3[a]	13.4[b]	19.9[b]
Forb cover	32.3[a]	29.4[a]	34.6[a]	22.0[a]
Healthy Douglas-fir	83.5[a]	87.1[a]	90.1[a]	84.1[a]
Healthy noble fir	32.5[a]	41.5[a]	67.2[b]	86.6[b]

[1]Means within rows followed by the same letter are not significantly different at the 0.05 level according to Tukeys HSD test.

[2]Formulations:
1) Urea prill plus hexazinone spray
2) Nitrazine®/urea prill plus hexazinone spray
3) Nitrazine®/urea plus hexazinone co-graule prill
4) Nitrazine®/urea plus hexazinone co-liquid slurry

Tables 4 and 5 compare the total ground cover and grass cover responses when hexazinone spray was applied alone and in combination with nitrogen. Total ground cover is the same with or without nitrogen in the first two formulations. In the last two formulations, the co-granule and co-liquid, ground cover is decreased significantly by close association of the Nitrazine/urea nitrogen with the hexazinone. When hexazinone spray is followed by an application of urea prills, grass cover increases as compared to a hexazinone spray alone.

Overall, incorporation of Nitrazine/urea and hexazinone into co-granule prills or co-liquid slurry appears to significantly enhance weed control compared to separate applications of the components or applications with urea nitrogen. In this study, Douglas-fir was not responsive, but noble fir showed positive responses to the increased levels of weed control Douglas-fir mortality in unweeded plots would have been considerably more severe in an average summer, and both species would have been responsive to the treatments.

Table 4. Comparisons of total ground cover with and without nitrogen for each formulation over all rates of hexazinone.[1]

Treatment Formulation [2]	Nitrogen Rate 0	100	200
1	76.0[a]	84.5[a]	86.3[a]
2	76.0[a]	81.8[a]	78.8[a]
3	76.0[a]	63.8[ab]	51.0[b]
4	76.0[a]	-	50.5[b]

[1]Means within rows followed by the same letter are not significantly differnet at the 0.05 level according to Tukeys HSD test.

[2]Formulations:
1) Urea prill plus hexazinone spray
2) Nitrazine®/urea prill plus hexazinone spray
3)Nitrazine®/urea plus hexazinone cogranule prill
4) Nitrazine®/urea plus hexazinone co-liquid slurry

Table 5. Comparisons of grass cover with and without nitrogen for each treatment over all hexazinone rates.[1]

Treatment Formulation[2]	Nitrogen Rate 0	100	200
1	39.9[a]	45.3[a]	65.9[b]
2	39.9[a]	50.1[a]	54.6[a]
3	39.9[a]	26.1[a]	21.1[b]
4	39.9[a]	-	25.3[a]

[1] Means within rows followed by the same letter are not significantly different at the 0.05 level according to Tukeys HSD test.

[2]Formulations:
1) Urea prill plus hexazinone spray
2) Nitrazine®/urea prill plus hexazinone spray
3) Nitrazine®/urea plus hexazinone co-granule prill
4) Nitrazine®/urea plus hexazinone co-liquid slurry

ONE-YEAR RESULTS FOR A COASTAL BRITISH COLUMBIA GLYPHOSATE CONIFER RELEASE TRIAL

Phillip E. Reynolds[1], Keith King[2], Roger Whitehead[2]
and Timothy S. MacKay[1]

Abstract. In early September 1984, portions of the Carnation Creek Watershed, located on the west coast of Vancouver Island (48°54'N, 125°01'W), were aerially treated with 2 kg ai/ha of glyphosate [N-(phosphonomethyl) glycine] using a Bell-47 helicopter equipped with a Microfoil Boom to minimize herbicide drift into an adjoining salmon-bearing stream. Since 1970, the watershed has been a focal point for interagency cooperative research designed to assess the effects of forest practices (i.e., harvesting, prescribed burning, herbicide use) on resident salmonid fish populations. The present herbicide study was undertaken in support of this overall objective. From 1975 to 1981, portions of the watershed were logged, and various post-harvesting silvicultural treatments, inclusive of scarification, prescribed burning and planting, were carried out commencing in the fall of 1976 and continuing through the spring of 1983. Crop species planted consisted of sitka spruce [Picea sitchensis (Bong.) Carr.], western hemlock [Tsuga heterophylla (Raf.) Sarg.], western red cedar (Thuja plicata Donn), Douglas fir [Pseudotsuga menziesii (Mirb.) Franco.], amabilis fir [Abies amabilis (Dougl.) Forbes.] and some grand fir (Abies grandis). Notable hemlock, cedar and amabilis fir natural regeneration occurred following harvesting. Prior to glyphosate treatment, major weed competition consisted of red alder (Alnus rubra Bong.) and salmonberry (Rubus spectabilis Pursh. RUBSP[3]). Weed efficacy following glyphosate treatment was species dependent, being generally high for most species present. Although salmonberry control was quite satisfactory after one post-spray growing season, control of red alder was quite variable, ranging from no control (i.e., completely healthy) to total control (i.e., totally dead). Salal (Gaultheria shallow Pursh.) was uncontrolled by the herbicide treatment. Despite variable alder control throughout the 45 ha treated watershed, higher alder control was observed on upslope microsites as contrasted with alders growing throughout the watershed valley bottom. A similar trend was noted for other important weed species including salmonberry, thimbleberry (Rubus parviflorus Nutt. RUBPA), stink currant (Ribes bracteosum Dougl.) and three fern species. The trend suggests that certain weed species growing on upslope microsites may be more physiologically stressed, and more susceptible to herbicide damage. The same weed species growing on valley bottom sites may be less stressed and more resistant to herbicide damage. Some minor crop tree injury resulted following glyphosate treatment for western hemlock and to a lesser extent for western cedar. Initial injury consisted of death or dieback of the primary leader and was unobserved for other crop trees (i.e., sitka spruce,

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[3]Letters following this symbol are a WSSA-approved computer code from Important Weeds of the World, 3rd. ed., 1983.

amabilis fir and Douglas fir) present. After one year, trees exhibiting initial injury showed full recovery with the damaged primary leader replaced by a more vigorously growing lateral.

Height growth for the hemlock or cedar laterals, assuming dominance in 1985, far exceed 1984 height growth for the original primary leader, often being upwards of two times the length of the original leader. A similar height growth increase was unobserved for treated sitka spruce. However, height growth response for untreated hemlock, cedar and spruce was quite variable. A slight decrease in growth was observed for hemlock in 1985, whereas untreated cedar showed an increase in growth for 1985. Height growth for untreated spruce declined in 1984 from 1983, but increased in 1985 over that observed in 1984. Although height growth increases were observed for treated amabilis fir and Douglas fir in 1985, only a limited number of individuals were measured, and no untreated individuals were observed. The variability in height growth response for untreated crop trees confirms that additional growth measurements are necessary in 1986 and subsequent years to substantiate the apparent dramatic height growth increase noted for treated hemlock and cedar in 1985. Continued monitoring of crop tree growth response may ultimately demonstrate that other species such as sitka spruce also show a growth response to herbicide treatment.

Additional index words. RUBPA, RUBSP, CHAAN, BLESP, ATUFF, POIMU, SAMRA.

Introduction

Canada's forests are the nation's most valuable natural resource. Nearly one out of ten Canadians is directly or indirectly employed in the forest sector. Despite the importance of Canadian forestry, Canada's recent annual harvest has been declining, and there is currently a backlog of approximately 26 million hectares of inadequately stocked productive forest land in Canada (7, 8). This is increasing at a rate of about 270,000 hectares each year. In British Columbia alone, there is approximately 2.9 million hectares of nonsatisfactorily restocked forest land, and this is being added to at a rate of 48,000 hectares per year (2). The significance of the British Columbia brush problem is paramount, since approximately half of Canada's forest production is derived from British Columbia forests, and approximately half of the wood fibre produced in British Columbia is derived from the fertile, highly productive coastal forests (1).

Successful attempts to renew Canada's forests are plagued by a lack of registered forestry herbicides. This lack of registered herbicides is due in large measure to environmental concerns, and the problem is especially acute in British Columbia where notable fisheries resources (i.e., pacific salmon) are located within coastal forest sites which would benefit most from herbicide use. At present only two herbicides, including glyphosate, are fully registered (i.e., inclusive of aerial applications) for forestry use in Canada. One herbicide, hexazinone [3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H, 3H)-dione], has a temporary registration for ground applications only. This compares with nearly a dozen registered forestry herbicides in the United States.

A role of the Canadian Forestry Service is to assist in the collection of weed efficacy, crop injury and environmental impact data, specific to Canadian plant species and environmental conditions, needed to fully register additional herbicides and forestry herbicide use patterns for Canadian use. Since provincial permits are required to use registered herbicides, and since issuance of such permits has been hampered by a lack of regional data specific to registered herbicides, the Canadian Forestry Service is playing a significant role in helping to answer regional silvicultural and environmental concerns which extend beyond federal registration data requirements. Silviculturally, herbicide conifer release is generally performed two to five years after planting. It is intended to release the newly established conifers from competing forest weeds and to ensure that the crop trees achieve a free-to-grow status.

Study area. The Carnation Creek Watershed is located on the west coast of Vancouver Island. The watershed is located near the town of Bamfield on the south side of Barkley Sound (48°54'N, 125°01'S) and is approximately 10 km^2 in area. Since 1970, the watershed has been a focal point for interagency cooperative research designed to assess the effects of forest practices (i.e., harvesting, prescribing burning, herbicides use) on resident salmonid fish populations.

Elevation of the watershed ranges from sea level to 670 meters, although most of the drainage is located below 450 meters and the level of snowfall (4, 6). Prior to harvesting, the watershed consisted of an overmature western hemlock-amabilis fir-western red cedar forest growing on colluvial materials (6). Annual precipitation at the watershed ranges from 250 cm to 380 cm (1). Carnation Creek, the primary creek draining the watershed, is approximately 6 km in length (6). Stream discharge for the creek ranges from approximately 0.071 m^3/sec in late summer to around 48 m^3/sec in the winter (1). Spawning fish populations consist of coho salmon, steelhead and cutthroat trout, chum salmon and pink salmon, and range in numbers from a few individuals to 4200 (1).

From 1979 to 1981, portions (i.e., approximately 404 ha) of the watershed were logged, and various post-harvesting silvicultural treatments inclusive of scarification, prescribed burning and planting, were carried out commencing in the fall of 1976 and continuing through the spring of 1983 (3). Crop species planted consisted of sitka spruce, western hemlock, western red cedar, Douglas fir, amabilis fir and some grand fir. Post-harvest revegetation of the watershed has been described in detail elsewhere (5). Notable hemlock, cedar and amabilis fir natural regeneration occurred following harvest. Prior to herbicide treatment, major weed competition consisted of red alder and salmonberry. The present herbicide study was undertaken to assess environmental impacts on resident salmonids, to monitor weed efficacy and crop injury resulting from glyphosate treatment and to monitor long-term crop tree growth response resulting from conifer release. The present report focuses on preliminary silvicultural considerations resulting from glyphosate treatment.

Materials and Methods

Glyphosate (2 kg ai/ha was aerially applied to a 45 ha portion of the watershed as described in Table 1. Treatment was performed in September 1984 using a Bell-47 helicopter equipped with a MICROFOIL BOOM[4] to minimize herbicide drift into an adjoining salmon-bearing stream. The watershed was operationally sprayed by dividing the spray area into ten spray blocks easily delineated by natural topographic features. Untreated control areas

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[4]Registered trademark of Union Carbide, Inc., Ambler, PA.

Table 1. Treatment conditions

Herbicide (a.i.)	glyphosate (356 g/L)
Treatment rate	2.0 kg/ha
Spray volume	258.25 L/ha
Aircraft	Bell-47 helicopter
Boom and nozzles	MICROFOIL BOOM, 26 ft in length, .060 hayrake nozzles
Orientation of nozzles	180°
Boom pressure	172.5 kPa
Airspeed	40.2 km/hr
Swath width and altitude	12.2 m; 6 to 18 m
Weather (prior)	Sunny and calm winds immediately prior to Sept. 6; intermittent showers on Sept. 7 and each day from Sept. 9 through Sept. 12; sunny and very windy on Sept. 13
(at times of spraying)	Sept. 6 - time: 1900-2005 hr; air temperature: 15°C; wind conditions: calm, E to W; skies: cloudy, overcast, intermittent sun; precipitation: none
	Sept. 8 - times: 1416-1445 hr and 1913-1940 hr; wind conditions: gusty to calm, E to W; skies: overcast, black clouds, threatening showers; precipitation: none
	Sept. 14 - time: 1430-1931 hr; air temperature: 21°C; wind conditions: gusty to calm, E to W; skies: sunny, overcast, white clouds; precipitation: none
	Sept. 15 - time: 1041-1101 hr; air temperature: 14°C; wind conditions: calm, E to W; skies: sunny; precipitation: beginning at 1345.
(after)	Winds increasing in speed and changing direction (W to E) by 1130 hr on Sept. 15; cloudy and overcast, with rain clouds moving in from sea by 1200 hr; rain showers began at 1345 hr on Sept. 15, and heavy rain continued through 1500 hr on Sept. 16.

were located throughtout the sprayed water shed, and their locations and boundaries were delineated by orange garbage bags tied to wooden markers or tree tops.

Weed efficacy, crop injury and crop tree growth response were assessed from September 18 to 20, 1985, by establishing circular vegetation sample quadrats (1.8 m radium for herbaceous and 25 m for brush) at 50 to 75 metre intervals along transects running throughout the watershed. Where possible, most of transects were located within the watershed valley bottom, since most of the herbicide treatment occurred within the floodplain of Carnation Creek. Changes in transect compass bearing of sampling interval were minimized and were necessitated by changing terrain features mediated by the natural course of Carnation Creek itself (i.e., the watershed is essentially a ravine, with Carnation Creek flowing through the valley bottom). A total of 36 permanently marked treated sample quadrats were established. Five untreated quadrats were established. The 41 quadrats will be monitored in subsequent years for additional vegetation changes associated with glyphosate spraying.

Weed efficacy or crop injury were rated on a scale of 0 to 10, 0 being no control or injury and 10 being total weed kill or maximum crop injury. Representative (i.e., silviculturally superior) crop trees were tagged in each sample quadrat, and height and diameter measurements for all tagged specimens recorded. Height measurements consisted of recording 1985 terminal leader length and measuring 1983 and 1984 internodal length where feasible. In instances where the 1985 terminal leader was found to be dead or partial dieback was evident, the length of any lateral having assumed dominance was measured. In addition, the extent of dieback or the length of the dead terminal leader was measured.

Results and Discussion

Weed efficacy following glyphosate treatment was species dependent, being generally high for most species present (Table 2). Weed efficacy values ranged from 7 to 10 for stink currant (Ribes bracteosum Dougl.), red elderberry (Sambucus racemosa L. SAMRA), lady fern [Athyrium filix-femina (L.) Roth ATUFF], bitter cherry [Prunus emarginata Dougl. ex Hook.) Walp.], salmonberry (Rubus spectabilis Pursh. RUBSP), deer fern [Blechnum spicant (L.) With. BLESP], false azalea (Menziesia ferruginea Smith) and Pacific crabapple (Pyrus fusca). Although salmonberry control was quite satisfactory after one post-spray growing season, control of red alder was quite variable, ranging from no control (i.e., completely healthy) to total control (i.e., totally dead). Salal was uncontrolled by the herbicide treatment. Some minor crop tree injury resulted following glyphosate treatment for western hemlock and to a lesser extent for western red cedar (Table 2). Initial injury consisted of death or dieback of the primary leader and was unobserved for other crop trees (i.e., sitka spruce, amabilis fir and Douglas fir) present.

Despite variable alder control throughout the 45 ha treated watershed, higher alder control was observed on upslope microsites as contrasted with alders growing throughout the watershed valley bottom (Table 3). A similar trend was noted for salmonberry, thimbleberry, stink currant, deer fern, lady fern and sword fern [Polystichum munitum (Kaulf.) Presl. POIMU]. Other weed species growing throughout the watershed valley bottom, including red huckleberry (Vaccinium parvifolium Smith), tall huckleberry (Vaccinium ovalifolium Smith), false azalea and fireweed (Epilobium angustifolium L. CHAAN), were observed to have higher efficacy control values as contrasted

Table 2. Mean weed efficacy and crop injury values following glyphosate treatment.

Species	0 kg/ha		2 kg/ha	
	Value[a]	n[b]	Value	n
red alder (Alnus rubra)	0	5	6.8	36
salmonberry (Rubus spectabilis)	0	5	8.2	39
thimbleberry (Rubus parvifolium)	0	5	5.6	17
salal (Gaultheria shallor)	0	5	0.0	30
red huckleberry (Vaccinium parvifolium)	0	5	2.4	34
tall huckleberry (Vaccinium ovalifolium)	0	1	3.9	22
evergreen huckleberry (Vaccinium ovatum)	-	0	0.0	3
false azalea (Menziesia ferruginea)	0	1	9.3	18
bitter cherry (Prunus emarginata)	0	2	7.9	8
stink currant (Ribes bracteosum)	-	0	7.1	5
Pacific crabapple (Pyrus fusca)	-	0	10.0	1
red elderberry (Sambucus racemosa)	0	3	7.4	25
willow (Salix sp.)	-	0	2.2	6
deer fern (Blechnum spicant)	0	5	8.3	39
lady fern (Athyrium felix-femina)	0	5	7.5	20
sword fern (Polystichum munitum)	0	5	4.4	34
fireweed (Epilobium angustifolium)	0	5	1.8	35
sitka spruce (Picea sitchensis)	0.2	5	0.0	37
western hemlock (Tsuga hetrophyla)	0	4	0.9	35
western cedar (Thuga plicata)	0	5	0.3	36
amabilis fir (Abies amabilis)	-	0	0.0	5
Douglas-fir (Pseudotsuga menziesii)	-	0	0.0	1
western yew (Taxus brevifolia)	-	0	0.0	1

[a] Mean value based upon number of individuals observed.

[b] Number of individuals observed.

Table 3. Influence of watershed microsite on weed efficacy or crop tree injury.

Species	2 kg/ha			
	Valley bottom		Upland microsite	
	Value[a]	n[b]	Value	n
red alder (Alnus rubra)	6.3	26	7.8	10
salmonberry (Rubus spectabilis)	8.0	27	8.4	12
thimbleberry (Rubus parvifolium)	4.5	12	8.0	5
salal (Gaultheria shallor)	0.0	19	0.0	11
red huckleberry (Vaccinium parvifolium)	2.9	18	2.3	12
tall huckleberry (Vaccinium ovalifolium)	3.9	14	3.8	8
evergreen huckleberry (Vaccinium ovatum)	0.0	2	0.0	1
false azalea (Menziesia ferruginea)	9.8	10	8.8	8
bitter cherry (Prunus emarginata)	7.9	6	7.8	2
stink currant (Ribes bracteosum)	6.6	4	9.0	1
Pacific crabapple (Pyrus fusca)	10.0	1	-	0
red elderberry (Sambucus racemosa)	7.4	19	7.4	6
willow (Salix sp.)	2.2	5	2.0	1
deer fern (Blechnum spicant)	8.1	27	8.8	12
lady fern (Athyrium felix-femina)	7.7	17	8.8	3
sword fern (Polystichum munitum)	4.0	25	5.3	9
fireweed (Epilobium angustifolium)	2.1	24	1.2	11
sitka spruce (Picea sitchensis)	0.0	26	0.0	11
western hemlock (Tsuga hetrophyla)	0.9	23	0.8	12
western cedar (Thuga plicata)	0.3	25	0.2	11
amabilis fir (Abies amabilis)	0.0	1	0.0	4
Douglas-fir (Pseudotsuga menziesii)	0.0	1	-	0
western yew (Taxus brevifolia)	-	0	0.0	1

[a] Mean value based upon number of individuals observed.

[b] Number of individuals observed.

with the same species growing on upland microsites. Weed species, such as salal, evergreen huckleberry (Vaccinium ovatum Pursh.) or red elderberry exhibited no notable difference in weed efficacy for the two microsites. Similarly, no noteworthy difference in crop injury was observed for the two microsites.

Microsite differences (e.g., moisture, solar radiation, wind, temperature, nutrients) throughout the watershed may be expressed as physiological differences within individual plants and may explain why some weed species are better controlled on one microsite (i.e., hillside) as opposed to another (i.e., valley bottom). Certain weed species growing on upslope microsites may be more stressed and more susceptible to herbicide damage, due to desiccation resulting from greater wind exposure and less available water. By contrast, the same weed species growing on valley bottom sites may be less stressed and more resistant to herbicide damage.

Such differences could result in the use of different herbicide rates depending upon microsite. This practice could have high operational and environmental advantages. Differences in plant physiological stress, mediated by microsite variations, may be the key to explaining frequently observed differences in herbicide efficacy or crop injury reported by operational foresters. Where such differences are noted, foresters often look for all sorts of explanations for why herbicide x didn't work for location y when the same herbicide worked great just over the hill on location z. Frequently alleged causes such as plugged-up nozzles, morning versus evening treatment, rain or no rain shortly before or after the application, etc. may not be the true causative agent(s) for the efficacy differences. Clearly, more in-depth investigations of the influence of plant stress and microsite on herbicide efficacy are warranted. Vegetation studies focusing on whole watersheds or ecosystems may be of greater value in detecting differences in plant susceptibility than replicated treatments consisting of small (i.e., 2-4 ha), homogenous spray blocks, since microsite differences are likely best expressed over large geographic areas. Should plant stress be positively implicated, operational foresters will need to be better educated concerning plant growth and development and pay greater attention to these details in developing herbicide prescriptions.

Height growth for hemlock and cedar in 1985, following glyphosate treatment, far exceeded that attained in 1984 (Table 4). After one growing season, hemlock and cedar trees exhibiting initial injury following glyphosate treatment showed full recovery with the damaged primary leader replaced by a more vigorously growing lateral. Height growth for hemlock or cedar laterals, assuming dominance in 1985, far exceeded 1984 height growth for the original primary leader, often being upwards of two times the length of the original leader. This is reflected in Table 4 which encompasses 1985 growth for uninjured crop trees as well as those damaged by the glyphosate spraying. A similar height growth increase for treated sitka spruce was unobserved in 1985. Height growth response for untreated (0 kg ai/ha glyphosate) hemlock, cedar and spruce was quite variable. A slight decrease in growth was observed for untreated hemlock in 1985, whereas untreated cedar showed an increase in growth for 1985. Height growth for untreated spruce declined in 1984 from 1983, but increased in 1985 over that observed in 1984. Although height growth increases were observed for treated (2 kg ai/ha glyphosate) amabilis fir and Douglas fir in 1985, only a limited number of individuals were measured, and no untreated individuals were observed.

Table 4. Crop tree growth response to glyphosate treatment.

Treatment	1983		1984		1985	
	height[a]	n[b]	height	n	height	n
0 kg/ha						
western hemlock	-	0	45.0	4	43.5	4
western cedar	-	0	39.0	2	49.5	2
sitka spruce	40.3	6	29.7	6	51.0	6
amabalis fir	-	0	-	0	-	0
Douglas-fir	-	0	-	0	-	0
2 kg/ha						
western hemlock	-	0	34.3	25	44.4	30
western cedar	-	0	23.9	15	40.5	25
sitka spruce	36.7	24	48.5	26	52.2	26
amabalis fir	-	0	53.0	2	59.5	2
Douglas-fir	-	0	49.0	1	60.0	1

[a] Mean annual incremental leader growth based upon number of individuals observed.

[b] Number of individuals observed.

The variability in height growth response for untreated crop trees confirms that additional growth measurements are necessary in 1986 and subsequent years to substantiate the apparent dramatic height growth increase noted for treated hemlock and cedar in 1985. Continued monitoring of crop tree growth response may ultimately demonstrate that other species such as sitka spruce also show a growth response to herbicide treatment.

Results of the Carnation Creek trial should be very encouraging to operational foresters, since they clearly demonstrate that crop injury, although unavoidable for certain species, is of a temporary fleeting nature and that notable growth increases are likely to be achieved within one growing season following a conifer release treatment. The dramatic increase in hemlock and cedar growth following glyphosate treatment suggests that significant growth gains may be achieved by releasing naturally regenerated conifers from weed competition and that these growth gains may far exceed those attainable by releasing plantations from similar competition. If this is true, a greater growth advantage may result from using herbicides on naturally regenerated sites rather than on man-made plantations.

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HERBICIDAL CONTROL OF SILVERLEAF NIGHTSHADE

Robert E. Stubblefield and Ronald E. Sosebee

Abstract. Silverleaf nightshade (*Solanum eleagnifolium* (Cav.) is a serious noxious weed infesting valuable crops and rangelands on the High Plains of Texas and Oklahoma. Areas infested with this plant exhibit heavy losses of nutrients and soil water, thus contributing to the reduced productivity of the land. In heavy infestations, the closed canopy cover restricts the available light thereby reducing production of understory vegetation. In addition, there is the ever-present danger of poisoning because the plant is toxic to livestock.

This study began in June 1984 and was designed to measure herbicidal control of silverleaf nightshade through phenological development. The influence of irrigation vs. no irrigation is also being tested for the most appropriate time to control nightshade with a foliar applied herbicide. The experimental design was completely randomized consisting of four treatments and three replications. The treatments consisted of monthly applications of glyphosate (*N*-phosphonomethyl)glycine) at rates of 0, 1, 2 and 4% v/v) with a 1% (v/v) surfactant (AG-98) added to each herbicide solution.

The environmental parameters measured at each sampling date were soil temperature and soil water content. Soil temperature was measured at depth of 15, 30 and 45 cm and soil water content was measured in 15-cm increments from the surface to a depth of 45 cm. Soil temperature was measured with a glass, mercury-filled laboratory thermometer inserted at prescribed depths in a hole made with a 0.95-cm steel shaft. Soil water was measured gravimetrically.

From June 1984 through the present, ten plants have been collected from an irrigated and non-irrigated site for TNC analysis. Upon collection, the plants were immediately frozen for transportation to the lab and phenological stage was recorded. The plants were then dried in a forced-air oven at 60°C for a minimum of 48 hr. They were subsequently dissected

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[1]Texas Tech University, Lubbock, TX

into above- and below-ground plant portions. Each sample was then ground to pass through a 0.5 mm screen and stored by acid hydrolysis and measured spectrophotometrically using anthrone reagent with a glucose standard.

Timing of herbicidal application appears to be the most important factor in the control of silverleaf nightshade. Preliminary results suggest that the soil water content was the most influential environmental parameter. However, after analyzing yields one year post treatment, it is apparent that phenological stage and physiological condition play a very important role in the control of silverleaf nightshade with a systemic herbicide.

It was apparent, through visual observations, that plots treated during the "green-berry" stage provided the most optimal control at all rates. This was true in both the irrigated and non-irrigated sites. Treatments following the "green-berry" stage provided reasonable results. The TNC trend during the "green-berry" stage represents a rapid increase of assimilates moving into the below-ground portion of the plant. During this phase, herbicidal application provided the best results.

Timing of herbicidal application, therefore, to coincide with TNC translocation throughout the entire plant enhances the effectiveness of glyphosate and increases root mortality.

CONTROL OF YELLOW TOADFLAX (LINARIA VULGARIS MILL.) ON IDAHO RANGELANDS

S.A. Dewey, R. Mickelson and P.W. Foote[1]

Abstract: Yellow Toadflax (*Linaria vulgaris* Mill.) has spread over many acres of summer rangeland and pasture in central and southwestern Idaho. Results from previous studies, and experiences of ranchers and county weed supervisors indicate that this is a difficult species to control. Field trials were established in August of 1982 near Soda Springs to evaluate the performance of several standard herbicides. Treatments included 2,4-D ester { (2,4-dichlorophenoxy) acetic acid } (2.0 lb ae/A), dicamba (3,6-dichloro-2-methoxybenzoic acid) (2.0 lb ae/A), picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) (2.0 lb ae/A), 2,4,5-T { (2,4-5-trichlorophenoxy) acetic acid} (2.0 lb ae/A), triclopyr {{ (3,5,6-trichloro-2-pyridinyl)oxy}-acetic acid} (4.0 lb ai/A), glyphosate { (N-phosphonomethyl)glycine} (2.0 lb ai/A), and amitrole (1H-1,2,4-triazol-3-amine) (1.0 lb ai/A). Only glyphosate and picloram provided greater than 80 percent control of yellow toadflax 12 months after application (8/83), but both caused excessive injury (100 and 62 percent, respectively) to grass species (*Bromus marginatus* Nees.). Dicamba, 2,4-D and 2,4,5-T resulted in 68, 68 and 63 percent control, respectively. Twenty-four months after treatment glyphosate provided 78 percent control while the picloram rating dropped to 23 percent. Toadflax control from other treatments ranged between 0 and 5 percent after 24 months.

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In June of 1983, a second series of plots were established adjacent to the 1982 trial to evaluate the effectiveness of new sulfonyl-urea herbicides on yellow toadflax. Treatments included chlorsulfuron {2-chloro-N{{(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino}carbonyl}benzenesulfonamide} (2 oz ai/A), metsulfuron {2-{{{{(4-methoxy-6-methyl-1,3,5 triazin-2-yl) amino} carbonyl}amino} sulfonyl} benzoic acid} (1.87 oz ai/A), sulfometuron (2-{{{{(4,6-dimethyl-2-pyrimidinyl) amino} carbonyl}amino}sulfonyl}benzoic acid) (2.0 oz ai/A), 2,4-D (2 lb ae/A) and triclopyr (3 lb ai/A). Evaluations in August of 1984 indicated fair control (69 to 73 percent) from the sulfonyl-urea herbicides, no control from 2,4-D and an average of 15 percent control in triclopyr plots. All treatments except 2,4-D caused some initial injury to grasses. By August of 1984, grass injury in the sulfometuron plots was estimated at 96 percent, while grasses had recovered from all other treatments.

A third trial was established in August of 1984 to compare herbicide treatments from the 1982 and 1983 studies. The experiment was designed to continue for at least three years, allowing for evaluation of long-term results from single and repeat applications. By August of 1985, chlorsulfuron (1 1/2 oz ai/A and 3 oz ai/A), picloram (2 lb ai/A) and glyphosate (2 lb ai/A) still provided 97, 99, 96 and 87 percent control of yellow toadflax, respectively. Metsulfuron treatments resulted in 50 to 76 percent control while ratings for all other treatments ranged from 0 to 20 percent. Grass lands were too light to evaluate for herbicide injury.

Preliminary results indicate that chlorsulfuron could provide an effective alternative for control of yellow toadflax on rangeland. Further studies are needed to determine the lower limits of effective rates, as well as results of combinations with other herbicides.

EVALUATION OF HERBICIDES FOR CONTROL OF ASSOCIATED POPULATIONS OF BLESSED MILKTHISTLE AND SLENDERFLOWER THISTLE IN PASTURELAND

T.D. Whitson[1], D. Humphrey[2], P.S. Friedrichsen[3], and K. French[2]

Introduction

Blessed milkthistle (*Silybum marianum* Gaertn.) and slenderflower thistle (*Carduus tenniflorus* W. Curtis) have been reported in Oregon in the southern part of the state since before 1980 (1). These species were reported as problems in California as early as 1951 (2). Blessed milkthistle and slenderflower thistle are considered biennial or winter annuals. They are both very aggressive and have completely taken over approximately 20,000 acres of rangeland near Roseburg, Oregon. MCPA (4-chloro-2-methylphenoxy)acetic acid) has been recommended as a control but has not been effective in long-term control programs (3).

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The objective of this study were to determine how new herbicides would compare to MCPA as controls for blessed milkthistle and slenderflower thistle and to determine their selectivity in pastures with subclover and perennial grasses as important forage species.

Materials and Methods

Herbicides were applied April 12, 1985, in a randomized complete block design with four replications. They were applied with 40 gallons of water per acre with a 10-foot, 6 nozzle, hand-held boom at 45 lbs pressure per square inch. A non-ionic surfactant at 0.25% v/v was added to the sulfonyl urea, DPX-T6376 (methyl 2-[C[[(-methoxy-6-methyl)-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoate (Table 1). Plots were 10 feet by 27 feet on a hill with a slope of approximately 8%.

The grass and subclover were three to four inches in height and the two thistle species were in the bud stage four to eight inches in height at application time. Moisture was in good supply during the morning of spray application. No previous treatments had been applied to the study area.

Results

Three parameters were determined in this study; slenderflower thistle control, blessed milkthistle control and clover damage obtained. Clover damage was estimated two months following application but will be reconsidered after the hard seed produced by subclover has had time to germinate.

Dowco 290 at 0.5 lb ai/A provided 100% control of both thistle species. The plots receiving the 0.25 lb ai/A dowco 290 application rate had over 90% control on both species with only 53% clover damage. DPX-T6376 provided effective control of slenderflower thistle but had no effect on blessed milkthistle. DPX-T6376 damaged clover 100%. 2,4-D LVE at 1.5 lb ae/A provided 80% control levels of both thistle species with no clover damage. When MCPA, bromoxynil (3,5-dibromo-4-hydroxybenzonitrile), dicamba (3,6-dichloro-2-methoxybenzoic acid) and 2,4-D (2,4-dichlorophenoxy)acetic acid) LVE were added to DPX-T6376, partial control of blessed milkthistle was obtained but clover was still damaged 100%. Picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) 2E applications at 0.25 lb ae/A provided 90% control on both thistle species but subclover was also damaged. Dicamba and dicamba/2,4-D combinations provided good control of slenderflower thistle but failed to control blessed milkthistle. They also damaged the subclover.

Conclusions

When mixed populations of slenderflower thistle and blessed milkthistle are present in pastureland containing both subclover and perennial grass species, Dowco 290 (M-3972) shows considerable activity on both thistle species and is somewhat selective on clover when used at the 0.25 lb ai/A application rate. The clover stand will need to be evaluated again in 1986 to determine damage to the clover. 2,4-D LVE gave partial control of the thistle species and caused no apparent damage to the subclover.

Table 1 Evaluation of herbicides for control of blessed milkthistle and slenderflower thistle

Herbicide[1]	Application Rate	% Control[2] Slenderflower thistle	% Control Blessed milkthistle	% Clover Damage
Dowco 290 (M-3972)	0.25 lb ai/A	95.5	92.5	52.5
Dowco 290 (M-3972)	0.5 lb ai/A	100.0	100.0	98.0
Fluroxypyr	0.25 lb ai/A	42.5	0	85.0
Fluroxypyr	1.0 lb ai/A	78.8	0	99.8
DPX-T6376	0.17 oz/A	98.0	0	100.0
DPX-T6376	0.7 oz/A	100.0	5.0	100.0
dicamba	0.5 lb ai/A	82.5	30.0	100.0
2,4-D LVE	1.5 lb ae/A	77.5	80.0	0
MCPA +	0.75 lb ai/A			
DPX-T6376	0.17 oz ai/A	92.0	73.3	98.8
MCPA	1.5 lb ae/A	76.3	-	0
2,4-D amine	3.0 lb ae/A	86.3	50.0	0
Triclopyr 4E	0.75 lb ae/A	46.3	35.0	75.0
picloram 2E	0.25 lb ae/A	90.0	91.7	100.0
dicamba + 2,4-D	0.5 + 1.4 lb/A	90.8	-	98.8
Triclopyr + 2,4-D LVE	0.25 + 0.5 lb/A	53.8	50.0	50.0
DPX-T6376	0.17 oz/ai/A			
+ bronoxynil	0.5 lb ai/A	97.5	37.5	100.0
DPX-T6376	0.17 oz ai/A			
+ dicamba	0.5 lb ai/A	100.0	66.3	100.0
DPX-T6376	0.17 oz ai/A			
2,4-D LVE	0.5 lb ai/A	98.8	83.3	100.0

* = Insufficient population in plot for estimate

[1] Herbicides were applied April 12, 1985

[2] Evaluations were made June 12, 1985

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EVALUATION OF 2,4-D LVE AS A SETUP TREATMENT FOR LOW RATES OF PICLORAM FOR LEAFY SPURGE CONTROL

Gamal S. Heneidi, Mark A. Ferrell and Stephen D. Miller[1]

Leafy spurge is considered one of the most serious weeds in Wyoming, presently infesting over 48,000 acres of rangeland and pastures in the state. Picloram is the most effective herbicide for leafy spurge control; however, the high cost of picloram has limited its use. This experiment was conducted to evaluate the use of 2,4-D (2,4-dichlorophenoxy)acetic acid LVE (low volatile ester) as a setup treatment prior to light rates of picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid).

The experiment was conducted at the University of Wyoming greenhouse at Laramie. Leafy spurge plants were established from root cuttings and transplanted in 15 by 18 cm metal pots. Each of the thirteen treatments was replicated ten times in a randomized complete block design. Data collected included visual injury rating, length of shoot and roots and fresh and dry weight yield of shoot and roots. Results indicate that 2,4-D LVE at 0.0625 and 0.125 lb ai/A did not injure leafy spurge. Picloram at 0.125 lb ai/A resulted in severe plant injury and at 0.25 lb ai/A resulted in total control. Combination treatments tended to be less effective than picloram alone (Table 1).

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Table 1. Plant growth responses to the selected herbicide treatments.[1]

No.	Treatment (lb a.i./A)	Injury index[2]	Shoot length (cm)	Root length (cm)	Fresh shoot wt. (g)	Dry shoot wt. (g)	Fresh root wt. (g)	Dry root wt. (g)
1.	.0625 2,4-D LVE (D_1)	1	70.5	66.0	10.2	3.2	25.7	11.9
2.	.1250 2,4-D LVE (D_2)	1	52.1	62.7	17.0	5.0	29.0	9.3
3.	.1250 Picloram (P_1)	4	17.2	31.2	.6	.3	2.9	.8
4.	.2500 Picloram (P_2)	5	25.1	19.7	.5	.3	1.2	.3
5.	$D_1 + P_1$ (0 day)	3.8	34.9	72.6	8.6	2.7	13.6	3.4
6.	$D_1 + P_1$ (14 day)	4.1	32.0	70.1	4.5	1.4	19.7	3.9
7.	$D_1 + P_2$ (0 day)	4.5	32.0	56.4	2.5	.8	19.0	4.0
8.	$D_1 + P_2$ (14 day)	4.6	27.3	61.5	1.7	.8	21.0	4.6
9.	$D_2 + P_1$ (0 day)	4	38.1	68.6	3.4	1.0	17.1	3.2
10.	$D_2 + P_1$ (14 day)	4.4	29.9	62.0	4.2	1.5	19.4	3.7
11.	$D_2 + P_2$ (0 day)	4.4	28.2	84.3	3.1	1.2	22.8	4.5
12.	$D_2 + P_2$ (14 day)	4.8	27.9	68.1	2.1	1.0	18.0	5.6
13.	Check	1	44.3	81.8	10.2	2.8	36.0	10.8
	LSD (0.05)	0.52	10.45	17.95	3.45	0.96	8.70	3.09
	C.V. %	16.66	33.70	33.06	74.65	65.00	53.02	69.26

[1]Each value is an average of ten replications.

[2]1 = healthy, 5 = dead.

CONIFER TOLERANCE AND SHRUB RESPONSE TO TRICLOPYR, 2,4-D AND CLOPYRALID

Bruce R. Kelpsas and Diane E. White[1]

Two herbicides that are frequently used for brush control in commercial conifer plantations are triclopyr ([(3,5,6 trichloro-2-pyridinyl)oxy] acetic acid), and 2,4-D (2,4-dichlorophenoxy)acetic acid). These compounds control a wide range of shrub species but are particularly suited for broadleaved evergreen brush when applied as the ester formulation. A primary constraint to the widespread use of these compounds in the evergreen vegetation type has been phytotoxicity to the dominant conifer species, ponderosa pine (*Pinus ponderosa*), during the optimum season of usage.

A field study was initiated in 1984 in the southern Oregon Cascade mountains to evaluate the response of ponderosa pine and two evergreen shrubs, greenleaf manzanita (*Arctostaphylos patula*) and snowbrush ceanothus (*Ceanothus velutinus*) to triclopyr, 2,4-D and clopyralid (3,6-dichloro-2-pyridinecarboxylic acid), an experimental forestry compound. Two rates of triclopyr (0.75 and 1.5 lbs/A), or 2,4-D (0.5 and 1.0 lbs/A) were applied alone and in combination with clopyralid at 0.75 and 1.5 lbs/A. Clopyralid was also applied alone at the above rates. A completely randomized factorial design was used. Two application timings were compared--a spring series treated in May and a late summer series treated in August. All plots were sprayed with a backpack sprayer applying 10 gal/acre using a water carrier.

Second-year evaluations indicate that both triclopyr and 2,4-D were effective in controlling ceanothus and manzanita. Crown reductions of 70 to 100 percent were observed for the May treatment at the high rates. August treatments generally provided less control. Clopyralid was not effective alone, with crown reductions of zero to two percent occurring for all rates and timings. The addition of clopyralid to triclopyr or 2,4-D did not consistently increase crown reduction over that provided by either compound alone, although improvement was seen for the low rates under the May timing.

Conifer tolerance to triclopyr and 2,4-D was improved by the addition of clopyralid (Tables 1 and 2). Pines were severely damaged when treated with 0.75 or 1.5 lbs/acre triclopyr in May (58 and 81 percent crown reduction), but this injury was substantially reduced (5 and 44 percent crown reduction) by the addition of 1.5 lbs/acre of clopyralid. Although 2,4-D was less injurious to the pines (no damage at the August timing), injury was still reduced by the addition of clopyralid to the spray solution at the May application. Pines treated with either rate of clopyralid alone showed no signs of damage at either timing.

The results of these trials suggest that clopyralid may be useful in reducing pine injury from triclopyr or 2,4-D while maintaining operationally acceptable brush control in conifer plantations.

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Table 1. Mean percent crown reduction of ponderosa pine treated in May. Standard errors are shown in parentheses.

Clopyralid Rate (lbs/a)	Triclopyr Rate (lbs/a) 0	0.75	1.5	2,4-D Rate (lbs/a) 0	0.5	1.0
0	0 (0)	58 (10)	81 (1)	0(0)	6 (1)	29 (5)
0.75	0 (0)	20 (7)	53 (8)	0(0)	0 (0)	3 (3)
1.50	0 (0)	5 (1)	44(11)	0(0)	1 (1)	6 (5)

Table 2. Mean percent crown reduction of ponderosa pine treated in August. Standard errors are shown in parentheses.

Clopyralid Rate (lbs/a)	Triclopyr Rate (lbs/a) 0	0.75	1.5	2,4-D Rate (lbs/a) 0	0.5	1.0
0	0 (0)	1 (0)	21(17)	0 (0)	0 (0)	0 (0)
0.75	0 (0)	1 (1)	2 (2)	0 (0)	0 (0)	0 (0)
1.50	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

WEED MANAGEMENT STRATEGIES IN CORN BASED ON BIOECONOMIC MODELING

Edward E. Schweizer, Donald W. Lybecker
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Abstract. Weeds and their control have been and will continue to be a major consideration in corn production, But what degree of weed control is feasible today when costs of weed control have risen sharply recently relative to corn prices? Since decision making for weed control should be based on biological and economic considerations, we built a corn bioeconomic model to evaluate alternative weed management strategies for continuous corn, with analyzed net returns as the performance indicator. The principal model components were grass and broadleaf weed seed numbers in soil (25 cm deep), grass and broadleaf populations, weed control responses, grain yield, herbicide cost and grain price. One hypothesis that resulted from the model was that fully flexible weed management strategies should outperform more traditional fixed strategies; i.e. weed control actions should be based on biological factors (weed seed banks and weed populations) and economic considerations, rather than employing a "fixed" strategy where herbicides are applied regardless of biological and economic factors. In 1985, we tested this hypothesis in 128 corn plots where one fixed, two mixed and one flexible strategies were employed. For the fixed strategy, all plots were treated with herbicides applied preplanting, preemergence, postemergence and layby. For the mixed strategies, each plot received a herbicide before planting (fixed), but postemergence herbicides were applied only if weed populations exceeded their economic thresholds (flexible). For the flexible strategy, herbicide actions were based on weed seed numbers in the soil (preplanting applications) and weed populations present after corn had emerged (postemergence applications). For the fixed strategy (16 plots), the average reduction in broadleaf and grass populations was 96% and 66%, respectively, and grain yields averaged 10,840 kg/ha. For the two mixed strategies (32 plots), reduction is broadleaf and grass populations were 89 and 40%, respectively, and grain yields averaged 10,990 kg/ha. For the five flexible strategies (80 plots), reduction in broadleaf and grass populations were 94 and 74%, respectively, and grain yields averaged 10,770 kg/ha. Thus, weeds can be controlled in continuous corn by employing weed actions based on bioeconomic modeling.

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TOTAL WEED CONTROL IN SUGARBEETS WITH POSTEMERGENCE HERBICIDES

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Abstract. Weed control in sugarbeets (Beta vulgaris cv WS 76) with only postemergence herbicides was tested in the field at Aberdeen, Idaho, during 1985. Sugarbeets were planted May 1, 1985. Weeds are mostly controlled presently by preplant and preemergence herbicides and hand weeding, but several reasons exist to use more postemergence herbicides. Phenmedipham (3-[methoxycarbonyl)amino]phenyl(3-methylphenyl)carbamate]) + desmedipham (ethyl[3-[[(phenylamino)carbonyl]oxy]phenyl]carbamate] (as a prepackaged mixture), sethoxydim (2-[1-(ethoxyimino)butyl]-5-[2-ethylthio)propyl]3-hydroxy-2-cyclohexen-1-one], fluazifop ((±)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid), DPX-6202, RE-36290 and SC-1084 were applied alone or in combination for total weed control in sugarbeets. Herbicides were applied at 8.8 gpa with tractor-mounted sprayer to plots 11 by 42.5 ft. Each treatment was replicated four times. Single applications were applied May 31 and double applications on May 21 and 31. Sugarbeets were at the cotyledon to two true-leaf stage on May 21. Phenmedipham + desmedipham (0.5 lb ai/A) in combination with a grass herbicide applied twice, gave excellent (mostly 90% or better) weed control. Antagonism from tank mixtures was only observed with SC -1084 + phenmedipham + desmedipham. late germinating broadleaved weeds, particularly kochia (Kochia scoparia), required an additional application of phenmedipham + desmedipham, but green foxtail (Setaria viridis) and wild oats (Avena fatua) could be controlled with a single application of a grass herbicide. Crop injury occurred from early treatments of phenmedipham + desmedipham at 0.5 lb ai/A but sugarbeets grew out and yielded well. Addition of crop oil to tank mixtures generally increased phytotoxicity to sugarbeets and tended to increase weed control. Sugarbeet yields were only reduced by phenmedipham + desmedipham in combination with SC-1084 or fluazifop with crop oil. The SC-1084 combination treatment reduced yields probably due to weed interference.

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INTERFERENCE IN BARLEY AND PEA MIXTURES

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Abstract. Spring barley (Hordeum vulgare L. cv 'Advance') and long-vined spring peas (Pisum sativum L. cv 'Garfield'), were established in the greenhouse to study the interference between an upright grass species and a tendriling broadleaf species. Pots were arranged to stimulate a field seeded on an 18-cm rowspacing with rows planted to either peas or barley in monoculture or alternate-row mixture. Plant populations were 31 and 62

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plants m^{-2} for pea and barley rows, respectively. Pots containing barley were fertilized with regular Hoagland's solution, while those containing peas were inoculated with a commercial Rhizobium inoculant and fertilized with a low-nitrogen Hoagland's solution. Dry weight of leaves and stems, leaf areas and plant and canopy heights were measured one, two, three, four and six weeks after emergence.

When barley was mixed with peas, barley dry matter production six weeks after emergence was only 70% of the monoculture value, while peas in the mixture had 75% greater dry matter when compared with the pea monoculture. The pea-barley mixture, therefore, fits a type II model for negative interference. More than 90% of the relative decrease in dry weight in barley grown in a mixture with peas was accounted for by decreased stem dry weight. The increased dry weight of peas grown in mixtures was largely due to increased leaf weight, although stem dry weight was also increased.

Differences in dry weights of mixture components with respect to monoculture dry weights occurred between four and six weeks after emergence. During this period, barley structures were subject to tendril attachment by peas causing significant deformation of barley leaves, kinking of stems and entrapment of heads. The number of tendril attachments per barley plant averaged 0.44, 1.06 and 0.24 for leaf, stem and head tissues, respectively.

Leaf area index (LAI) of peas was greater than barley at all sampling times whether in mixture of monoculture and averaged 5.2 and 4.3 for peas and barley, respectively. While greater LAI may have provided peas a competitive advantage for light, the ability of pea tendrils to gain support at the expense of the barley must also be considered a competitive advantage.

WILD OAT CONTROL IN NO-TILLAGE SPRING BARLEY

Joan M. Lish, D.C. Thill and R.H. Callihan[1]

Abstract. Wild oat (Avena fatua L.) is a major weed problem in small grain production in Idaho. The use of both conventional tillage for cultural control of wild oat and soil incorporation of herbicides is restricted in reduced tillage production systems. The responses of wild oat and spring barley (Hordeum vulgare L.) to one pre-emergence and three postemergence herbicides were evaluated in dryland and irrigated no-tillage spring barley in southeastern Idaho. Granular triallate [S-(2,3,3-trichloro-2-propenyl)bis(1-methylethyl)carbamothioate] was applied at 0 and 1.4 kg/ha with a no-tillage drill at the time of planting. Diclofop [(±)-2-(4-(2,4-dichlorophenoxy)phenoxy)propanoic acid], AC-222,293 [(m-Toluic acid,6-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl), methyl ester and p-Toluic acid 2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl) p-toluate)] and difenzoquat (1,2-dimethyl-3,5-diphenyl-1H-pyrazolium) were applied post emergence at 1.12, 0.56, and 1.12 kg/ha, respectively. The experimental design was a randomized complete split block with triallate as main plots. The three postemergence herbicides and a no postemergence treatment checks were the

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subplots. The experiment had four replications and was duplicated. Barley and wild oat height, tiller number and biomass were measured on July 30, and barley grain was harvested on August 22. Treatments did not affect barley height. Wild oat grain yield, tiller number, and biomass, and barley biomass were averaged over locations. AC-222,293 applied alone reduced wild oat grain yield, tiller number and biomass as much as any herbicide combination. Barley yield was higher with AC-222,293 than triallate, diclofop or triallate plus diclofop. Wild oat height, barley tiller number and barley yield were averaged over triallate treatments and locations. Wild oat was shortest in AC-222,293 treated plots. Barley tiller number decreased successively with AC-222,293, difenzoquat, diclofop and the check. Barley grain yield was lowest in the check.

In a second experiment, granular triallate at 1.4 kg/ha was applied to standing stubble 30 and 10 days before no-tillage seeding spring barley. Wild oat tiller number and biomass were approximately 40% of the untreated control with both application dates.

Postemergence wild oat herbicides were compared in a third experiment. Barban [4-chloro-2-butynyl 3-chlorophenylcarbamate] at 0.28 and 0.43 kg/ha, diclofop at 0.84 and 1.12 kg/ha and AC-222,293 at 0.43, 0.57 and 1.112 kg/ha were applied to no-tillage planted spring barley at the 1 to 3 leaf stage of wild oat. Difenzoquat at 0.84 and 1.12 kg/ha was applied at the 4 to 5 leaf stage of wild oat. Wild oat control was best with AC-222,293. Barban and diclofop did not control wild oat. Difenzoquat reduced wild oat vigor early in the season but control was inadequate by August 14. Frost and aphids during kernel fill reduced barley grain yield; however, grain yield was highest with AC-222,293 which indicates no injury to barley.

METSULFURON METHYL - A NEW ALTERNATIVE FOR BROADLEAF WEED CONTROL IN CEREALS AND REDUCED TILLAGE FALLOW

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Abstract. Metsulfuron methyl (2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid) was widely tested during 19844 and 1985 at the proposed use rate of 4.2 g ai/ha on spring and winter cereals and reduced tillage fallow in the Great Plains and certain areas of the Pacific Northwest. In 1984 the majority of tests were replicated hand-plots, while in 1985 emphasis was placed on applications with grower equipment under a Federal Experimental Use Permit (EUP) program.

Results indicate that metsulfuron methyl is effective on the broad spectrum of broadleaf weeds while showing good crop safety. A label is anticipated in time for the 1986 spring application season for the states of Colorado, Kansas, Montana, Nebraska, new Mexico, Texas, Utah, Wyoming and portions of Idaho, North Dakota, Oklahoma and South Dakota.

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[1]E.I. DuPont de Nemours & Company.

Introduction

A need for a low use rate, non-volatile herbicide giving broad spectrum control and good selectivity to small grains is apparent in many of the dryland cereal areas of the western United States. This is readily shown by the rapid acceptance of chlorsulfuron following its introduction in 1983. Unfortunately, chlorsulfuron has not been available to many farmers due to restrictions on soil pH and crop rotation. Also economic considerations have been a deterrent to use by some farmers, especially in areas where yields are generally low.

Metsulfuron methyl, trade name "Ally" herbicide, provides many of the advantages of chlorsulfuron but within a greater soil pH range and with greater rotational crop flexibility.

Materials and Methods

In early 1984 a data review indicated that the best use rate for metsulfuron methyl in small grains and reduced tillage fallow was 4.2 g ai/ha. To verify this hypothesis, replicated tests with hand equipment were installed in the spring of 1984. In the spring of 1985, these tests were supplemented with a large number of field sized trials applied with grower equipment under a Federal EUP program.

The replicated hand plots were applied with either compressed air or CO_2 plot equipment. Randomized complete block designs were used. Treatments were applied broadcast postemergence to both the crop and the weeds. In all cases, a non-ionic surfactant of at least 80% active ingredient was added to the treatment at .25% to .50% v/v.

The EUP trials were applied with a wide variety of grower and commercial aerial application equipment. Generally these tests were not replicated but an untreated check and local standard were included to aid in evaluation.

Visual ratings of percent weed control and crop injury were taken during the season by DuPont investigators. Yield data were gathered with plot combines from the replicated tests and with grower equipment in the EUP tests.

Through the 1985 season, over 100 replicated tests were conducted and evaluated in the Great Plains region, Idaho and Utah testing metsulfuron methyl at 4.2 g ai/ha postemergence on cereals. In addition, 253 in-crop and 67 reduced tillage fallow trials were conducted under the 1985 EUP program.

Results and Discussion

Results of these trials indicated broad spectrum control or suppression of many economically important broadleaf weeds. Weed suppression is defined as a visual reduction in weed competition (reduced population or vigor) as compared to an untreated area. The data also demonstrated the importance of including a surfactant at .25% to .50% v/v as well as thorough coverage of target weeds. Furthermore four to six weeks of residual control was noted with the more sensitive species such as mustards and pigweeds. Finally, season long top growth control of Canada thistle was observed.

Table 1 is a list of weeds controlled or suppressed at 4.2 g ai/ha in cereals.

Table 1. Weeds controlled at 42. g ai/ha

Bittercress	Field pennycress	Prickly lettuce
Blue mustard	Filaree	Russian thistle*
Wild buckwheat*	Flixweed*	Shepherdspurse
Canada thistle*	Henbit	(ladysthumb)
Chickweed (common)	Knotweed (prostrate)	Sowthistle
Conical Catchfly	Kochia*	Common purslane
Corn cockle	Lambsquarters*	Common sunflower*
Corn gromwell*	(common, slimleaf)	Tansymustard*
Cow cockle	Mayweed	Treacle mustard
Dogfennel	Miners lettuce	Tumble mustard
Smallseed falseflax	Pigweed (redroot,	Waterpod
False chamomile	smooth, tumble)	Wild mustard
Fiddleneck tarweed*	Volunteer sunflower	

*may only be suppressed

Crop safety was well established in these trials as indicated by Table 2, which summarizes 61 trials on durum, 60 on barley, 81 on spring wheat and 41 on winter wheat from Montana and the Dakotas. These data were based on visual estimates made early in the season. Significant reductions in yield were not noted in trials where visual injury ratings were less than 20%.

Table 2. Percent injury (0-100; 0=no injury, 100-complete kill) of Cereal crops at various rates of metsulfuron methyl (g ai/ha)

Crop	4.2 (X rate)	8.8 (2X rate)	17.6 (4X rate)
winter wheat	0	1	6
spring wheat	2	4	8
barley	3	4	9
durum	1	8	18

These trials also established that on non-stressed crop plants, metsulfuron methyl at 4.2 g ai/ha could be safely applied any time from the two leaf until just before the boot stage. Optimum results on weed control were achieved by applications made early postemergence to the main flush of actively growing weeds. A surfactant was always included.

Table 3 lists weeds controlled or suppressed by metsulfuron methyl at 4.2 g ai/ha in reduced tillage fallow. In addition, work was done tank-mixing metsulfuron methyl with glyphosate or the glyphosate/2,4-D combination sold under the trademark Landmaster. Good control of both grass and broadleaf species was obtained by these tankmix treatments.

Table 3. Weeds controlled at 4.2 g ai/ha

Wild buckwheat*	Prickly lettuce
Canada thistle*	Common purslane
False chamomile	Russian thistle*
Flixweed*	Volunteer sunflower
Kochia*	Common sunflower*
Lambsquarters (common, slimleaf)	Tansymustard*
Pigweed (redroot, tumble)	Tumble mustard
	Wild mustard

*may only be suppressed

In general, metsulfuron methyl has performed better than the 2,4-D standard. Table 4 compares results of these two treatments on selected hard to control weeds in Montana and the Dakotas.

Table 4. Metsulfuron methyl at 4.2 g ai/ha compared to 563 g ai/ha 2,4-D

Weed	% Control "Ally"	% Control 2,4-D
Wild buckwheat	90	42
Kochia	80	60
Russian thistle	78	62
Common sunflower	75	55
Tansymustard	65	64

In situations where weed size exceeded that for optimum control or adverse environmental conditions existed, improved control was obtained by tankmixes with labeled foliar herbicides such as 2,4-D.

Crop rotational studies have indicated increased flexibility as compared to chlorsulfuron. Proposed guidelines are given in Table 5. Furthermore, metsulfuron methyl use will be permitted on soils up to pH 8.0 as compared to the 7.5 maximum pH restriction for chlorsulfuron in northern areas.

Table 5. Rotational intervals following 4.2 g ai/ha metsulfuron methyl

Crop	Minimal Interval (Months)
Winter/spring wheat	1
Durum wheat, barley, proso millet*, oats, dryland grain sorghum*	10
Dryland corn, flax, safflower, sunflower	22
All other crops	34 or more, do field bioassay

*In Montana, North Dakota, South Dakota and northern Wyoming, the interval is 22 months for these crops.

Conclusion

Extensive testing of metsulfuron methyl during 1984 and 1985 in both crop and reduced tillage fallow have demonstrated that 4.2 g ai/ha is the ideal use rate for this compound. Good control of a wide range of broadleaf weeds was obtained along with good crop safety. Rotational studies have also confirmed improved crop rotation flexibility and safety on higher pH soils than are permitted with chlorsulfuron.

Based on these and other data, DuPont has submitted to the EPA for a label permitting the use of metsulfuron methyl on land dedicated primarily to the production of wheat (including durum) and barley in the states of Colorado, Kansas, Montana, Nebraska, New Mexico, Texas, Utah, Wyoming and portions of Idaho, North Dakota, Oklahoma and South Dakota. Registered uses will be as a spring postemergence treatment in wheat or barley or in reduced tillage fallow as either a post harvest or spring (during fallow) treatment. The label is expected to issue before the 1986 use season.

PRONAMIDE AND COMBINATIONS FOR THE CONTROL OF ANNUAL GRASSES IN CHEMICAL FALLOW IN THE INTERMOUNTAIN AREA

Jim Klauzer and Tom Tillett[1]

Pronamide (3,5-dichloro)N-1,1-dimethyl-2-propynyl)benzamide) at rates of 0.38 lb. ai/acre and above provided adequate annual grass control A combination of Pronamide (0.25 to 0.38 lb ai) with chlorsulfuron (2-chloro-N[[(4-methoxy-6-methyl-1,3,5-triazin-2yl)amino]carbonyl]benzene-sulfonamide) (0.12 lb. ai) per acre provided control of all major weed species in fallow in the intermountain area. A combination of pronamide with metsulfuron methyl (2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino] carbonyl]amino]sulfonyl]benzoic acid) also provided control of most of the major weeds in fallow.

Pronamide applied alone required 0.38 lb. ai/acre or greater to consistently provide adequate annual grass control. In many of the tests in which pronamide was applied alone, the broadleaf weeds were released. Pronamide provides adequate grass control; however, many growers would be dissatisfied with the overall weed control.

A combination of pronamide and chlorsulfuron provided excellent control of all major annual grasses and annual broadleaf weeds. The tankmix improved consistency of annual grass control at the lower rate of pronamide (0.25 lb/ ai/acre). This treatment was superior to all other treatments for overall weed control. Many of the broadleaf weeds were only controlled by the pronamide tankmix combination with chlorsulfuron. Chlorsulfuron is well accepted in much of the intermountain area as most growers do not rotate and do not consider the residual effects of chlorsulfuron to be detrimental. The combination is, therefore, well suited for chemical fallow in the intermountain area.

The tankmix with oxyfluorfen (2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene) did not provide any more control than the same rate of pronamide alone for annual grasses or broadleaf weeds. The control of tansy mustard with this combination was improved. The influence of early

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burn down that was observed with the addition of oxyfluorfen did not increase the final control observed in the spring.

Conclusion

Annual Grass Control. Pronamide is effective for the control of several annual grasses which are of major importance in the intermountain area. Pronamide alone requires .38 lb. A.I./acre to provide economic (>95%) control. This can be attributed to the climatic conditions found in the intermountain area. The rainfall in much of the intermountain area is quite variable. Under these conditions a pronamide rate of 0.38 lb. A.I./acre is required for consistent control of the grasses. The addition of chlorsulfuron at 0.12 lb. A.I./acre (1/4 ounce of product), with pronamide at both the .25 and .38 lb. A.I./acre rates, appears to improve grass control. This increase in consistency is needed for acceptance by growers in the intermountain area.

Annual Broadleaf Control. Pronamide was ineffective for the control of all of the annual broadleaf weeds evaluated. Again, the combination of pronamide + chlorsulfuron was superior for control of most of the common broadleaves. This combination was consistently the most effective treatment in controlling the broad spectrum of weeds in the intermountain area. The combination of pronamide and metsulfuron methyl provided good control of many of the weeds.

Time of Application. Applications of pronamide made between October 1 and November 1 provided the most consistent grass control. Earlier applications were not as effective due to soil temperatures above 55° F and later applications did not have maximum benefit of rainfall based on precipitation probabilities. October applications therefore appear optimum based on soil temperatures and annual rainfall patterns.

At the present, many progressive growers are looking forward for novel ways to reduce costs and erosion. They recognize that stubble traps more snow and reduces erosion than worked or undercut fields. They also see that standing stubble often becomes infested with volunteer cereals and/or downy brome that utilize the stored moisture that is needed for the wheat crop. Chemical fallow is on the increase in the intermountain area with larger growers leading the way. In summary pronamide or a pronamide tankmix combination with chlorsulfuron is suited for large part of the intermountain area's chemical fallow.

Synopsis of Overall Evaluations of Pronamide in the Intermountain Region for Chemical Fallow Weed Control up until June 1

WEED	Pronamide (lb. A.I./Acre) .25	.38	.50	.75	Pronamide + Chlosulfuron .25 + .012	Pronamide + Chlorsulfuron .38 + .012	Pronimide + Oxyfluorfen .38 + .012
Volunteer Wheat	P	E	E	E	E	E	E
Downy Brome	P	G	E	E	E	E	E
Wild Oats	P	P	P	P	P	E	P
Persian Darnel	P	P	P	P	P	E	P
Tansy Mustard	P	P	P	P	E	E	P
Wild Buckwheat	P	P	P	P	E	E	P
Kochia	P	P	P	P	E	E	P
Russian Thistle	P	P	P	P	E	E	P
Lambsquarter	P	P	P	-	E	E	P
Prickly Lettuce	P	P	P	-	E	E	P
Cutleaf Nightshade	P	P	-	-	-	P	G
Field Pennycress	P	P	P	-	-	E	P

P = Poor (<89% overall)
G = Good (90%-94% overall)
E = Excellent (>95% overall)
\- = No Data on Weed

COMPETITIVE INTERACTIONS OF ANZA WHEAT AND WILD OATS UNDER IRRIGATED CONDITIONS IN SOUTHERN CALIFORNIA

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Abstract. An interactive comparison of wheat (*Triticum aestivum* L.) and wild oats (*Avena fatus* L.) in Riverside, California, showed that their phenological development was similar when grown alone or in mixed populations. The Haun scale proved to be a good estimator for the phenological development of both species. Substituting degree days for the time scale improved the fit of the Haun scale when two dates of planting were compared. A wild oat removal study showed that the most critical time for interaction of the two species was between stem elongation and flowering.

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PERFORMANCE OF TRIALLATE AS INFLUENCED BY INCORPORATION WITH VARIOUS PIECES OF TILLAGE EQUIPMENT

D.K. Ryerson[1]

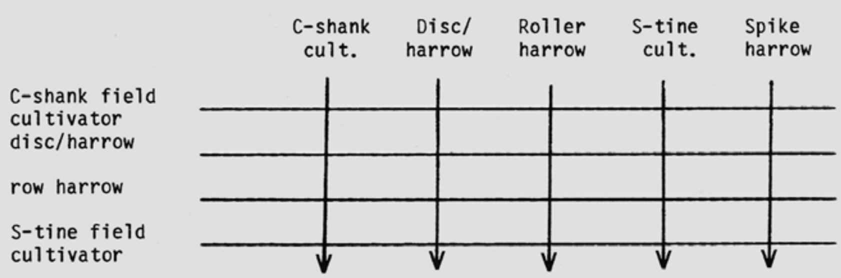
Introduction

Wild oats (*Avena fatua* L.) can be effectively controlled with triallate [S-(2,3,3-trichloroallyl) dissopropylthiocarbamate] a preemergence herbicide, widely used in cereal grains and broadleaf crops. The product should be soil applied and incorporated by two passes from a tillage implement for best results. The recent trend toward reducing tillage operations for the production of small grains led to the establishment of these experiments. The objective of these trials was to evaluate the performance of triallate as influenced by the use of various tillage implements.

Materials and Methods

Trials were established in sprinkler irrigated fields with a silt loam soil type. Wild oat populations were uniform over the trials areas, varying between 60 to 400 wild oats per square meter (just prior to harvest) depending on trial location. Trials evaluating the granular formulation (Far-Go 10G) were established in May 1983 and 1984 preplant incorporated to spring barley. Applications were made with a Barber granular applicator at the rate of 1.68 kg/ha triallate. Trials evaluating the liquid formulation (Far-Go EC) were established in May 1984 and May 1985. Applications were made preplant incorporated to spring barley (1984 and 1985) and spring wheat (1985) at 1.4 and 1.12 kg/ha triallate respectively. Applications were made over 3 to 4 ha blocks and immediately followed by incorporation treatments with different tillage implements. Plots design for these trials are represented schematically below:

GRANULAR TRIALS (1983, 1984)



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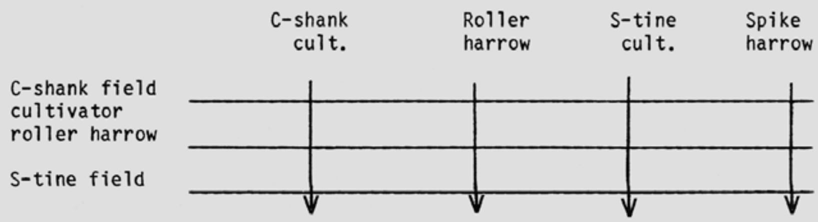
[1]Monsanto Agricultural Products Co., Twin Falls, ID.

LIQUID TRIALS (1984, 1985)



This incorporation scheme resulted in treatments where the performance of the triallate could be evaluated with one pass incorporation and two pass incorporation with the various implements and implement combinations.

Results

Results from the granular trials indicated that incorporation of the triallate utilizing any of the implements tested for the first pass, followed by a second pass with a roller harrow or spike harrow resulted in the best overall wild oat control. (Table 1)

TABLE 1. Percent Wild Oat Control from Liquid Formulation as Influenced by Incorporation with Various Pieces of Tillage Equipment, 1983, 1984

		C-shank cult.	disc/ harrow	S-tine cult.	roller harrow	spike harrow
		------------------	% Wild Oat Control	-------------------		
C-shank field cultivator	73	70	63	70	80	85
disc/harrow	76	67	55	63	83	83
S-tine field cultivator	72	67	74	69	80	78
roller harrow	74	65	67	70	85	84

1. Application Rate 1.68 kg/ha triallate (average of two locations, crop spring barley.

Results from the liquid formulation trials indicate that one pass incorporation with C-shank field cultivators resulted in superior performance compared to one pass with a roller harrow or S-tine field cultivator. Performance of the liquid formulation tended to improve with two pass incorporation with the various implement combinations (Table 2).

Table 2. Percent Wild Oat Control from Liquid Formulation as Influenced by Incorporation with Various Pieces of Tillage Equipment, 1984, 1985.

	--	C-shank cult.	Roller harrow	S-tine cult.	Spike harrow
	------------------% Wild Oat Control-------------------				
C-shank field cultivator	85	94	91	85	91
roller/harrow	74	83	88	81	82
S-tine field cultivator	63	85	85	85	88

1. Average of three trials. Two spring barley trials with liquid triallate applied at 1.4 kg/ha and one spring wheat trial applied at 1.12 kg/ha.

Discussion

One pass incorporation of the granular formulation should not be recommendation for commercial use. The improvement in wild oat control with two pass incorporation when a second pass was made with a roller harrow or spike harrow is interesting. This occurrence can probably be explained by the fact that these implements left the seed bed in a firmer condition and allowed better granular to soil contact. This probably resulted in a faster release of the triallate from the clay carrier and increased performance. A delay of three to five days after the first incorporation before making a second incorporation may result in similar wild oat control with any of the implement combinations tested.

With the exception of the C-shank field cultivators with sweeps, no implement provided satisfactory incorporation of the liquid formulation to give commercially acceptable wild oat control with one pass. The use of drag harrow attachments behind the various implements should be evaluated to determine if they would provide acceptable incorporation of the liquid formulation with one pass. At the present time, it appears that for optimum performance of the liquid formulations, two pass incorporation should continue to be recommended.

CGA-131036: A NEW HERBICIDE FOR SMALL GRAIN CROPS

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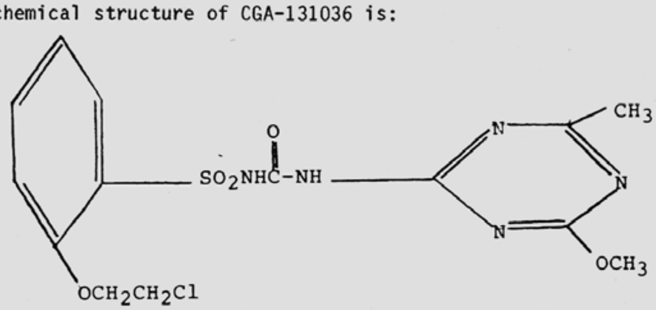
Abstract. CGA-131036 (N-(6-methoxy-4-methyl-1,3,5-triazin-2-yl-aminocarbonyl)-2-(2-chloroethoxy)-benzenesulfonamide) is a new selective, broad spectrum herbicide that is being developed by CIBA-GEIGY Corporation for small grain crops. It is completely safe on wheat and barley and controls many of the weeds in these crops. For the most consistent control, it is being used early postemergence with an adjuvant. Combinations with other small grain herbicides are being evaluated to broaden the spectrum of control.

Introduction

CGA-131036 is a new sulfonylurea herbicide that was synthesized by CIBA-GEIGY Corporation and first evaluated in the field in 1982. Since then, CGA-131036 has been tested throughout the world and is in full development for selective weed control in wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), and turf, and for industrial weed control. On April 30, 1985, a U.S. patent was issued. The development schedule on wheat and barley is for an experimental use permit in 1987 and 1988, submission for full registration in April, 1987, and first sales in October, 1988.

Chemical and Physical Properties

The chemical structure of CGA-131036 is:



The proposed common name is trisulfuron, and the registered trade name is Amber. The active ingredient is a colorless, odorless crystalline solid with a melting point of 186 C. The vapor pressure is 7.5 X 10^{-3} Torr at 20 C. The solubility in water depends on the pH. As the pH is increased, the solubility increases.

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[1]CIBA-GEIGY Corporation, Citrus Heights, CA 95610

pH	Solubility in ppm at 20 C
2.5	5
5.0	40
7.0	1,500
8.0	10,000

The current formulation is 20WDG (water dispersible granular). However, this will be changed to a more concentrated formulation in the future.

Toxicological Properties. Toxicologically, CGA-130136 is a very safe herbicide. The following are the results of some short-term tests:

Acute oral LD_{50} (Rat): >5000 mg/kg

Acute dermal LD_{50} (Rat): >2000 mg/kg

Eye Irritation (Rabbit): Non-irrigating

No unusual findings in 90-day studies

Ames Test: Negative

Other tests are in progress.

Mechanism of Action: CGA-131036 is rapidly taken up by both the foliage and roots. It is translocated to the growing points where it inhibits growth of the meristems. Currently, tests are being conducted to determine the precise mechanism and metabolism.

Behavior in Soil. CGA-131036 has a low adsorption rate in the soil. Its main process of decomposition is both hydrolytic and microbial. Photodecomposition and volatilization are not significant processes in the breakdown of CGA-131036. Half-life studies have resulted in variable results with a range from four to twelve weeks. Degradation increases with higher temperature, high soil moisture and low soil pH. Because of its residual activity and a high sensitivity of many broadleaf crops to low rates of CGA-131036, crop rotation restrictions are expected.

Selectivity. Wheat and barley have excellent tolerance to CGA-131036 at rates of 5 to 60 g/ha with or without an adjuvant applied postemergence between the second leaf and just before the "boot" stage. The following adjuvants were tested with CGA-131036: X-77 (non-ionic) at 0.25, 0.5 and 1.0 percent by volume; Compex (anionic) at 0.25 and 0.5 percent by volume; ethomeen T/25 (cationic) at 0.25 and 0.5 percent by volume; Atplus 411F (crop oil concentrate) at 0.25 percent by volume; Unite (compatibility agent) at 0.25 and 0.5 percent by volume; Agridex (crop oil concentrate) at 2.3 and 4.7 L/ha; soybean oil concentrate at 1.2 and 2.3 L/ha; and soybean oil at 2.3 and 4.7 L/ha.

No significant phytotoxicity has been noted in any tests.

Weed Control. CGA-131036 is highly active both preemergence and postemergence on a broad spectrum of weeds that occur in wheat and barley. The main emphasis has been on postemergence applications. However, since many of the early postemergence applications are also preemergence to some of the weeds, the residual activity of CGA-131036 has controlled susceptible species preemergence. There are some indications that certain weeds may be easier to control preemergence than postemergence.

Tables 1, 2 and 3 list the weed response to postemergence applications of CGA-131036 at 5 to 40 g/ha plus an adjuvant. As more is learned about the use of CGA-131036, the control of some weeds may improve.

Three tests from the West will be described to illustrate different aspects of control.

Materials and Methods

Two tests were conducted at Pendleton, OR, on winter wheat to evaluate control with and without an adjuvant, different adjuvants, rates of an adjuvant and weed size at application. The soil was a slit loam with 3 percent organic matter and a pH of 5.9. The mechanical soil analysis was 14.8 percent sand, 70 percent silt and 15.2 percent clay. Stephens winter wheat was planted on October 15, 1984. The plots were 1.8 x 6 m and replicated three times in a randomized complete block. The first test was applied April 18, 1985, when the wheat was 7.5 to 15 cm high and the blue mustard rosettes were 1.3 to 10 cm in diameter. The second test was applied April 18, 1985, when the wheat was 25 to 30 cm high and the blue mustard varied from rosettes 3.8 cm in diameter to flowering plants 20 cm high. Applications were made with a CO_2 sprayer delivering 280 L/ha of spray at 207 kPa.

A test was conducted at Reedley, CA, with low rates of CGA-131036 alone and in combination with three commonly used postemergence small grain herbicides. The purpose of this test was to improve the weed control spectrum and to use as low rates as possible of CGA-131036. The soil was a sandy loam with 0.9 percent organic matter and a pH of 7.1. The mechanical soil analysis was 64 percent sand, 27.2 percent silt and 8.8 percent clay. W-911 wheat was planted on November 8, 1984. The plots were 3 x 9 m and replicated three times in a randomized complete block. The test was treated January 1, 1985, when the wheat was 13 to 15 cm high, coast fiddleneck 8 to 10 cm high, desert rockpurslane 2 to 5 cm high and wild radish rosettes 5 to 10 cm in diameter. The herbicides were applied with a compressed air plot sprayer delivering 187 L/ha of spray at 241 kPa. Amine formulations were used of both MCPA and 2,4-D.

Results and Discussion

Table 4 gives the weed control results from the two tests conducted at Pendleton, OR, at the same location. Both applications showed an advantage of adding an adjuvant, especially at the lower rates. All of the adjuvants were qual except for Unite, which was slightly weaker. There was no advantage to doubling the amount of X-77. The earlier application provided better control. Other tests confirm these results: for best control, an adjuvant should be used with CGA-131036, and the application should be made while the weeds are still small.

Table 1. Weeds Controlled at 5 to 40 g/ha Postemergence.

Annual Sowthistle (Sonchus oleraceus L.#[2]SONOL)
Ball Mustard [Neslia paniculata (L.) Desv. #NEAPA]
Blue Mustard [Chorispora tenella (Pallas) DC. #COBTE]
Bouncingbet (Saponaria officinalis L.#SAWOF)
Bull Thistle [Cirsium vulgare (Savi) Tenore #CIRVU]
Buttercup (Ranunculus sp.)
California Burclover (Medicago polymorpha L.#MEDPO)
Carolina Geranium (Geranium carolinianum L.#GERCA)
Coast Fiddleneck (Amsinckia intermedia Fisch. and Mey. #AMSIN)
Common Chickweed [Stellaria media (L.) Vill. #STEME]
Common Groundsel (Senecio vulgaris L.#SENVU)
Common Mallow (Malva neglecta Wallr. #MALNE)
Common Ragweed (Ambrosia artemisiifolia L.#AMBEL)
Common Sunflower (Helianthus annuus L.#HELAN)
Cornflower (Centaurea cyanus L.#CENCY)
Corn Gromwell (Lithospermum arvense L.#LITAR)
Corn Spurry (Spergula arvensis L.#SPRAR)
Cuckoo Bittercress (Cardamine pratensis L.CARPR)
Cudweed (Gnaphalium sp. #GNA)
Cutleaf Eveningprimrose (Oenothera laciniata Hill EOEOLA)
Curly Dock (Rumex crispus L.#RUMCR)
Dandelion (Taraxacum officinale Weber #TAROF)
Desert Rockpurslane [Calandrinia ciliata (R. and P.) DC. Var menziesii (Hook) Macbr. #CLNCM)
Fleabane (Erigeron sp.)
Flixweed [Descurainia pinnata (Walt.) Britt. #DESPI]
Field Pennycress (Thlaspi arvense L.#THLAR)
Forget-me-not (Myosotis micrantha Pall. ex Lehm. #MYOMI)
Hedge Mustard [Sisymbrium officinale (L.) Scop. #SSYOF]
Knawel (Scleranthus annuus L.#SCRAN)
Kochia [Kochia scoparia (L.) Schrad. #KCHSC]

[2]Letters following this symbol are a WSSA-approved computer code from Important Weeds of the World, 3rd ed., 1983.

London Rocket (Sisymbrium irio L.#SSYIR)
Marshelder (Iva xanthifolia Nutt. #IVAXA)
Mouseear Chickweed (Cerastium vulgatum L.#CERVU)
Musk Thistle (Carduus nutans L.#CRUNU)
Prickly Lettuce (Lactuca serriola L.#LACSE)
Purple Deadnettle (Lamium purpureum L.#LAMPU)
Redroot Pigweed (Amaranthus retroflexus L.#AMARE)
Russian Thistle (Salsola iberica Sennen and Pau #SASKR)
Shepherdspurse [Capsella bursa-pastoris (L.) Medik. #CAPBP]
Skeletonleaf Bursage (Ambrosia tomentosa Nutt. #FRSTO)
Smartweeds (Polygonum sp.)
Smooth Catsear (Hypochoeris glabra L.#HRYGL)
Smooth Pigweed (Amaranthus hybridus L.#AMACH)
Tall Hedge Mustard (Sisymbrium loeselii L.#SSYLO)
Tansymustards (Descurainia sp.)
Toadflax (Linaria sp.)
Tumble Mustard (Sisymbrium altissimum L.#SSYAL)
Velvetleaf (Abutilon theophrasti Medik. #ABUTH)
Virginia Pepperweed (Lepidium virginicum L.#LEPVI)
White Clover (Trifolium repens L.TRFRE)
Whitlowgrass (Draba sp.)
Wild Buckwheat (Polygonum convolvulus L.#POLCO)
Wild Mustard (Sinapis arvensis L.#SINAR)
Wild Garlic (Allium vineale L.#ALLVI)
Wild Radish (Raphanus raphanistrum L.#RAPRA)
Violets (Viola sp.)

Table 2. Weeds partially controlled at 5 to 40 g/ha postemergence.

Canada Thistle [Cirsium arvense (L.) Scop. #CIRAR]
Catchweed Bedstraw (Galium aparine L.#GALAP)
Common Lambsquarters (Chenopodium album L.#CHEAL)
Foxtails (Setaria sp.)
Henbit (Lamium amplexicaule L.#LAMAM)
Mayweed Chamomile (Anthemis cotula L.#ANTCO)
Morningglory (Ipomoea sp. #IPO)
Redstem Filaree [Erodium circutarium (L.) L'Her. ex Ait.#EROCI]
Ryegrass (Lolium sp.)
Sida (Sida sp.)
Speedweed (Vernonica sp.)
Windgrass [Apera spica-venti (L.) Beauv.]

Table 3. Weeds not controlled at 5 to 40 g/ha postemergence.

Annual Bluegrass (*Poa annua* L.#POAAN)
Black Nightshade (*Solanum nigrum* L.#SOLNI)
Cheat (*Bromus secalinus* L.#BROSE)
Downy Brome (*Bromus tectorum* L.#BROTE)
Field Bindweed (*Convolvulus arvensis* L.#CONAR)
Sedges (*Cyperus* sp.)
Volunteer Barley (*Hordeum vulgare* L.#HORVX)
Volunteer Wheat (*Triticum aestivum* L.)
Wild Oats (*Avena fatua* L.AVEFA)

Table 4. Control of blue mustard with CGA-131036 at Pendelton, OR

Herbicide Treatment	Rate of Application (g/ha)	(% v/v)	Weed Control Blue Mustard Treated Rated 3/20/85[a] 5/23/85	4/18/85[b] 5/23/85
CGA-131036	15		73	77
CGA-131036	25		88	83
CGA-131036 + X-77	10	+ 0.25	92	77
CGA-131036 + X-77	15	+ 0.25	97	94
CGA-131036 + X-77	25	+ 0.25	100	94
CGA-131036 + X-77	40	+ 0.25	100	93
CGA-131036 + X-77	15	+ 0.5	98	92
CGA-131036 + X-77	25	+ 0.5	100	96
CGA-131036 + Atplus 411F	25	+ 0.25	99	92
CGA-131036 + Compex	25	+ 0.25	99	92
CGA-131036 + Ethomeen T/25	25	+ 0.25	100	88
CGA-131036 + Unite	25	+ 0.25	90	83
Check			0	0

[a]Blue Mustard was in 1.3 to 10 cm diameter rosettes.
[b]Blue Mustard was in 3.8 cm diameter rosettes to 20 cm high and flowering.

Table 5. Control of coast fiddleneck, desert rockpurslane and wild radish with CGA-131036 and combinations at Reedley, CA.

Herbicide Treatment	Rate of Application	Weed Control Coast Fiddleneck	Desert Rockpurslane	Wild Radish	Yield[a]
	(g/ha)	-------	%	-------	(kg/ha)
CGA-131036	5	78	68	73	4308 bcde
CGA-131036	15	89	72	79	5289 ab
CGA-131036 + Dicamba	5 + 138	80	53	74	4543 bcde
CGA-131036 + Dicamba	15 + 138	87	63	83	4254 bcde
CGA-131036 + MCPA	5 + 138	93	71	86	5114 ab
CGA-131036 + MCPA	15 + 138	95	78	90	5772 a
CGA-131036 + 2,4-D	5 + 138	60	33	68	4543 bcde
CGA-131036 + 2,4-D	15 + 138	85	65	75	4986 ab
CGA-131036 + Bromoxynil	5 + 138	98	88	93	4852 abcd
CGA-131036 + Bromoxynil	15 + 138	100	93	94	4906 abc
Dicamba	138	50	30	30	4173 bcde
MCPA	138	7	7	13.3	3548 e
2,4-D	138	13	16	17	3756 de
Bromoxynil	138	65	55	55	5161 ab
Check		0	0	0	3783 cde

[a]Yields followed by the same letter are not significantly different at the P<0.05 level.

Low rates of CGA-131036 alone provided marginal to good control of all three weed species in the test conducted in Reedley, CA, (Table 5). If an adjuvant had been used with CGA-131036, the control would have been better. The control with dicamba, MCPA, 2,4-D and bromoxynil alone was poor to fair. The control of all three weeds was improved with the combinations of CGA-131036 plus bromoxynil and CGA-131036 plus MCPA over either herbicide alone. The combinations of CGA-131036 plus dicamba and CGA-131036 plus 2,4-D improved control over dicamba or 2,4-D alone but not over CGA-131036 alone.

Based on this and other tests, it is obvious there are advantages to combinations for some weeds. This is especially true of weeds on which CGA-131036 only provides partial control.

Research for the Future. More research is needed to better define the weed spectrum, the lowest rates needed for good weed control for each situation, combinations with other herbicides, the factors for optimum weed control and the factors influencing soil residual.

CHLORSULFURON AND METSULFURON CARRYOVER IN GRAIN AND FORAGE SORGHUM

P.W. Stahlman

Abstract. Studies were conducted for two years near Hays, Kansas to determine if grain and forage sorghums (*Sorghum bicolor* L. Moench) could be grown successfully on land treated the previous fall with either chlorsulfuron (2-chloro-*N*-[[(4-methoxy-6-methyl-1,3,5-triazin-2yl)-amino]carbonyl]benzenesulfonamide) or metsulfuron (2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2yl)amino]carbonyl]amino]sulfonyl]benzoic acid). The herbicides were applied to two soils (pH 6.8 and pH 7.8) in late September, 1984, and late October, 1984, at rates of 0, 1.9, 2.9, 3.8 and 4.3 g ai/ha. The sorghums were planted the following June. Neither herbicide reduced crop stands, but both chlorsulfuron and metsulfuron suppressed early growth of grain and forage sorghum and delayed flowering of the grain sorghum both years of the study, moreso on the higher pH soil. Both grain and forage yields were not reduced significantly.

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[1]Fort Hays Branch, Kansas Agricultural Experiment Station, Hays.

RECROPPING AFTER CHLORSULFURON USE

C.C. Reyes and R.L. Zimdahl[1]

The effect of chlorsulfuron (2-chloro-*N*-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)-amino]carbonyl]benzenesulfonamide) on beans (*Phaseolus vulgaris* L.), barley (*Hordeum vulgare* L.), corn (*Zea mays* L.), sugarbeets (*Beta vulgaris* L.), and sunflower (*Helianthus annuus* L.) planted for two (Study II) or three (Study I) years after application (yaa) was determined.

Two replicated, randomized block design field studies were initiated at Fort Collins, CO, on a Weld clay loam soil with a pH of 7.5. On June 1, 1981, chlorsulfuron was applied to 12 to 25 cm tall barley in Study I. In Study II chlorsulfuron was applied on October 5, 1982, to bare soil. The same cultural practices were employed for both studies. One season after application, the five crops were planted, and the plots were rototilled 7.6 cm deep between seasons. During subsequent seasons, each crop was planted on the row it occupied the previous season. Immature (six- to eight-week-old) dry crop weight was determined each season for yield comparison. In 1984, lentils (*Lens esculenta* Moench. J.), which are sensitive to chlorsulfuron, replaced barley in both studies. In 1985, corn and lentils replaced the five crops in both studies.

In Study I, chlorsulfuron applied at 70.0 g ai/ha caused in both studies, 1 or 2 yaa,;however, it injured lentils 3 yaa. Sunflower and beans were injured by 8.75 and 17.5 g ai/ha, respectively, 1 yaa; however, neither crop was injured by 70.0 g ai/ha 2 yaa. Corn and sugarbeets were injured by

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[1]Weed Research Laboratory, Colorado State University, Fort Collins, CO.

8.75 g 1 yaa and by 17.5 g 2 yaa. Three yaa, neither crop was injured. In Study II, barley injury was not observed 1 yaa at 70.0 g ai/ha. Two yaa the lentils were injured at 35 g ai/ha. One yaa, corn, sunflower and sugarbeets were injured by 17.5 g. No injury was observed in corn and lentils planted during 1985 in either study. When compared to Study I, Study II suggested that a higher rate and shorter recrop time would not result in injury. The difference was attributed to the additional rainfall (+17.0 cm) that occurred during the first year of Study II. The results suggest that more moisture increases the rate of chlorsulfuron degradation and crop safety.

DPX-F5384: A NEW, HIGHLY FLEXIBLE, BROAD-SPECTRUM HERBICIDE FOR CALIFORNIA RICE

J.L. Pacheco and C.L. Pope[1]

Abstract. "Londax" herbicide (formerly DPX-F5384), Methyl 2-[[[[[(4,6-dimethoxypyrimidin-2-yl)amino]carbonyl]amino]sulfonyl]methyl]benzoate, is a new sulfonylurea herbicide being developed for paddy rice in Asia, Australia, Europe, South America, North American and, in particular, California. Studies have shown this compound provides residual control of most annual and perennial broadleaf weeds and sedges at low use rates under continuously flooded conditions. Application flexibility has proven to be extraordinary with timing as broad as 1-2 LSR (leaf stage of rice) to 4-5 LSR.

Extensive field trials have been carried out in the Sacramento Valley of California where "Londax" has been used at rates of .66 - 1.0 oz. ai/ac (46-70 gm ai/ha) in conjunction with, or as a sequential treatment to grass herbicides (i.e., Molinate, Thiobencarb). Greater than 90% control has been achieved on important weed species such as barnyardgrass (*Echinochloa crus-galli*), bearded sprangletop (*Leptochloa fascicularis*), roughseed bulrush *Scirpus mucronatus*), smallflower umbrellaplant (*Cyperus difformis*), California arrowhead (*Sagittaria montevidensis*), ducksalad (*Heteranthera limosa*), purple ammannia (*Ammannia coccinea*), and others.

Introduction

Economic weed infestation continues to be a serious challenge in all rice (*Oryza sativa*) producing areas of the world. In California, the weed problems associated with aquatic culture began in 1912, the year after commercial rice culture was introduced. This method of seeding rice into continuously flooded fields was developed in the early 1920's to reduce severe infestation of barnyardgrass (*Echinochloa crus-galli*) var. *crus-galli*), a major problem in drill seeded rice production. This cultural practice change led to new weed problems that were unknown or unimportant. Weeds that became established and of economic importance after the change to to the water-seeding method included common marsh plants such as, smallflower umbrellaplant (*Cyperus difformis*), roughseed bulrush (*Scirpus*

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[1]E.I. DuPont de Nemours & Co., Menlo Park, CA and Rice Researchers, Inc., Glenn, CA.

mucronatus), California arrowhead (Sagittaria montevidensis), purple ammannia (Ammannia coccinea) and ducksalad (Heteranthera limosa).

The cultivation of rice in California is made possible only by an aggressive weed control program. it has been estimated that 7-10% of the rice cultural costs are invested in weed control. Additional emphasis must now be made on effective weed control because the current transition from taller to semi-dwarf varieties has reduced the effectiveness of rice competition with weeds. This is primarily a result of decreased shading due to the shorter rice stature and shallow water culture (3-6 inches in depth) which favors both an adequate rice stand and rapid weed growth. There is no weed control method suitable in all situations primarily because of the variation in growth habits and life cycle of sedges and broadleaf weeds. Nevertheless, it is becoming apparent that a combination of both cultural and chemical practices is more effective in controlling weeds in rice than either practice used alone. A prime example of this is that water management during the early growth stages of rice is recognized as a major factor in weed control.

The main objective in controlling weeds is to provide favorable conditions for maximum growth of rice. MCPA (2 methyl-4-chlorophenoxy acetic acid), a selective, translocated herbicide, can be phytotoxic to rice plants, particularly at early growth stages and at high or low temperatures (1). Bentazon (3-isopropyl-1 H-2,1,3,-benxothiadiazin-4(3H)-one 2,2,-dioxide) a selective, translocated herbicide formulated as a sodium salt is most effective when applied early in the growing season, does not cause phytotoxic expressions in rice but requires water to be removed so that weeds can be exposed for treatment. This water removal encourages new grass and broadleaf weed seed germination. Previous work has demonstrated that both MCPA and Bentazon can effectively control broadleaf weeds when the environmental factors are favorable. Each, however, has certain limitations that restrict its effectiveness.

"Londax" Herbicide (formerly DPX-F5384), a new sulfonylurea herbicide being developed by E.I. DuPont de Nemours & Company, Inc., shows excellent activity for the control of a wide range of broadleaf weeds and sedges under rice paddy conditions and may have certain advantages over both MCPA and Bentazon.

"Londax" appears to be an improvement over MCPA in that it effectively controls a broad range of weed species at different stages of growth, expresses minimal or no phytotoxic responses in rice and provides exceptional residual weed control. In addition, "Londax" appears to perform equal to or better than Bentazon in controlling both smallflower umbrellaplant (Cyperus difformis) and roughseed bulrush (Scirpus mucronatus), yet can be applied in flooded paddy fields as early as the 1-2 leaf stage of rice (LSR). Early applications minimize rice-weed competition thus facilitating stand establishment. Moreover, this eliminates the need to remove or lower water from the flooded fields as is needed with Bentazon or MCPA.

Materials and Methods

In 1985, field trials were conducted in direct seeded rice in the Sacramento Valley of California. Randomized complete block designs with four replications were used. Plot size was 20 ft. x 40 ft. Each plot was set up with the capability of being fed by an inlet ditch or drained by an outlet ditch. A warming basin was used to warm the frigid water before entering the inlet ditches and plots. Rice boxes were used within the inlet ditches, if needed, to regulate water depth in the ditch so that syphon tubes or spillways could be used, if necessary, to bring water from the inlet ditch to the plots and maintain desired water depths. Depth stakes were installed in the centers of the plots to monitor water depth. Levees were constructed with a tractor and border disk 6 ft. wide and 18-24 inches high from the base of the borrow pit. Levees were built high and wide for five reasons. First, to maintain the integrity of water/treatments from plot to plot for purposes of efficacy evaluations and residue monitoring. Secondly, so that paddy water could be kept at levels commonly used for rice production (3-6 in.). Thirdly, so that individual plots could be lowered or drained for MCPA or Bentazon + Oil applications without affecting the water in other treated plots. Fourth, so that plots could be refilled with water individually; and finally, so that a tractor and blade could be used to knock down levees to facilitate harvest.

In trial number one, at Rio Oso, Sutter Co. and trial two at Delevan, Colusa Co., Molinate 10G was applied over the entire test area by a commercial aerial applicator at 1-2 LSR/9-10 days after seeding (DAS) at the rate of 64.0 oz. ai/ac (4486 g ai/ha) for grass control. In trial number three, at Ord Bend, Glenn, Co., Thiobencarb 10G or Molinate 10G treatments were hand applied at 2 LSR/10 DAS.

In all trials, "Londax" 10W, Bentazon 4E + Oil and MCPA 4E were applied with a two-man 20 ft. boom, CO_2 plot sprayer at 20 GPA and 30 PSI.

In trials one and two, weed control results, expressed as percent (%) control, were determined for each species by a visual assessment versus an untreated check where 0 = no control and 100 = complete control.

In trial number three, weed control results, expressed as percent (%) control, were determined for each species based on density measurement ($\overline{x}/m^2$) of surviving plants versus the untreated check.

In all three trials, crop response ratings were made with visual assessments versus the untreated check where 0 = no visible stunting/stand reduction and 100 = total loss of crop.

Yields were also taken from each trial. Yield data is presented with standardized moisture content of 14%

These trials were designed to evaluate "Londax" flexibility in the timing of applications, to evaluate weed control and crop safety, to monitor paddy water and soil residues after applications, and to take soil residues, crop residues and yields at harvest.

Results and Discussion

In trial number one, sequential treatments of Molinate 10G and "Londax" 10W at rates of .5 - 2.0 oz. ai/ac (35-140 g ai/ha) performed exceptionally well at both the early timing, 1-2 LSR/9 DAS, and the late timing, 4-5 LSR/22 DAS. These sequential treatments gave greater than 94% control of all broadleaf and sedge weeds including California arrowhead (*Sagittaria montevidensis*), ducksalad (*Heteranthera limosa*), roundleaf waterhyssop (*Bacopa rotundifolia*), purple ammannia (*Ammannia coccinea*), smallflower umbrellaplants (*Cyperus difformis*, and roughseed bulrush (*Scirpus mucronatus*). In addition, excellent crop safety was demonstrated from all sequential "Londax" treatments.

In trial number two, sequential treatments of Molinate 10G and "Londax" 10W at rates of .66 - 2.0 oz. ai/ac (46-140 g ai/ha) at 1-2 LSR/10 DAS gave greater than 98% control of all broadleaf and sedge weed species. Sequential treatments of Molinate 10G at 1-2 LSR/10 DAS and "Londax" 10W at

4-5 LSR/21 DAS gave nearly 90% or greater control of all broadleaf and sedge weed species at rates of 1.0 and 2.0 oz. ai/ac (70 and 140 g ai/ha), including California arrowhead (*Sagittaria montevidensis*), ducksalad (*Heteranthera limosa*), roundleaf waterhyssop (*Bacopa rotundifolia*), purple ammannia (*Ammannia coccinea*), smallflower umbrellaplant (*Cyperus difformis*), and roughseed bulrush (*Scirpus mucronatus*).

In trial number three, "Londax" 10W applied early (1-2 LSR/10 DAS) or late (4-5 LSR/19 DAS) as sequential treatments at 1.0 oz. ai/ac (70 g ai/ha) with either Thiobencarb 10G or Molinate 10G gave effective control of barnyardgrass (*Echinochloa crus-galli* var. *crus-galli*) bearded/sprangletop (*Leptochloa fascicularis*) and roughseed bulrush (*Scirpus mucronatus*). Excellent crop safety was demonstrated on rice, and yields were significantly better than the untreated.

Conclusion

The results of these trials show the outstanding spectrum of weeds controlled, crop safety and application timing flexibility in direct seeded rice by "Londax." The utility of such a flexible, broad spectrum herbicide that does not require the manipulation of paddy water to achieve effective weed control could be a very significant and important tool for California rice growers.

Acknowledgements

The authors wish to thank the excellent growers/cooperators for their experimental test sites, equipment and help in pest and water management, the University of California Cooperative Extension for their suggestions and help at harvest, and to colleagues within DuPont and Rice Researchers, Inc. for their helpful advice, support and hard work throughout the trials.

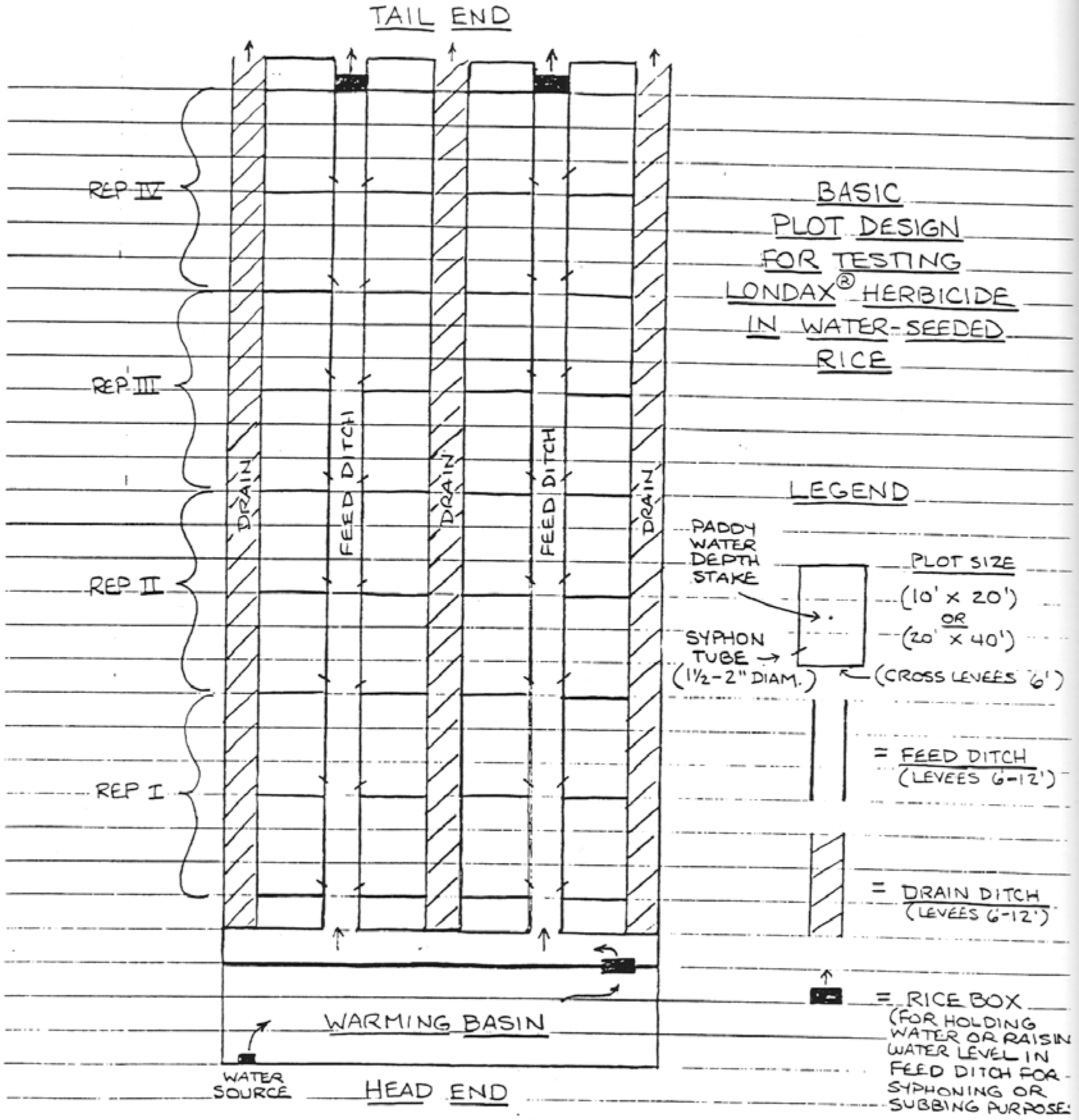
Literature Cited

1. Shibayama, H. 1980. Morphological Responses of Rice Plants to MCPA. Japan. Agric. Res. Quart. 14:1-33.

Table 1. Experimental details of "Londax" trials in California.

TRIAL NUMBER:	1	2	3
LOCATION:	Rio Oso	Delevan	Ord Bend
COUNTY:	Sutter	Colusa	Glenn
COOPERATOR:	A. Driver	A. Detlefsen	C. Bruce & Rice Researchers Inc.
RICE VARIETY:	S-201	M-201	M-201
SEEDING DATE:	5-8-85 (Pre-soaked seed)	5-15-85 (Coated seed)	5-19-85 (Pre-soaked seed)
APPLICATION DATE:	5-17-85 (1-2 LSR/9 DAS)	5-25-85 (1-2 LSR/10 DAS)	5-29-85 (1-2 LSR/10 DAS)
	5-30-85 (4-5 LSR/22 DAS)	6-5-85 (4-5 LSR/21 DAS)	6-7-85 (4-5 LSR/19 DAS)
	6-14-85 (Late post/ 37 DAS)	6-19-85 (Late post/ 35 DAS)	6-21-85 (Late post/ 35 DAS)
PLOT SIZE:	20' x 40'	20' x 40'	20' x 40'
SOIL TYPE:	SILTY CLAY	SILTY CLAY	SILTY CLAY
SOIL pH:	5.8	7.2	6.3
% O.M.	.9	1.5	1.7
C.E.C.:	13.9	15.2	17.5
HARVEST DATE:	10-23-85	10-9-85	10-15-85

BASIC PLOT DESIGN FOR TESTING LONDAX® HERBICIDE IN WATER-SEEDED RICE



*BASINS THAT ARE NOT FLAT MAY NEED TO HAVE RICE BOXES PLACED AT VARIOUS LOCATIONS WITHIN THE FEED DITCH IN ORDER TO HOLD WATER AT EQUAL OR DESIRED LEVELS FOR SYPHONING OR SUBBING PURFUSES.

Table 2. Weed control performance of "Londax", Bentazon and MCPA applied sequentially with Molinate in water-seeded rice, CV. S-201, at Rio Oso, Sutter County, California in 1985.

HERBICIDE FORMULATION	APPLICATION			WEED CONTROL AT 79 DAS				
	STAGE (LSR)*	TIME (DAS)**	RATE (OZ AI/A)	SAGMO (%)	HETLI (%)	AMMCO (%)	CYPDI (%)	SCPMU (%)
1) "Londax" 10W	1-2	9	.5	100	99	100	100	100
2) "Londax" 10W	1-2	9	.66	99	100	100	100	98
3) "Londax" 10W	1-2	9	1.0	100	100	100	100	100
4) "Londax" 10W	1-2	9	2.0	100	100	100	100	100
5) "Londax" 10W	4-5	22	.5	96	95	99	100	94
6) "Londax" 10W	4-5	22	.66	100	96	100	100	100
7) "Londax" 10W	4-5	22	1.0	100	100	100	100	100
8) "Londax" 10W	4-5	22	2.0	100	100	100	100	100
9) Bentazon 4E + Oil	---	37	16.0	99	99	100	88	99
10) MCPA 4E	---	37	16.0	100	100	100	73	79
11) Untreated (Except Molinate 10G)	1-2	10	64.0	0	0	0	44	56

* LSR = Leaf Stage of Rice
** DAS = Days After Seeding

SAGMO = *Sagittaria montevidensis* (California arrowhead)
HETLI = *Heteranthera limosa* (Ducksalad)
AMMCO = *Ammannia coccinea* (Purple ammannia)
CYPDI = *Cyperus difformis* (Smallflower umbrellaplant)
SCPMU = *Scirpus mucronatus* (Roughseed bulrush)

Table 3. Crop response results of "Londax", Bentazon and MCPA applied sequentially with Molinate in water-seeded rice, CV. S-201, at Rio Oso, Sutter County, California in 1985.

	APPLICATION			CROP RESPONSE		
HERBICIDE FORMULATION	STAGE (LSR)*	TIME (DAS)**	RATE (OZ AI/A)	6/21 (%SR)***	7/26 (%SR)	10/23 (CM)****
1) "Londax" 10W	1-2	9	.5	0	0	82.8
2) "Londax" 10W	1-2	9	.66	0	0	82.3
3) "Londax" 10W	1-2	9	1.0	0	0	84.5
4) "Londax" 10W	1-2	9	2.0	3.75	0	85.8
5) "Londax" 10W	4-5	22	.5	0	0	82.8
6) "Londax" 10W	4-5	22	.66	0	0	82.5
7) "Londax" 10W	4-5	22	1.0	0	0	83.5
8) "Londax" 10W	4-5	22	2.0	2.5	0	83.5
9) Bentazon 4E + Oil	---	37	16.0	0	0	83.0
10) MCPA 4E	---	37	16.0	10.0	0	79.0
11) Untreated (Except Molinate)	1-2	10	64.0	0	0	81.0

* LSR = Leaf Stage of Rice
** DAS = Days After Seeding
*** SR = % Stunted Rice
**** CM = Height of Rice in Centimeters

Table 4. Weed control performance of "Londax", Bentazon and MCPA applied sequentially with Molinate in water-seeded rice, CV. M-201, at Delevan, Colusa County, California in 1985.

HERBICIDE FORMULATION	APPLICATION			WEED CONTROL AT 84 DAS				
	STAGE (LSR)*	TIME (DAS)**	RATE (OZ AI/A)	SAGMO (%)	HETLI (%)	AMMCO (%)	CYPDI (%)	SCPMU (%)
1) "Londax" 10W	1-2	10	.5	100	100	74	100	100
2) "Londax" 10W	1-2	10	.66	100	99	100	100	100
3) "Londax" 10W	1-2	10	1.0	100	98	100	100	99
4) "Londax" 10W	1-2	10	2.0	100	100	100	100	100
5) "Londax" 10W	4-5	21	.5	100	86	58	100	100
6) "Londax" 10W	4-5	21	.66	100	70	58	100	100
7) "Londax" 10W	4-5	21	1.0	100	95	89	100	100
8) "Londax" 10W	4-5	21	2.0	100	97	94	100	100
9) Bentazon 4E + Oil	---	35	16.0	100	97	92	92	99
10) MCPA 4E	---	35	16.0	100	93	98	61	50
11) Untreated (Except Molinate 10G)	1-2	9	64.0	98	68	3	24	75

* LSR = Leaf Stage of Rice
** DAS = Days After Seeding

SAGMO = *Sagittaria montevidensis* (California arrowhead)
HETLI = *Heteranthera limosa* (Ducksalad)
AMMCO = *Ammannia coccinea* (Purple ammannia)
CYPDI = *Cyperus difformis* (Smallflower umbrellaplant)
SCPMU = *Scirpus mucronatus* (Roughseed bulrush)

Table 5. Weed control performance from sequential treatments of Molinate or Thiobencarb followed by "Londax", Bentazon and MCPA in water-seeded rice, CV. M-201, at Ord Bend, Glenn County, California in 1985.

HERBICIDE FORMULATION	APPLICATION STAGE (LSR)*	TIME (DAS)**	RATE (OZ AI/A)	RICE SR*** (%)	WEED CONTROL AT 110 DAS ECHCG (%)	LEFFA (%)	SCPMU (%)
1) Thiobencarb 10G	1-2	10	64.0	0	95	100	92
+ "Londax" 10W	1-2	10	1.0				
2) Thiobencarb 10G	1-2	10	64.0	0	97	100	89
+ "Londax" 10W	4-5	19	1.0				
3) Thiobencarb 10G	1-2	10	64.0	0	98	99	95
+ Bentazon 4E	---	35	16.0				
+ Oil							
4) Molinate 10G	1-2	10	64.0	0	100	100	100
+ "Londax" 10W	1-2	10	1.0				
5) Molinate 10G	1-2	10	64.0	0	100	100	98
+ "Londax" 10W	4-5	19	1.0				
6) Molinate 10G	1-2	10	64.0	0	100	99	99
+ Bentazon 4E	---	35	16.0				
+ Oil							
7) Molinate 10G	1-2	10	64.0	4	99	99	63
+ MCPA 4E	---	35	16.0				
8) Untreated	--	--	--	10	33	83	15

* LSR = Leaf Stage of Rice
** DAS = Days After Seeding
*** SR = Stand Reduction

ECHCG = *Echinochloa crus-galli* var. *crus-galli* (Barnyardgrass)
LEFFA = *Leptochloa fascicularis* (Bearded sprangletop)
SCPMU = *Scirpus mucronatus* (Roughseed bulrush)

Table 6. Yield performance from sequential treatments of Molinate or Thiobencarb followed by "Londax", Bentazon and MCPA in water-seeded rice, CV. M-201, at Ord Bend, Glenn County, California in 1985.

HERBICIDE FORMULATION	APPLICATION STAGE (LSR)*	TIME (DAS)**	RATE (OZ AI/A)	YIELD (LBS./AC)***
1) Molinate 10G +	1-2	10	64.0	8,493 a
Bentazon 4E + Oil	---	35	16.0	
2) Molinate 10G +	1-2	10	64.0	8,050 a,b
"Londax" 10W	1-2	10	1.0	
3) Molinate 10G +	1-2	10	64.0	8,030 a,b,c
"Londax" 10W	4-5	19	1.0	
4) Thiobencarb 10G +	1-2	10	64.0	8,020 a,b,c
Bentazon 4E + Oil	---	35	16.0	
5) Thiobencarb 10G +	1-2	10	64.0	7,935 a,b,c,d
"Londax" 10W	1-2	10	1.0	
6) Thiobencarb 10G +	1-2	10	64.0	7,342 a,b,c,d,e
"Londax" 10W	4-5	19	1.0	
7) Molinate 10G +	1-2	10	64.0	6,581 b,c,d,e,f
MCPA 4E	---	35	16.0	
8) Untreated	--	--	--	3,939 g

* LSR = Leaf Stage of Rice
** DAS = Days After Seeding
*** Numbers in vertical column followed by the same letter are not significantly different at the 0.01 level of probability; coefficient of variation = 17.75%; LSD = 1,729.19.

BAS 514 H: A NEW HERBICIDE FOR WEED CONTROL IN RICE

J.O. Pearson and C.W. Carter[1]

Abstract. BAS 514 H is anew herbicide selective in rice. The chemical number is 3,7-dichloro-8-quinolinecarboxylic acid, and the proposed common name is quinclorac. Excellent grass control with good rice tolerance has been achieved in California as well as other rice growing areas in the world. Weed control can be obtained when used as a soil or foliar applied treatment. A 50% wettable powder and a 1% granular formulation have been tested at 0.125-1.0 lb/A with barnyardgrass (*Echinochloa crus-galli*) as the target weed. Control was excellent and similar with both formulations, and the current recommended rates for evaluation are 0.25-0.75 lb/A. The lower rates are suggested for barnyardgrass control in the 2-3 leaf stage. The granular formulation was slightly phytotoxic at the high rate, and symptoms were expressed as onion leaf-roll, chlorosis and stunting. Uptake in weeds is primarily through roots, with some leaf uptake also, and is greater in light textured soils with low organic matter. Application on moist soils has been more effective than on dry soils, in general. BAS 514 H has been successfully combined with other grass and broadleaf herbicides to broaden the spectrum of control and the time of application. No antagonism has been observed.

[1]BASF Wyandotte Corporation, Parsippany, NJ.

RESULTS OF AN EXPANDED EXPERIMENTAL USE PROGRAM IN THE NORTHWEST FOR ASSERT (AC 222,293) IN SMALL GRAINS

O.G. Bain and J.L. Johnson

Abstract. Assert (methyl-6-(4-isopropyl-4-methyl-5-oxo-2-imidazolium-2yl)-*m*-toluate and methyl-2-(4-isopropyl-4-methyl-5-oxo-2-imidazolium-2-yl)-p-toluate formally known as AC 222,293, has been shown to have activity on wild oat (*Avena fatua*) and certain broad leaf species. Assert was tested extensively on small grains throughout the Pacific Northwest in 1985 as part of an Experimental Use Program to gather additional information on wild oat and broad leaf efficacy as well as tankmix flexibility.

Assert was applied to 483 acres at 32 sites in the states of Washington, Idaho, Oregon and Montana. Treatments varied in size from 5 to 20 acres and were applied by the grower or a commercial applicator. Plots were arranged in unreplicated blocks and included treatments of a CHECK, Assert alone at two rates, Assert with either chlorsulfuron (2-chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide], chlorsulfuron + metribuzin (4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one), MCPA ester (4-chloro-2-methylphenoxy)acetic acid), bromoxinyl (3,5-dibromo-4-hydroxybenzonitrile), or bromoxinyl + MCPA

[1]American Cyanamid Company, Princeton, NJ.

and the standard wild oat herbicides diclofop ((±)-2-[4-(2,4-dichlorophenoxy)phenoxy]propanoic acid) and/or difenzoquat (1,2-dimethyl-3,5-diphenyl-1H-pyrazolium). Assert was applied at 0.38 and 0.47 lb ai/A. Diclofop was applied most commonly at 1.0 lb ai/A. Assert treatments were applied at the 1-4 leaf stage of the wild oat. Other materials were applied at label rates and timing. Treatments were evaluated at 0-2, 4-6 weeks post treatment and at harvest. Wild oat and other prevalent grass and broad leaf species were counted on a random per square foot basis. Harvest samples were collected from each treatment hen possible.

The four-state study area was divided into five areas for the purpose of data compilation. Comparing the percent wild oat control provided by Assert/diclofop/difenzoquat, the results were: Montana (95%/65%/ND); Eastern Idaho (92%/87%/ND); Southeastern Washington (91%/89%/ND); Idaho-Camas Prairie (87%/79%/88%); Idaho - Palouse (62%/47%/84%).

Of the 31 grass and broad leaf weed species identified over 72 treatments, Assert effectively controlled three: Field mustard (Brassica kaber) 94%, Field Pennycress (Thlaspi arvense) 97% and wild buckwheat (Polygonum convolvulus) 97%. Additionally, Assert was successfully tank-mixed with all broad leaf herbicides tested except the chlorsulfuron + metribuzin combination.

Yield comparisons collected from 40% of the treatments indicated that Assert increased winter wheat yields 24% over the untreated check. Barley yields from two Assert treatments showed an increase of 110% over the untreated check.

SELECTIVE CONTROL OF CANADA THISTLE IN CEREAL WITH 3,6-DICHLOROPICOLINIC ACID (CLORPYALID)

R.E. Curtis and T. Haaagsma[1]

Abstract. Field experiments conducted in 1984 showed the effectiveness of clopyralid alone and in mixtures with other broad-leaved herbicides for the control of Canada thistle (Cirisium arvense (L.) Scop.) in cereals. Clopyralid applied post emergence at the 5 leaf stage of cereals at rates of 100-140 g/ha provided top growth control during the season and extended control into the second year. Canada thistle counts taken the following summer indicate the potential of clopyralid in reducing one of the worst perennial weed problems in western Canada.

Canada Thistle (Cirisium arvense (L.) Scop.) is one of the most troublesome weeds infesting cereals, canola and other broad-leaved crops in western Canada. Surveys conducted by Dew from 1975 - 1977 indicate that one-third of all cultivated fields in Alberta had an incidence of Canada thistle at a density of at least five plants per square metre. Partly due to the competitive nature of this plant and its ability to spread through an extremely well-developed underground root system as well as the lack of an effective means of control in canola, Canada thistle has become widespread.

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[1]Dow Chemical Canada Inc., Edmonton, Alberta, Canada.

Herbicidal activity of clopyralid (3,6-dichloro-2-pyridinecarboxylic acid) on Canada thistle has been reported by various workers. O'Sullivan 1982 reported that clopyralid applied to canola at rates of 200 g/ha or more, provided excellent top growth control and suppressed root regrowth of treated Canada thistle plants.

In addition to the development of clopyralid for canola, various formulations, generally containing 2,4-D (3,6-dichloro-2-pyridinecarboxylic acid) or MCPA (4-(4-chloro-2-methylphenoxy)butanoic acid) have been evaluated for use in wheat and barley. This paper deals with field tests established to determine the herbicidal activity of clopyralid when applied to Canada thistle-infested wheat and barley.

Materials and Methods

Two field tests were established in 1984 near Edmonton, Alberta to determine broad-leaved weed control of clopyralid applied at 60-140 g/ha in combination with MCPA and mecoprop ((±)-2-(4-chloro-2-methylphenoxy)propanoic acid) compared to a commercial product, bromoxynil (3,5-dibromo-4-hydroxybenzonitrile)/MCPA. Individual plot size was 3.0 x 10.0 m using a randomized complete block design with four replicates. Canada thistle was sprayed while at 5-15 cm tall, and plant density varied from 28-45 plants per square metre. Treatments were applied on June 11 (at Site #1) or June 26 (at site #2) using an Oxford CO_2 pressurized small plot sprayer, using T-jet 80015 nozzle tips, calibrated to deliver 108.3 L/ha at a spray pressure of 240 kPa. Wheat and barley were at the 3 to 5 leaf stage when sprayed. Visual observations of cereal tolerance and weed control were taken two weeks and four weeks after spraying. These evaluations were based on a 0-9 scale where 0 = no weed control and no crop tolerance and 9 = complete weed control and complete crop tolerance. Six weeks after spraying, the number of Canada thistle plants were determined from plant counts taken from two random 1/2 square metre quadrates per plot. At harvest a 30 cm x 10 m grain sample was cut and threshed for yield determination.

At each site, no fall tillage was applied in 1984. Spring tillage (1985) included 2-3 passes with either a heavy-duty field cultivator or disc. Fertilizer and a pre-emergent wild oat herbicide were applied prior to seeding. On May 12, barley cultivar Leduc (at site #1) and May 15, (cultivar Diamond/at site #2) were planted using a hoe-drill.

When barley was at the 3 to 4 leaf stage, plant counts were taken from a 2 x 1/2 M^2 quadrate per plot. (At both sites metribuzin at 200 g/ha was applied to control *Stellaria media*, *Galeopsis tetrahit* without adversely affecting the Canada thistle stand). After four to five weeks, a second plant count was taken.

Results and Discussion

Visual evaluations indicate negligible apparent injury to wheat and barley following application of clopyralid at the 3 to 5 leaf stage. Minimal injury to wheat (Table 1) consisting of transient leaf discoloration at leaf tips and temporarily reduced growth rate two weeks after application was observed. No other visual injury was observed later in the season. No visual injury to barley was observed.

Yield data collected at harvest show a minimum 2-fold grain yield increase following application of clopyralid at 80-140 g/ha (Tables 1 and 2).

Tables 3 and 4 indicate the effectiveness of clopyralid in reducing the number of Canada thistle plants during the season when a competitive crop such as wheat or barley is present. Generally, following application of clopyralid at 100-140 g/ha, the level of top growth control of Canada thistle shoots was 80-90% whereas the commercial product bromoxynil/MCPA (1:1) applied at 0.56 kg/ha provided about 40% control.

Continuous application of herbicides in cereals has been shown to reduce the competitive effect of Canada thistle and will reduce the spread of seeds. However, the use of a selective, systemic herbicide that gives some degree of root kill would be advantageous to prevent the spread of Canada thistle.

From plant counts taken in June, 1985, and repeated in late July (1985), it is apparent that the number of Canada thistle shoots that developed were significantly reduced. This suggests that sufficient herbicide entered the plants and root system to give effective control of treated plants, as well as limit the number of shoots produced from any of the root buds along the extensive underground root system. The field test does not allow the study of the direct effects of the herbicide on the root system as well as the ability of the surviving root system to produce new shoots. However, this test suggests that following application of clopyralid at 100-140 g/ha, the number of Canada thistle shoots was reduced about 80-85%. At lower rates, there is a trend for sightly diminished control of Canada thistle during the year of application and more shoot re-growth the following season.

The results of this study indicate that clopyralid (3,6-dichloro-picolinic acid) can be safely applied to wheat and barley (in combination with phenoxy herbicides) for control of Canada thistle at the 5-15 cm stage.

Due to the excellent level of control obtained with rates of clopyralid at 100-140 g/ha and the reduced number of shoots produced from treated plants, indicating root kill, clopyralid offers the potential of effectively reducing Canada thistle infestations in cereals.

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TABLE 1

Tolerance of Wheat (cv. Neepawa) to Clopyralid Application Using 0-9 Visual Score 14 and 28 Days After Treatment (DAT)

9.0 = complete crop tolerance, 0 = no tolerance

Clopyralid* Rate g/ha	14 DAT	28 DAT	Yield g/m^2
Weedy Check	9.0	9.0	88.1 b
140	8.3	9.0	218.7 a
120	8.0	9.0	150.5 a-e
100	8.4	9.0	197.6 ab
80	8.1	9.0	192.5 abc
60	8.3	9.0	187.0 a-d
bromoxynil/MCPA	8.0	9.0	170.8 a-h

Numbers within a column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range test.

*Clopyralid was tank mixed with mecoprop and MCPA at 400 + 400 g/ha.

TABLE 2

Tolerance of Barley (cv. Leduc) to Clopyralid Application Using 0-9 Visual Score 14 and 28 Days After Treatment (DAT)

9.0 = complete crop tolerance, 0 = no tolerance

Clopyralid* Rate g/ha	14 DAT	28 DAT	Yield g/m^2
Weedy Check	9.0	9.0	97.5 b
140	9.0	9.0	280.5 a
120	9.0	9.0	273.0 ab
100	9.0	9.0	255.7 a-d
80	9.0	9.0	272.6 a-c
60	9.0	9.0	249.2 a-e
bromoxynil/MCPA	9.0	9.0	238.6 a-f

C.L. = 99% DMR

Numbers within a column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range test.

*Clopyralid was tank mixed with mecoprop and MCPA at 400 + 400 g/ha.

TABLE 3

1984 Canada Thistle (Cirisium arvense) Stand Following Application of Clopyralid - (Site #1)

Number of Plants/m^2

Clopyralid* Rate g/ha	08/84
Weedy Check	55.8 a
140	10.0 c
120	8.0 c
100	8.5 c
80	8.7 c
60	7.5 c
Bromoxynil/MCPA	33.5 b

C.L. = 99% SNK

Numbers within a column followed by the same letter are not significantly different at the 5% level using student - Neumen - Keuls test.

*Clopyralid was tank mixed with mecoprop and MCPA

TABLE 4

1984 Canada Thistle (Cirisium arvense) Stand Following Application of Clopyralid - (Site #2)

Number of Plants/m^2

Clopyralid* Rate g/ha	08/84
Weedy Check	28.8 a
140	4.5 b
120	4.0 b
100	6.0 b
80	3.5 b
60	5.5 b
Bromoxynil/MCPA	25.5 a

C.L. = 99% SNK

Numbers within a column followed by the same letter are not significantly different at the 5% level using student - Neumen - Keuls test.

*Clopyralid was tank mixed with mecoprop and MCPA

TABLE 5

Effect of Clopyralid on Canada Thistle (Cirisium arvense)
Plant Density One Year After Treatment

Plant Density Numbers/m^2

Clopyralid* Rate g/ha	06/85	07/85
Weedy Check	42.9 a	36.2 a
140	12.4 b	5.0 a
120	10.2 b	5.1 b
100	9.5 b	9.6 b
80	13.9 b	4.6 b
60	13.8 b	11.1 b
Bromoxynil/MCPA	22.5 a	26.2 a

C.L. = 99% SNK

Numbers within a column followed by the same letter are not significantly different at the 5% level using student - Neumen - Keuls test.

*Clopyralid was tank mixed with mecoprop and MCPA in the 1984 treatments.

FLUROXYPYR: A NEW ENVIRONMENTALLY COMPATIBLE HERBICIDE

A.E. Shober, S.A. McMaster and R. L. Gantz[1]

Fluroxypyr is the common name for the new, environmentally compatible broadleaf herbicide "4-amino-3,5-dichloro-6-fluoro-2-pyridyl-oxyacetic acid." Fluroxypyr is also being evaluated under the experimental code of DOWCO 433. The structure and several chemical and physical properties are shown (in this slide). You will note fluroxypyr is pyridine based and as such does not contain any dioxins, dibenzo furans or nitrosamine impurities. Fluroxypyr is a readily translocatable, non-phenoxy herbicide exhibiting a high degree of activity in postemergence foliar applications to a wide spectrum of broadleaf species. It induces characteristic auxin type responses in susceptible species with a few hours of application.

Formulations containing the methylheptyl ester of fluroxypyr are registered and being marketed in Europe for the control of certain broadleaf weeds infesting cereal grains. Research has been initiated in North America to define its spectrum of activity in small grain, forestry, range and pasture, turf, right-of-way and other sites of application.

Fluroxypyr and its methylheptyl ester have a low order of acute toxicity to laboratory animals, fish and wildlife. Chronic feeding studies in the rat and mouse have demonstrated that fluroxypyr did not cause tumors at daily dose levels up to 320 mg/kg body weight in either sex. The no-observed effect level (NOEL) was 80 mg/kg/day in rats and 320 mg/kg/day in mice. Laboratory studies have indicated no evidence of teratogenicity, mutagenicity or reproductive effects at maximum tolerated dosages. Metabolism studies in the rat have shown that fluroxypyr is not metabolized but is rapidly excreted unchanged, primarily in the urine.

The result of investigations in spring wheat indicate that fluroxypyr is also not metabolized in plants but for the major part, undergoes biotransformation and forms conjugates. These conjugates, after extraction, can be converted to fluroxypyr by acid hydrolysis.

The methylheptyl ester undergoes hydrolysis in water to fluroxypyr. The half-life of the ester at 22° C and a pH of 5, 7 or 9 is 9.8, 17.5 and 10.2 days, respectively. The half-life of fluroxypyr in water under the same conditions is 220, 260 and 185 days.

Aerobic soil metabolism studies have shown that fluroxypyr undergoes microbial degradation at a fairly rapid rate. Degradation of fluroxypyr under anaerobic conditions occurs at a much slower rate.

Laboratory studies were conducted with both fluroxypyr and the methylheptyl ester in standard soils following the German protocol, Merkblatt 36. The ester was hydrolyzed rapidly to fluroxypyr with a half-life of less than one day in the two soil types. The half-life of fluroxypyr (the acid) was 45 days in standard soil 2.2, which is a very humus loamy sand and 55 days in standard soil 2.3, a moderately humus loamy sand.

The methylheptyl ester of fluroxypyr has a vapor pressure of 1.07×10^{-7} mm Hg at 25° C. It has very low water solubility at 0.9 ppm at 27.7°C and a K_{OC} of 5594 indicating it will be strongly adsorbed by soil.

Calculated distribution ratios for the compound between water and air and wet soil and air indicate that the compound will have no movement in soil by diffusion and will not volatilize significantly from soil. The chemical can be considered immobile in soil according to Helling's system of mobility classification.

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[1]Dow Chemical, Midland, MI.

Wild oats (Avena fatua) was described by Linnaeus in 1753. It was introduced from Europe and became established in California by 1848. It grows at elevations below 6000 feet throughout the state, especially on rich valley soils. The geographical distribution of wild oats in California corresponds closely to the areas planted to wheat and barley. Wild oats invaded valley and foothill rangelands soon after its introduction and is still used for winter and spring forage in such areas.

Prior to the advent of wild oat herbicides, tillage was used to control the weed. Growers destroyed one or more flushes of wild oats with disks or cultivators prior to planting small grains. This practice continues in many parts of the state.

Another accepted practice for controlling wild oats prior to the 1960's was harrowing wheat (not barley) just at emergence. Normal straw varieties grown at that time were planted deeper than the currently grown semi-dwarf varieties, permitting harrowing without crop damage.

Thomas K. Pavlychenko (1892-1958) was the first researcher to study the relationship of crop and weed root systems to competition effects. His studies with wheat and wild oats revealed that the weed developed a root system as large or larger than that of wheat in the same number of days after germination. The effects of this precocity are visible statewide.

Each wild oat plant can produce from 250-500 viable seeds; in badly infested fields, the top 4-6 inches of soil contain 2000-3000 wild oat seeds per square yard.

Barban (4-chloro-2-butynyl 3-chlorophenylcarbamate), one of the first wild oat herbicides, appeared on the scene 25 years ago. It also controls Italian ryegrass and canarygrass, making it particularly useful in the Imperial Valley. Barban is applied at 0.25-0.375 lb/A to weeds in the 2-leaf stage and at 0.5 lb/A to those in the 2.5-3.5 leaf stage. The herbicide may be reapplied at the low rate. However, the high rate cannot be applied to spring-seeded durum.

While it can produce spectacular control of wild oats, the use of barban is not without hazards--injury occurs all too frequently to barban-treated wheat in California. Crop damage occurs when the herbicide is applied during continuous chilly, foggy weather in January and February, at the height of the small grain spraying season. To reduce possible injury to wheat and barley, barban should be applied when daytime temperatures will exceed 50 F for at least several hours during each of the first three days following application. Barban differs from most herbicides in inducing greater phytotoxicity at low temperatures. The higher rate (0.5 lb/A) should be used at temperatures above 85 F under conditions of low soil fertility and drought.

Triallate (S-(2,3,3-trichloro-2-propenyl)bis(1-methylethyl)carbamothioate), the only preplant incorporated or preemergence incorporated wild oat herbicide, also became commercially available a quarter of a century ago. Triallate is used only in barley in California, since it injures shallow-planted semi-dwarf wheats of Mexican origin. Wild oats which germinate in triallate-treated soil typically develop a pinched tip and resultant loop-shaped coleoptile; similar injury occurs in semi-dwarf wheat. Triallate can produce excellent control of wild oats in barley but is ineffective on highly organic soils. This herbicide is volatile and must be incorporated immediately after application.

Difenzoquat (1,2-dimethyl-3,5-diphenyl-1H-pyrazolium) was the next wild oat herbicide to be registered. It is most effective at the 5 leaf stage of wild oats; control is improved by good crop competition. Difenzoquat kills only wild oats but does so effectively. Its shortcoming is that it cannot be used on many varieties of wheat, including durum.

Diclofop ((±)-2-[4-(2,4-dichlorophenoxy)phenoxy]propanoic acid) became commercially available in California in 1982. Since it controls Italian ryegrass well, its release was eagerly awaited by the state's wheat farmers. Diclofop also controls wild oats. It is applied at 0.75-1.0 lb/A to wild oats in the 1 to 3 leaf stage or at 1.0-1.25 lb/A to wild oats in the 3 to 4 leaf stage.

Wet winters cause diclofop injury problems. The first instances of injury occurred in 1982-1983, the wettest winter on record. Wheat injury was conspicuous in water-logged fields treated during chilly, foggy weather. Affected wheat plants develop disease-like symptoms, and severely affected plants' break off at ground level. Some injury has occurred in California each year since. Italian ryegrass (*Lolium multiflorum* Lam.), introduced from Europe, is widely distributed in California at low elevations, especially in the coast ranges. It sometimes is used for forage and occasionally is planted for that purpose. Heavy infestations of Italian ryegrass are common throughout the Sacramento and San Joaquin valleys. Diclofop at 0.75-1.0 lb/A provides outstanding control of this weed. Though barban is used occasionally for ryegrass control, fear of crop injury curtails its use.

Hood canarygrass (*Phalaris paradoxa* L.), introduced from the Mediterranean region, is now a common weed in grain, including rice, grown on the rich soils of the Sacramento and San Joaquin valleys. Heavy infestations frequently occur in wheat. Barban and diclofop provide fair to good control of hood canarygrass, depending on seedling size and on growing conditions at the time of treatment.

Littleseed canarygrass (*Phalanis minor* Retz.), another native of the mediterranean region, has adapted well to California. It occurs throughout central and southern California and is frequently encountered in disturbed areas or waste ground. Littleseed canarygrass is abundant, especially in the Imperial Valley, where it is the number one grass weed in wheat. Its reputation as a major weed in clearly justified. The prominent ligule on the seedlings helps distinguish the species. An even better characteristic for identifying the plant, however, is the red pigment (anthocyanin) visible when the stem is broken off at the base. Barban is commonly used in the Imperial Valley to control littleseed canarygrass; diclofop also provides fair to good control.

Two similar species are known as ripgut brome in California--*Bromus diandrus* Roth and *B. rigidus* Roth. The first is the most abundant and is the species under consideration. Both grasses were introduced from Europe and are naturalized statewide, particularly at low elevations. Ripgut brome is common on valley flats and foothill slopes and is abundant in southern California. The weed grows well on all soils, especially disturbed ground. No herbicides are presently cleared for the control of ripgut brome in small grains in California.

Downy brome (*Bromus tectorum* L.), a species closely related to ripgut brome, is not important in small grains in California and will not be discussed in this paper.

Another grass weed in California small grains is rabbitfoot polypogon (*Polypogon monspelienus* (L.) Desf.), also known as rabbitfootgrass due to its dense, bristly, spike-like panicles. This species, introduced from Europe, is widespread in California along irrigation ditches, in over-irrigated tilled land and in moist waste places. Because it prefers moist soils, rabbitfoot polypogon often becomes in impurity in hay, reducing its sale value. The grass is grazed by livestock on alkaline plains of the Central Valley. There are no herbicides labeled for controlling rabbitfoot polypogon in small grains in California.

Table 2 summarizes the grass weed control provided by several herbicides. Weed grasses followed by a "C" are controlled by the herbicide according to the label. No labels claim control of some of the species. In the early 1980's, another wild oat herbicide became available for testing.

Table 2: Control of selected grasses in cereals as provided by several herbicides.

	Herbicide			
Weeds	Barban (CARBYNE)	Difenzoquat (AVENGE)	Diclofop (HOELON)	Triallate (FAR-GO)
Wild oats	C	C	C	C
Italian ryegrass	C	-	C	-
Canarygrass spp.	C	-	-	-
Ripgut brome	-	-	C	-
Rabbitfoot polypogon	-	-	-	-

C = Controlled according to label
\- = Not mentioned on label

At the Tulelake Field Station in 1982, we began evaluating AC 222,293 (Assert; methyl-6-(4-isopropyl-4-methyl-5-oxo-2-imidazolium-2yl)-m-toluate) on numerous varieties of hard red wheat and durum for crop tolerance and wild oat control. Additional testing has been conducted at the University of California at Davis. All wheat varieties tested have shown excellent tolerance to the herbicide, and yields have been significantly higher when wild oats were controlled. While AC 222,293 does not control any of the other grass weeds of cereals, it does control wild mustard (*Sinapsis arvensis* L.)

Mobay's new herbicide, SMY 1500 (Tycor, (4-amino-6-(1,1-dimethylethyl)-3-(ethylthio)-1,2,4-triazin-5(4*H*)-one) is being evaluated now. Indications are that it will control several important annual grasses in winter cereals. In January, 1986, SMY 1500 was applied at 0.75 and 1.5 lb/A at Davis. Early evaluations look excellent--good control of grasses coupled with excellent crop tolerance.

California small grain growers await better herbicides for controlling the grass weeds of cereals. Progress is being made--someday the ideal herbicide may come. Growers look forward to weed-free grain fields.

GERMINATION OF FOUR ANNUAL GRASS WEEDS AT THREE TEMPERATURES

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

Abstract. The seeds of four annual grass weeds of northern Idaho were germinated for 49 days at 8 C, 18 C and 28 C with a photoperiod of 14 h light/10 h dark. The species were interrupted windgrass (*Apera interrupta* (L.) Beauv.), downy brome (*Bromus tectorum* L. - BROTE), Medushahead (*Taeniatherum caput-medusae* (L.) Nevski-ELYCM) and Ventenata (*Ventenata dubia* (Leers) Coss & Dur). The seed lots were collected during June and July 1984. The medushahead and downy brome florets were deawned within 10 days of collection to facilitate handling and placement in the germination plates. The experimental design was a split plot with repeated measures with temperatures as main plots, species as split plots and counting days as repeated measures. Five petri plates (30 seed per plate) were prepared for each species at each temperature. The experiment was run twice; the first time was six months after seed harvest and the second the 8.5 months after harvest. Medushahead germination at 8 C was 76% , windgrass 62%, downy brome 45% and Ventenata 24% (Table). Maximum germination for all species occurred at 18 C. Again medusahead was highest with 96% germination, Ventenata 93%, interrupted windgrass 78% and downy brome 48%. The highest germination at 28 C was Ventenata with 50%, downy brome was next with 37%, then medusahead with 33% and windgrass was 7%. The number of days to 75% of maximum germination was used as a germination speed indicator (Table). Downy brome germinated more rapidly than the other species at all temperatures, averaging five days to 75% of maximum germination for all temperatures. Downy brome also had the most uniform germination. Windgrass with the slowest germination required an average of 28 days to 75% of maximum germination for the three temperatures. Ventenata averaged ten days and medusahead averaged fifteen days to 75% of maximum germination for the three temperatures. Germination speed within species showed that windgrass germinated fastest at 8 C (18 days at 8 C, 23 days at 18 C and 35 days at 28 C). Medusahead germinated fastest at 18 C (6 days at 18 C, 11 days at 8 C and 30 days at 28 C), Ventenata also germinated fastest at 18 C (6 days at 18 C, 10 days at 28 C and 13 days at 8 C). Downy brome was slightly faster at 28 C than 18 C (2 days at 28 C, 3 days at 18 C and 8 days at 8 C). All four species germinated across a wide range of temperatures but medushahead, downy brome and interrupted windgrass performed best at low to moderate temperatures while Ventenata did best at moderate to high temperatures. Germination speed among species varied widely.

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EFFECTS OF INDUCED WATER STRESS ON THE GROWTH, GAS EXCHANGE AND WATER POTENTIALS OF WILD OAT AND SPRING BARLEY

Don W. Morishita, Donald C. Thill and Robert H. Callihan

Abstract. The effects of induced water stress and intra- and interspecific interference on growth, gas exchange and water potential of wild oat (*Avena fatua* L.) and spring barley (*Hordeum vulgare* L.) were measured in the greenhouse. Wild oat and barley were grown in mixed culture and monoculture using a 1:1.2 barley to wild oat (161 barley plants m^{-2} and 175 wild oat plants m^{-2}) replacement series. Short-term water stress (-0.55 MPa soil water potential) was imposed on the wild oat and barley monoculture and mixed culture treatments when the barley was at the tillering or boot stage. Non-water stressed controls were maintained at field capacity. In monoculture, the plant density was equivalent to the total density of the mixture. Plant growth was measured through the growing period while gas exchange and plant water potentials were measured immediately before, during and for nine days after the stress periods. In mixed culture, barley leaf and tiller number were greater than the wild throughout most of the growing period. When grown alone, wild oat had more leaves and tillers than the barley. Under nonstressed conditions, the apparent photosynthesis of barley, when averaged over time, was about 10% greater than wild oat. Stomatal resistance and transpiration were very similar between barley and wild oat. After tillering, total water potential and leaf turgor of the wild oat remained higher than the barley. At the plant density used, barley was more competitive than wild oat. Barley and wild oat responded to water stress very similarly. Water stress at tillering adversely affected plant height, gas exchange and plant-water relationships more than at the boot stage. Wild oat does not appear to be a better competitor for water than barley under conditions of short-term soil moisture deficit.

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PHOTOSYNTHETIC PRODUCTIVITY OF MAYWEED CHAMOMILE (*ANTHEMIS COTULA*) L.

S.A. Squier and D.R. Gealy[1]

Abstract. Mayweed chamomile (*Anthemis cotula* L.) is currently becoming a more serious weed problem in the wheat-growing regions of the Pacific Northwest. Because weed productivity ultimately depends on the ability of leaves to fix carbon dioxide, an infrared gas analysis system was constructed to measure several photosynthetic productivity parameters of mayweed chamomile leaves. At light saturation (1200 to 2000 $\mu E \cdot m^{-2} \cdot s^{-1}$, PAR) plants had a maximum apparent photosynthesis rate (AP) of 20 and 16 mg

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$CO_2 \cdot dm^{-2} \cdot h^{-1}$ in the greenhouse and field, respectively. In the greenhouse, the light compensation point was 16 $\mu E \cdot m^{-2} \cdot s^{-1}$. Diffusive resistance (DR) increased from 3.1 to 3.9 $s \cdot cm^{-1}$ as PAR increased from 100 to 2000 $\mu E \cdot m^{-2} \cdot s^{-1}$. AP increased from 21 to 31 mg $CO_2 \cdot dm^{-2} \cdot h^{-1}$ according to a quadratic response function as temperature increased from 15 to 30 C. Optimum temperature for AP was about 30 C. Carbon dioxide compensation points were unaffected by light intensity between 100 and 2000 $\mu E \cdot m^{-2} \cdot s^{-1}$, but increased from 29 to 45 ppm as temperature increased from 15 to 30 C.

Because several herbicides that are used to control mayweed chamomile also inhibit photosynthesis to varying degrees, an excised leaf system was devised to determine the response of AP and DR of mayweed chamomile leaves to herbicide exposure through vascular tissues. Concentrations of bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) less than 10^{-2} M did not affect AP for the 15 min duration of the experiment. At 10^{-4} M, both metribuzin ([4-amino-6-(1,1-dimethylethyl)-3-(methyl-thio)-1,2,4-Triazin-5(4*H*)-one] and terbacil (5-chloro-3-(1,1-dimethylethyl)-6-methyl-2,4(1H,3H)-pyrimidine-dione) reduced AP 4.2% of initial $AP \cdot min^{-1}$. DR began to increase several minutes after AP was affected.

EFFECT OF WINTER WHEAT (*TRITICUM AESTIVUM*) PLANTING GEOMETRY ON THE INTERFERENCE OF JOINTED GOATGRASS (*AEGILOPS CYLINDRICA*)

G.F. Fleming and F.L. Young

Abstract. Jointed goatgrass (*Aegilops cylindrica* Host), has become a serious annual weed problem in the winter wheat (*Triticum aestivum* L.) producing areas of the United States. At the present time, no selective control is available. Recently, in the small-grain producing regions, there has been increased interest in a no-till, paired-row system of planting which places a band of fertilizer between two closely spaced wheat rows. The theory behind the paired-row concept is that by reducing the distance between rows, fertilizer efficiency and weed control are increased. A field experiment was conducted in 1984 to evaluate the effect of two wheat-planting geometries on the growth and competition of jointed goatgrass. Treatments included paired and constant row planting geometries and locations of jointed goatgrass within each system. Paired wheat rows were spaced 12 cm apart with pairs of rows separated by 38 cm. Spacing of wheat rows planted in constant spacings was 25 cm. Jointed goatgrass locations were superimposed within each geometry and included: 1) weed-free, 2) over the fertilizer band, 3) in the crop row, and 4) 25 cm from the fertilizer band. "Daws" winter wheat was seeded at a rate of 90 kg/ha and weed rows were established by planting three jointed goatgrass segments per 7.5 cm of row. Growth measurements and percent nitrogen of both plant species were recorded at four stages of development. Heads/m row, dry weight and grain yield of both winter wheat and jointed goatgrass were reduced when jointed goatgrass was established in the wheat row regardless or row spacing. Weed location

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also affected percent nitrogen of the above-ground shoots of jointed goatgrass at the first harvest and percent nitrogen of the weed seed in the final harvest. Crop geometry did not influence growth and development parameters of either species.

ADSORPTION AND LEACHING CHARACTERISTICS OF ACC 222,293

G.M. Fellows and P.K Fay[1]

Abstract. ACC 222,293 (methyl 2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-p-toluate) is a promising herbicide for wild oat (*Avena fatua* L.) control in small grains. The adsorption properties of ACC 222,293 was measured for nine field soils. Soils varied in pH, cation-exchange capacity and organic matter. Freundlich K values were determined using a soil slurry with a water:soil ratio of 10:1. Radio labeled ACC 222,293 was added to the slurry and allowed to equilibrate on a mechanical shaker for 24 hours at room temperature. Adsorption of ACC 222,293 to soil is high. Adsorption to soil increased as the pH and CEC increased. ACC 222,293 was not mobile in soil leaching studies using soil thin layer chromatography plates.

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TOLERANCE OF SPRING PLANTED SMALL-GRAIN CULTIVARS TO RESIDUAL CHLORSULFURON

D.L. Spratling and R.E. Whitesides[1]

Abstract. Field studies were conducted to identify spring wheat (*Triticum aestivum* L.) and spring barley (*Hordeum vulgare* L. and *H. distichum* L.) cultivars tolerant enough to be seeded into soil containing residual chlorsulfuron (2-chloro-N-[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)aminocarbonyl]benzenesulfonamide). Owens and Waverly soft white wheat, Wampum and NK-751 hard red wheat, Steptoe and Kombar six-row barley, Andre and Clark two-row barley were all seeded into soil that was treated 30 days prior with chlorsulfuron. The herbicide was applied at 17.5 and 52.5 g/ha and incorporated into a Walla Walla silt loam soil with pH 5.4 and organic matter of 2%.

The yields of Andre and Clark (both two-row barleys) were significantly reduced, when compared to the untreated check, by chlorsulfuron at 52 g/ha. Herbicide treatments did not significantly affect the yields of any wheats or six-row barleys.

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SELECTION OF GLYPHOSATE-TOLERANT FIELD PEAS (*PISUM SATIVUM*)

S.P. Yenne, D.C. Thill, D. LeTourneau and D.L. Auld

Abstract. Different varieties of field peas (*Pisum sativum* L.) exhibit differential tolerance to the herbicide, glyphosate [*N*-(phosphonomethyl) glycine]. Three glyphosate susceptible, intermediately susceptible and tolerant varieties were selected from preliminary field experiments for additional testing. The effect of root versus liquid cell culture exposure to glyphosate on the differential susceptibility between the varieties and the use of tissue culture techniques to increase glyphosate tolerance in peas were investigated. Also investigated was the relationship between shikimic acid accumulation and glyphosate susceptibility. In root exposure experiments, germinated pea seeds were exposed to 0, 0.1, 0.5, and 1.0 mmole solutions of technical grade glyphosate in growth pouches for six days. Root length among the nine varieties in the 1.0 mmole concentration of glyphosate ranged from 35 to 89% of the untreated controls. Four varieties (Melrose, Glacier, Alaska and Frogel) were selected from the root experiment for use in liquid cell cultures. The cell cultures were initiated from excised cotyledonary nodes of each variety. After establishing the stock cell cultures for each variety, cells were transferred in a stepwise manner every 10 to 14 days onto media containing 0.01, 0.1, 0.5, 1.0, 5.0, 0.0 and then 1.0 mmoles of glyphosate. The packed cell volume was measured at each transfer time and cells were harvested for shikimic acid analysis before the glyphosate concentration was changed. Increasing concentrations of glyphosate did not affect the packed cell volume until the glyphosate concentration was increased to 1.0 mM. Packed cell volumes continued to decrease at 5.0 mM and when the cells were removed from glyphosate. When the cells were inoculated back onto glyphosate containing media PCV's decreased in Alaska, remained the same in Frogel and increased in Melrose and Glacier when compared to the PCV's at 5.0 mM of glyphosate. Shikimic acid didn't start to accumulate until the glyphosate concentration reached 0.5 mM with Glacier, 1.0 mM with Alaska and Frogel and 5.0 mM with Melrose. At 1.0 mM shikimic acid accumulation decreased and PCV increased in Glacier; indicating that enolpyruvyl shikimate phosphate synthase (enzyme inhibited by glyphosate) may have been altered.

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EFFECTS OF SIX HERBICIDES ON GROWTH, NODULATION AND NITROGEN FIXATION OF PEAS

E.M. Pomela and R.H. Callihan[1]

Abstract. The use of herbicides for weed control in peas is wide spread; however, susceptibility of pea nitrogen fixation processes to varying rates of herbicides is not known. This study was therefore initiated to measure

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herbicidal effects on pea nitrogen fixation as measured by nodulation and acetylene reduction activity. Since nitrogen fixation is dependent on available carbon, herbicidal effects on height and on root and shoot biomass were measured and correlated to nitrogen fixation responses.

Six herbicides: alachlor (2-chloro-(2,6-diethylphenyl)-N-(methoxy-methyl)acetamide), diclofop-methyl) (Methyl 2-[4-(2,4-dichlorophenoxy)-phenoxy]propanoic acid), MCPB (4-(4-chloro-2-methyl-phenoxy)butanoic acid, metribuzin, (4-amino-6-(1,1-dimethylethyl-3-methylthio)-as-triazine-5-(4H)-one, tiallate (S-(2,3,3-trichloro-2-propenyl)bis(1-methylethyl)-carbamothioate and trifluralin (2,6-dinitro-N,N-4-(trifluromethyl) benzamine) were applied at their recommended time of application in field (recommended), and twice and four times the commercial rates in the split-plot design in both the field and greenhouse. The rates of herbicides used in the greenhouse soil cultures were half those used in field studies.

Plant growth (height, and root and shoot biomass), nodulation (nodule numbers and weight), and nitrogen fixation (acetylene reduction) measurements were measured at early (14 days), middle (28 days) and mature (52 days) growth stages of peas.

Alachlor, diclofop-methyl and triallate had no significant effects on growth, nodulation and nitrogen fixation of peas. MCPB at 1.00 lb ai/acre significantly increased nitrogen fixation. Metribuzin and trifluralin decreased nitrogen fixation at all stages of growth. Metribuzin at 0.5 and 1.0 lb/acre and trifluralin at 1.0 and 2.00 lb/acre decreased pea growth and nodulation.

SMALL GRAIN RESPONSE TO HERBICIDES

D.A. Martin, S.D. Miller and H.P. Alley

Abstract. Misapplication of herbicides to small grains can reduce yield and crop quality dramatically. Ten herbicide treatments were applied to weed free winter wheat (*Triticum aestivum* L. "Buckskin"), spring wheat (*Triticum aestivum* L. "Oslo") and spring barley (*Hordeum vulgare* L. "Steptoe") at three predetermined growth stages in 1984 and 1985 to evaluate their effects on yield and crop quality.

Auxin herbicides applied at the 2-4 leaf stage caused the greatest yield reduction in winter wheat. Yield reductions could not be consistently correlated to effects on yield components. 2,4-D [(2,4-dichlorophenoxy)-acetic acid] applied at the 2-4 leaf stage reduced plant height with the ester formulation causing a greater reduction than the amine.

Spring wheat yields in 1985 were reduced by dicamba (3,6-dichloro-o-anisic acid) + 2,4-D at 0.14 + 0.42 kg/ha applied at the fully tillered stage and by dicamba at 0.14 kg/ha and dicamba + MCPA (2-methyl-4-chloro-phenoxyacetic acid) at 0.14 + 0.42 kg/ha applied at the boot stage. Results in 1984 were similar; however, differences were not significant. Yield reductions were generally due to a reduction in kernels/spike.

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Treatments applied to barley at the fully tillered stage resulted in the highest yields. Dicamba at 0.14 kg/ha and dicamba + MCPA at 0.14 + 0.42 kg/ha reduced yield at all growth stages, though differences in 1985 were not significant. Dicamba at 0.14 kg/ha and dicamba + 2,4-D at 0.14 + 0.42 kg/ha decreased kernel weight when applied to fully tillered barley.

Seed protein content of spring wheat and barley was generally increased by auxin herbicides, with the effect most evident in treatments applied at the fully tillered and boot stages. Similar results were found in winter wheat in 1984; however, 1985 data was not consistent with this trend. Changes in amino acid composition of seed proteins may accompany altered protein synthesis in response to herbicide treatment and warrants investigation.

LIFE CYCLE AND POPULATION DYNAMICS OF YELLOW FOXTAIL IN ESTABLISHED ALFALFA

Steven E. Jacobsen and Russell W. Wallace[1]

Introduction

Yellow foxtail (Setaria glauca L. Beauv.) is a summer annual grass that has become an economic pest in California alfalfa (Medicago sativa L.). A University of California Cooperative Extension Service survey revealed that in nine central valley counties yellow foxtail is the most serious summer annual weed problem in alfalfa hay fields (1).

Previous studies have demonstrated that many of yellow foxtail's biological characteristics may contribute to its adaptation to an established alfalfa hay environment. Yellow foxtail can emerge as early as February or March (2, 5, 6, 9, 11) and can achieve rapid germination when soil temperatures reach approximately 16° C and there is adequate soil moisture (1, 3). Under favorable conditions Setaria glauca) is known to be a prolific seed producer, with ranges from 540 to 8,460 seeds per plant being reported (4). This seed has a two- to four-month post harvest after-ripening period (2, 3, 4, 5, 7) which allows yellow foxtail to germinate the following late winter or early spring when growing conditions are again favorable.

These studies were initiated to ascertain the seasonal field life cycle of Setaria glauca in established alfalfa, time of emergence and its influence on length of growth stages and population dynamics, and germination and emergence potential after seed dispersal.

Materials and Methods

Two field studies, located in second year alfalfa fields in Fresno, California, were initiated during the 1984 and 1985 growing seasons. The experimental areas had no known previous yellow foxtail infestation and were treated with low rates of hexazinone and dinoseb for winter weed control, prior to trial initiation. Laboratory germination tests were also conducted in both years whereas the field emergence trial was carried out only in 1985.

Experiment 1: Seasonal Field Life Cycle

In both field studies, alfalfa plots in a completely randomized design were overseeded with Setaria glauca seed on December 12, 1983, and on March 20, 1985. In the 1984 experiment, two-year-old seed, collected from a Tulare County alfalfa field was used, and one-year-old seed collected in September, 1984, from an alfalfa field in Davis, California, was used in 1985. The experimental area was overseeded with 5,382 seeds (with 54% viability) per square meter in the 1984 field study and 299 seeds (with 92% viability) per square meter in 1985. During the 1984 experiment, plots were irrigated following normal irrigation schedules, whereas in 1985, plots were irrigated more frequently to favor the germination and growth of yellow foxtail. In both field studies, plots were mowed as needed. At Setaria

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glauca flowering, plots were hand cut with a scythe to minimize seedhead removal.

Data taken from Experiment 1 included yellow foxtail stand counts, tiller and seedhead production, seed production (1985 only), plant senescence, initial dates of all growth stages and alfalfa stand counts. A self-recording thermograph was used to obtain daily soil surface temperatures, and air temperatures were obtained from a weather station located within 3.2 kilometers of the field study.

Experiment 2: Time of Emergence and Its Influence on Length of Growth Stages and Population Dynamics

Experimental methods used and data taken were as for Experiment 1, except that existing yellow foxtail plants present in monthly treatment plots were removed at the beginning of each month; and dates of new emergence, tillering, flowering, seed maturation and plant senescence were recorded. In the 1984 field study, Experiment 2 consisted of eight non-replicated treatments (February through September) with additional data from a natural field population located within 450 meters of the test site. The 1985 field study utilized three replications of seven treatments (March through September) in a randomized complete block design.

Experiment 3: Germination and Emergence Potential After Seed Dispersal

Setaria glauca seed, collected on July 23, 1984, and August 9, 1985, from within the experimental areas, was tested for germination in the laboratory at monthly (1984) and weekly (1985) intervals. Four replications of 50 mature seeds were placed on moistened paper in petri dishes at 22 +/- 3 C° and with a 12-hour photoperiod. Germination percentages were recorded at the end of 17 days. Seed harvested in 1984 was stored outside in Fresno, California, whereas the 1985 seed was stored at a constant temperature of 22 +/- 3° C.

A field study was established to determine if a second generation of Setaria glauca was possible within one season. Six 0.25 square meter plots were overseeded on August 10, 1985, with the first dispersed seed from Experiment 1 in the 1985 field study.

Data from the field studies and laboratory tests were analyzed using statistical procedures from Microcomputer Statistics (MSTAT), Michigan State University.

Results and Discussion

Experiment 1: Seasonal Field Life Cycle

Setaria glauca seedling emergence began in late February in the 1984 field study and continued until a maximum population of 219 plants per square meter was achieved in May. In 1985, seedling emergence began in mid-March and reached 118 plants per square meter in August. These emergence dates confirm results of a University of California Extension Service Survey (1) that reported that yellow foxtail emergence begins in late February to early March throughout central California.

The formation of basally arising culms, or tillers, began six to ten weeks following initial plant emergence (early May in both years tested). At the 2 to 3 tiller stage the plants prostrate nature becomes apparent. This prostrate growth allows the plant to survive the frequent mowing associated with hay production (2, 8). As reported by others (4, 5, 6), tiller and seedhead production were affected by plant density; there is, as density decreased, the number of tillers and seedheads per plants were increased (Table 1). These data indicate that light infestations of *Setaria glauca* may exert a competitive effect equal to that of heavier infestations.

Table 1. *Setaria glauca* plant density and its effect on individual plant tiller and seedhead production.

Density (plants per meter)	Tillers per plant	Seedheads per plant
143.5	2.1	1.2
113.6	3.0	0.7
74.8	4.8	1.4
44.9	5.6	4.2
9.6	6.6	5.1
observation date:	5/24/84	8/15/84

Inflorescence emergence began in late June to early July, 15 weeks after initial seedling emergence. Results of the University of California statewide survey would substantiate this time period for all of central California (1). Seed maturation and dispersal occurs three to four weeks after seedhead (panicle) appearance. This short period allows *Setaria glauca* plants to disperse seed between normal alfalfa hay cuttings. *Steel, et al.* (10) reported that seeds fall free from subtending awns or bristles which are then left to contaminate the hay. Furthermore, after the first seed dispersal, the plant initiates culm branching which increases the number of seedheads per plant tiller. In 1984 this was observed to begin in late August and continue until the first frost. The total mature seedhead production was 112 seedheads per square meter by August 10 in the 1984 experiment and 1,495 seedheads per square meter by November 16, 1985 (after first frost).

Senescence, or aging of the plant, was first recorded in late August to early September in both field studies. These first symptoms of senescence included purpling of the flag leaf margins and chlorosis of individual plant tillers. In 1984 no further observations could be made since the study was terminated in September. In 1985, however, the first plant death was recorded on September 22; this occurred within areas of high plant density and may have been due to competition. Most plants within the field study (91%) died shortly after the first frost in mid-November. All Setaria glauca plants within the experimental area were dead by December 28, 1985, confirming that yellow foxtail is an annual plant (10).

Experiment 2: Time of Emergence and Its Influence on Length of Growth Stages and Population Dynamics

The field life cycle of Setaria glauca varied in relation to the month of emergence (Figure 1). Plants emerging in February 1984 and March 1985 exhibited longer established periods as compared to emergence in May. Flowering was initiated during mid-June to early July for plants that emerged in February through June, demonstrating the short day response of the species. Plants that emerged in June had a short tiller growth stage and flowered within seven weeks, (10.2 to 15.2 cms. in height). Plants emerging in August produced no tillers and flowered at the 3 to 4 leaf stage (5 cms. in height). Thus Setaria glauca demonstrated the potential for all plants emerging throughout the growing season to produce mature seed.

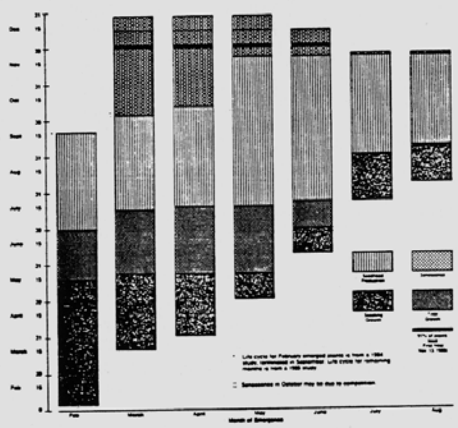

Figure 1. Growth stages of yellow foxtail in relation to month of emergence

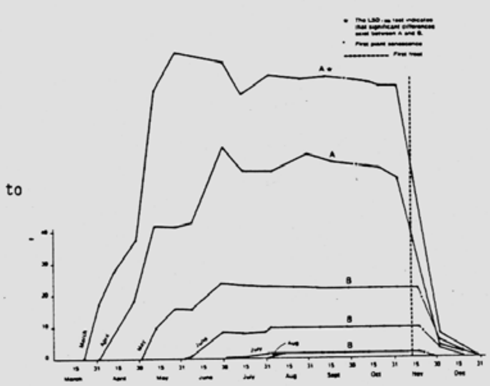

Figure 2. Setaria glauca populations in relation to month of seedling emergence

Potential yellow foxtail populations also varied in relation to month of emergence (Figure 2). Although there was no February emergence in 1985, yellow foxtail emergence was highest from February to April for the two years tested. in 1985, emergence percentages for the months of March through June were 5.7, 6.1, 5.1, and 2.7, respectively. In July and August, only 0.5% emergence was recorded in 1985, and no emergence occurred in 1984. Although not quantified, seedling emergence was observed outside the experimental area in July and August 1984. In both field studies, no seedlings emerged in September. The cumulative seasonal emergence was 3.4% of 5,382 seeds sown per square meter in the 1984 field study (2-year-old seed) and 39.6% of 299 seeds sown in 1985 (one-year-old seed).

Setaria glauca seedhead production was affected by changes in plant density and length of growth stages. Plants remaining in monthly treatment plots in 1985 demonstrated notable differences in seedhead production and ultimately viable seed production (Table 2). Results in Table 2 demonstrate that an alfalfa field with less than one seedhead per square meter has the potential to produce 43 plants per square meter the following season.

Table 2. Total Seedheads Produced and Estimated Seed Production in 1985

Month of Seedling Emergence	Actual Seedheads/M^2	Calculated Kg. of seed/ha.	Calculated Seeds/ha. (millions)
March	1,464	2,173	1,976
April	1,083	1,608	1,462
May	574	852	775
June	185	274	249
July	1.6	2.4	2.1
August	0.8	1.2	1.1

It was also observed that _Setaria glauca_ plant density had an effect on alfalfa plant density, for when yellow foxtail plant densities increases, alfalfa stands were decreased (Table 3). In addition, alfalfa crowns in areas of high _Setaria glauca_ plant density would resume top growth only after the death or removal of yellow foxtail plants. This may indicate that, when in competition with yellow foxtail, alfalfa plants are only suppressed.

Table 3. _Setaria glauca_ plant density and its effect on alfalfa stands

Yellow Foxtail plants/M^2	Alfalfa plants/M^2	Total
.8	273.6	274.4
8.3	251.2	259.5
21.9	221.6	243.5
57.8	214.4	272.2
93.4	181.4	274.8

observation date: August 24, 1985

Experiment 3: Germination and Emergence Potential After Seed Dispersal

The first mature seed in both field studies was collected and tested for germination immediately and at monthly or weekly intervals. Results from the 1984 seed are shown in Figure 3. Germination potential of 1985 seed was 0% within 12 weeks and only 28% at 26 weeks after harvest. The

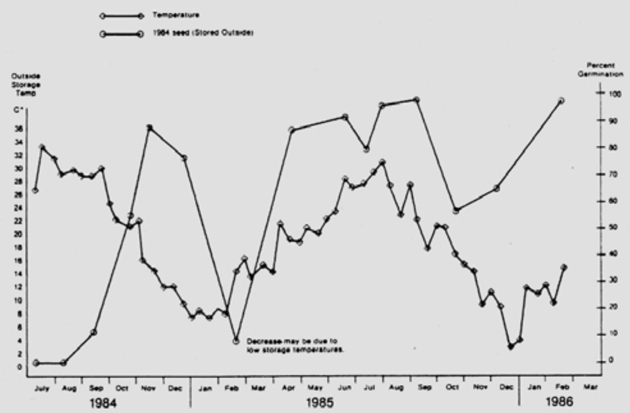

Figure 3. Germination potential of yellow foxtail seed after dispersal.

difference in the time required to complete after-ripening in these two seed lots may be due to differences in storage conditions as noted by others (10). These results show that Setaria glauca has a two- to four-month after-ripening period (3, 4, 5). The 1984 seed, which was exposed to outside fluctuating temperatures, demonstrated temperature-germination relationships (Figure 3). As storage temperatures decreased, potential yellow foxtail germination percentages were decreased.

A field emergence trial determined that a second generation of Setaria glauca was not possible within the 1985 season. Of the seed sown on alfalfa plots in August 1985, 0% emergence occurred before the first frost (15 weeks after sowing), and therefore emergence did not occur until February 1986.

The tests on the 1984 and 1985 seed lots and the field emergence trial are still in progress.

Summary

Yellow foxtail (Setaria glauca L. Beauv), a problem weed in California alfalfa, was investigated during 1984 and 1985 to determine its seasonal life cycle, a time of emergence and its influence on length of growth stages and population dynamics, and germination and emergence potential after seed dispersal. In 1984 and 1985 field studies, second year alfalfa plots were overseeded with yellow foxtail. Setaria glauca demonstrated the potential

to emerge as early as February and continue through August, with most seedlings emerging from February to April. Later emergence dates affected the length and/or presence of growth stages and decreased plant population and seedhead production. Post harvest tests indicated that seeds have a limited germination potential within two to four months after dispersal, and 1985 data indicated that yellow foxtail can have only one generation within a growing season.

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EFFECT OF SOIL pH ON THE CHEMICAL DEGRADATION OF CHLORSULFURON

Duane G. Flom, Donald C. Thill and Robert H. Callihan[1]

Abstract: The rate of degradation of chlorsulfuron (2-chloro-N-(((4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino)carbonyl)benzenesulfonamide) in soil usually is inversely related to the pH of the soil. Chemical hydrolysis generally is considered to be the major mechanism of degradation in acidic soils. A laboratory study was conducted to determine the rate of degradation of chlorsulfuron in six autoclaved soils which differed primarily in pH. Samples of a soil, initially at a pH of 5.9, were treated with sufficient 1.0 M sodium hydroxide (NaOH) or 0.1 M aluminum sulfate [$Al_2(SO_4)_3$] to alter pH to 4.0, 5.1, 6.0, 6.8, 8.0 and 9.0. ^{14}C-chlorsulfuron, labeled on the phenyl ring, was applied at a rate of 147 ppb (w/w) to 50 g samples of each soil. Specific activity was 0.085 μCi per 50 grams of soil. Soil samples had an initial moisture content of approximately 80% of field capacity and were incubated in the dark at a constant temperature of 30 C for 6 to 12 weeks. Soil samples were mixed with 100 ml of 0.1 M Na_2CO_3 - 0.1 M NaCCO3 buffer solution on a reciprocal shaker for 30 min and centrifuged at 10,000 rpm for 10 min. The pH of the supernatant was lowered to the range of 3 to 4 using 10% HCl, and the radiolabeled compounds were extracted with 100 ml of dichloromethane. The dichloromethane was evaporated to dryness under reduced pressure in a 45 C water bath. The labeled compounds were redissolved in dichloromethane and a 50 μl sample was spotted on a thin-layer silica gel chromatographic plate, and the chromatogram was developed with acetyl acetate: acetic acid (99:1). One cm increments of the silica gel were scraped from each plate beginning with the origin and placed into individual vials, and the radio- activity was measured using standard liquid scintillation techniques. Initial extraction efficiency was approximately 95% of the applied labeled compound. Extraction efficiency decreased with increasing age of the soil samples. Degradation rates increased as soil pH decreased. At six weeks, approximately 90% of the ^{14}C-chlorsulfuron applied to the pH, four soil samples were converted to the primary metabolite whereas in the pH nine soils samples, over 90% was the parent chlorsulfuron molecule.

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EXPERIMENTAL CONTROL OF SOIL WATER CONTENT

Daniel W. Kidder and Richard Behrens[1]

Abstract. A semipermeable membrane system was modified and evaluated for growing weed seedling at reproducible levels of water stress. The lumen of a 7.6 cm diameter semipermeable membrane (Spectra/Por 1) was conformed to thicknesses of 4, 2 and 1 cm. The membrane units were filled with soil and

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placed in buckets containing polyethylene glycol (PEG) 10,000 solutions. Soil water in the 1 cm thick units equilibrated with the external osmoticums within three to five days. The thicker units required slightly longer equilibration times. Water content of equilibrated units approximated values obtained by conventional pressure plate and pressure membrane devices. Water potential of green foxtail [*Setaria viridus* (L.) P. Beauv. #SETVI] in equilibrated membrane units was linearly related to the external osmoticum potential. This relationship permits nondestructive estimation of plant water potential. Green foxtail growth was reduced with decreasing osmoticum potential and completely arrested in -800 KPa osmoticum. The technique makes possible precise control of water stress intensity and duration for studies on seedling plants.

TOXICITY AND PYRROLIZIDINE ALKALOID CONTENT OF *CROTALARIA* SEED

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

Abstract. Several species of *Crotalaria* contain toxic levels of pyrrolizidine alkaloids (PA). The foliage and seed of two introduced species, *Crotalaria retusa* L. and *C. spectabilis* Roth, are highly toxic and cause losses in livestock and poultry.

Seed of 41 species of foreign *Crotalaria* were obtained from U.S. Department of Agriculture repositories and tested for toxicity to one-week-old chicks and for concentration of PA. Chicks were fed ground seed of all species in one dose at 10 mg/g of body weight. Seed of species that were toxic were fed in lower doses to establish in LD_{50} (lethal dose that kills 50% of the chicks). Seed of all species were analyzed for concentration of PA at the Western Regional Research Center, Berkeley, CA.

The percent PA and LD_{50} (mg of seed/g of body weight) for seed of four toxic species were: *Crotalaria quinquefolia* L. (PA = 1.2%, LD_{50} = 6.0 mg/g), *C. alata* Leveille (PA = 1.6%, LD_{50} = 4.0 mg/g), *C. retusa* (PA = 2.7%, LD_{50} = 2.0 mg/g), and *C. spectabilis* (PA - 3.9%, LD_{50} = 2.0 mg/g). The primary PA in these species was monocrotaline. *Crotalaria argyrolobioides* Bak. (PA= 1.0%) produced toxic signs but no deaths. All other species contained less than 0.6% PA and were nontoxic as tested. Seed of three species tested negative for PA: *Crotalaria australis* (E.G. Baker) E.G. Baker ex Verdoorn, *C. maxillaris* Klotzsch and *C. sphaerocarpa* Perr. ex DC.

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IMPACTS OF THREE YEARS OF HEXAZINONE APPLICATION TO ALFALFA ON SUBSEQUENT CROPS

Robert F. Norris[1]

Abstract. Hexazinone [3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione] was applied to alfalfa (Medicago sativa L. 'Moapa 69') to control winter annual weeds in the winter of 1982, 1983 and 1984. The same plots were retreated each year at rates of either 0.55, 1.1 and 0.55 kg/ai/ha respectively each year or with 0.55 and 1.1 kg/ha in 1982 and 1983 only. The experiment was conducted at the University of California farm at Davis on a Brentwood silt loam soil. Practices typical of alfalfa production in the Central Valley of California were followed: the alfalfa was cut six times per year, was flood irrigated twice between each cutting and no fertilizers were utilized. The field was mold-board plowed and harrowed on October 31, 1984, at the end of the fourth cutting season to remove the alfalfa. Wheat (Triticum aestivum L. 'Anza') was drill seeded directly following ground preparation. No fertilizer was applied to the field. Sufficient rainfall occurred for germination and initial growth. The field was flood irrigated March 4, April 10 and April 26, 1985, to maintain later growth. Visual observation of the crop on December 28, 1984, indicated no differences in crop vigor in relation to the prior hexazinone treatments. Visual observation of crop injury on June 24, 1985, prior to harvest were 40 ± 16% for the untreated check, 72 ± 20% for the two-year treatment and 98 ± 2% for the three years of treatment on a scale of 0 equaled dead and 100 equaled full vigor. The wheat was harvested on July 12, 1985; the untreated check had the lowest yield, and the plots receiving hexazinone each prior year had the highest yield. On May 1, 1985, a set of plots were planted with cotton (Gossypium hirsutum L. 'SJ-5'), kidney beans (Phaseolus vulgaris L. 'Sutter pink'), sugarbeets (Beta vulgaris L. 'SS-YI'), tomatoes (Lycopersicon esculentum L. 'VF 145-B 7879') and grain sorghum (Sorghum vulgare L. 'NC+Hybrid') and irrigated on May 7, 1985. Normal cropping practices for these crops were carried out, including appropriate spraying for weed, insect and disease control. The crops did not exhibit symptoms of herbicide damage at any stage during the growing season. Crop biomass and harvestable yield were obtained at maturity. The yields of the crops showed considerable variability, but there were no differences that corresponded with the hexazinone treatments in the preceding alfalfa crop. Under the conditions of this experiment, there was no evidence of adverse affects of hexazinone applied to alfalfa on the rotational crops sowed after the alfalfa had been plowed-out. The increase in yield in the wheat following three successive years of hexazinone treatments was attributed to the lack of weeds due to depletion of the seed bank and to the greater amount of alfalfa destroyed.

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Crop yields following alfalfa that had been treated two or three years for winter weed control with hexazinone.

		Crop yields		
		Hexazinone treatment (yr, kg ai/ha)		
			1982 1983	1982 1983 1984
Crop	Yield component	Untreated	0.55 1.1	0.55 1.1 0.55
		(kg/ha ± SE)		
Cotton	Tops fr. wt.	19200 ± 1400	23600 ± 4000	23400 ± 3700
	Bolls fr. wt.	20000 ± 2200	20000 ± 2600	20600 ± 2900
Tomato	Tops fr. wt.	21100 ± 5000	23000 ± 7000	23200 ± 6100
	Ripe fruit	62500 ± 9900	56200 ±26000	66100 ±26000
Beans	Dry tops	2680 ± 770	3000 ± 310	3110 ± 710
	Dry beans	2530 ± 980	2950 ± 450	3280 ± 590
Sorghum	Tops biomass	34000 ± 2000	32400 ± 2200	35300 ± 3300
	Dry grain	7950 ± 470	7880 ± 900	7440 ± 900
Sugarbeets	Tops fr. wt.	30100 ± 7300	19900 ± 2100	28000 ± 4000
	Roots fr. wt.	46200 ± 7700	40000 ± 9200	42900 ± 4400
Wheat	Dry grain.	2290 ± 800	4250 ± 1860	6380 ± 970

THE PROBABLE CAUSES OF HEXAZINONE INJURY TO ALFALFA

Mark Stannard, Peter K. Fay and James Nelson[1]

Introduction

There is a small certified alfalfa seed production industry in Montana. Weeds must be controlled because weed seed contamination of harvested alfalfa seed severely reduces seed quality. Although weed control is extremely important, the number of herbicides available for use in alfalfa is small. Hexazinone (3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine,-2,4)1H,3H)-dione) has been the most effective and commonly used herbicide by alfalfa seed producers in Montana.

Forty-two percent of the alfalfa seed producers in Montana used hexazinone in 1984 or 1985. It is popular because it controls a broad spectrum of weeds. Although hexazinone is a valuable herbicide, there has been considerable hexazinone injury to alfalfa reported in the last three years. In response to hexazinone injury, the DuPont Company has elected to withdraw the hexazinone label for use on seed alfalfa in Montana.

The purpose of this study was to determine the cause of hexazinone injury to alfalfa in an attempt to amend the current label to permit relabeling and safe use in Montana.

Methods and Materials

Three methods were used to collect information on the use of hexazinone on alfalfa. First, a weed survey was conducted in the summer of 1985. Second, a lengthy questionnaire related to the use of hexazinone was administered to the alfalfa seed producers. The third aspect of the study involved analysis of soil from fields where hexazinone was applied.

A total of 36 alfalfa seed production fields were surveyed. The weed density and frequency was measured in 20 one-meter locations in each field. The producer who farmed each of the surveyed fields completed a detailed questionnaire relating to his use of hexazinone.

The soil factors investigated as possible factors in hexazinone injury to alfalfa were soil texture, pH, electrical conductivity, calcium and sodium content, organic matter and cation exchange capacity.

Results and Discussion

The fifteen most frequently occurring weeds in Montana alfalfa seed fields are shown in Table 1. Ten of the fifteen most common weeds in alfalfa grown for seed are effectively controlled by hexazinone. Canada thistle, common dandelion and foxtail barley are suppressed by hexazinone. Hexazinone is a valuable herbicide for the Montana alfalfa seed producers because thirteen of the fifteen most frequently occurring weeds are either controlled or suppressed by hexazinone.

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Table 1. The 15 most frequently occurring weeds in alfalfa seed fields in Montana in 1985.

RANK	WEED	RANK	WEED
1.	Kochia (Kochia scoparia L.)	9.	Common Dandelion + (Taraxicum officale)
2.	Wild Oats *[1] (Avena fatua L.)	10.	Redroot Pigweed * (Amaranthus retroflexus)
3.	Green Foxtail * (Setaria viridis L.)	11.	Prickly Lettuce * (Lactuca serriola L.)
4.	Field Bindweed (Convolvulus arvensis L.)	12.	Barnyardgrass * (Echinochloa crus-galli)
5.	Canada Thistle +[2] (Cirsium arvense L.)	13.	Foxtail Barley + (Hordeum jubatum L.)
6.	Russian Thistle * (Salsola kali L.)	14.	Quackgrass * (Agropyron repens L.)
7.	Tansymustard * (Descurainia pinnata)	15.	Yellow Sweetclover * (Melilotus officinalis)
8.	Downy Brome * (Bromus tectorum L.)		

1 Weeds denoted by an asterisk are effectively controlled by hexazinone.

2 Weeds denoted by + are suppressed by hexazinone.

We identified nineteen producers that had used hexazinone. Seven of these producers had alfalfa injury on a total of eight fields following application of hexazinone. Twelve producers had no hexazinone injury on a total of thirteen fields. We based our discussion below on this sample population of nineteen producers. While this population is too small to permit firm conclusions, it should be noted that we were dealing with almost the entire population of seed producers who used hexazinone.

Three agronomic factors were analyzed as possible causes of hexazinone injury. First, successive annual applications where hexazinone was applied two or three years in a row, was considered. Secondly, application of hexazinone to nondormant, actively growing alfalfa was considered. We also investigated the possibility that certain alfalfa varieties are more sensitive to hexazinone. There appears to be no relationship between alfalfa variety and hexazinone injury since several varieties occurred both in fields with and without injury.

There were twelve producers that applied hexazinone in consecutive years. Three of these producers reported alfalfa injury. All three fields had high rates of hexazinone applied the second year. We propose that successive applications of hexazinone applied twelve months after the first application should be applied at rates equal to or less than the rates put on the first year of application. A more conservative label would state that hexazinone should be applied only once in twenty-four months to avoid the possibility of herbicide accumulation.

Two producers applied hexazinone to nondormant alfalfa, and both reported hexazinone injury which was described as chlorosis of the upper leaves and stunting of the crop. The current hexazinone label states that hexazinone should not be applied to actively growing alfalfa. We suggest that this part of the label receive increasing emphasis.

The only soil factors significantly correlated to injury were soil texture and organic matter. The average organic matter content for fields with injury was 1.8% (n=7, SE=.3). The organic matter for the fields without injury was 2.9% (n=13, SE=.2). The current label states that hexazinone should not be applied to gravelly soils with less than 1% organic matter. We feel that this portion of the label is not conservative enough.

In general, the soils in fields with injury were more coarse textured than the fields without injury. The sand content for the fields with alfalfa injury ranged from 12% to 77% with a mean of 47%. The sand content for the fields without injury ranged from 11% to 55% with a mean of 30%. The clay content for fields with injury ranged from 10% to 73% with a mean of 26%. The clay content for the fields with no injury ranged from 15% to 52% with a mean of 33%.

Coarse-textured soils are most droughty than fine textured soils. The current hexazinone label states that hexazinone should not be applied when under stress from weather conditions or from damage from insects or diseases. This statement is meaningless in Montana, since hexazinone is applied when there is not stress. We propose that hexazinone should only be labeled for use on irrigated fields in Montana. In addition, hexazinone should not be applied to coarse-textured soils where availability of irrigation water is limited. In conclusion, hexazinone injury potential appears to increase dramatically when drought stress occurs.

Hexazinone is a valuable herbicide for Montana alfalfa seed producers. We feel that the herbicide could be relabeled for use in seed alfalfa in Montana by adopting the label changes discussed above. We feel that these changes will lead to prevention of crop damage and a return to profitability for this valuable product.

EFFICACY AND ECONOMIC EVALUATIONS OF HERBICIDE TANKMIX APPLICATIONS TO CONTROL WINTER ANNUAL WEEDS OF DORMANT ALFALFA

Jerry Schmierer and Larry W. Mitich[1]

Introduction

Winter annual weeds are the major weed problem associated with growing alfalfa hay in the northeastern mountain valleys of California. The weed spectrum and growing conditions of these valleys are very similar to those of northern Nevada and central Oregon. The control of these winter annual weeds is important economically to the hay producer who markets hay in the California dairy hay market.

Even though there are some inexpensive and effective herbicides available that alfalfa growers can use in the fall after the last cutting to control winter annual weeds and prior to weed emergence, (i.e. simazine and diuron), these herbicides are not widely used. The reason for this lack of use is that the common practice is to graze the alfalfa regrowth in the fall following the third cutting. During this period of time, rainfall usually

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occurs that is sufficient to sprout some of our winter annual weeds. A third factor is that the timing of a herbicide application is usually such that it will not allow sufficient time for the preharvest interval before grazing.

The most probable timing for winter annual weed control would be in late fall, after the cows are removed from the field, until mid spring when the alfalfa breaks dormancy. The herbicide trials that are reported in this paper were applied during the late fall to late spring time period. In almost every case, there were winter annual weeds already germinated.

Materials and Methods

A series of nineteen separate evaluation trials were conducted on alfalfa over a four-year period from 1982 to 1985 in Lassen County, California. The evaluations of these trials were done on the prevalent weeds to the area: downy brome (*Bromus tectorum*), wild barley (*Hordeum leporinum*), bulbous bluegrass (*Poa bulbosa*), shepardspurse (*Capsella bursa-pastoris*), shield cress or yellowflower pepperweed (*Lepidium pertoliatum*) and tansy mustard (*Descurainia pinnata*). The herbicides tested as to their control of the above weeds were: 2,4-DB (4-(2,4-dichlorophenoxy) butyric acid); simazine (2-chloro-4,6-bis(ethylamino)-s-triazine); diuron (3-(3,4-dichlorophenyl)-1,1-dimethylurea); metribuzin (4-amino-6-tert-butyl-3-(methylthio)as-triazin-5(4*H*)-one); hexazinone (3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1*H*,3*H*)-dione); and paraquat (1,1'dimethyl-4,4'bipyridinium ion).

Trial sites were selected in grower cooperator fields for the specific objective to be evaluated. All of the trials were randomized in a randomized complete block design using the MSTAT microcomputer program. Each trial had either three or four replications. Herbicides were applied with a CO_2 constant pressure sprayer with mechanical means of agitation.

Each individual plot measured 10 feet wide by 25 feet long. Application of herbicides were made to the center 6 feet of the 10-foot wide plots. Evaluations of herbicide efficacy and crop sensitivity were done by visually comparing the treated area in each plot to the adjacent untreated area. After evaluations were taken, the crop in the plots that were treated with unregistered compounds were destroyed using a forage chopper and the residue removed from the field and destroyed.

Herbicide cost analysis was accomplished by obtaining current list prices of the various herbicides from local Susanville area agri-chemical retail dealers. The herbicide prices that were used did not reflect any discounts for volume purchases. The costs that are reported are for herbicides only and do not include the cost of the actual application of the herbicide.

Results and Discussion

Figure 1 shows the average efficacy rating for the 1983 trials. Four separate trials were used in this figure. The broadleaf weeds evaluated were shepardspurse, prickley lettuce and tansy mustard. Downy brome was the grass that was evaluated in these trials. Simazine at 0.8 lb. ai/ac was not effective in these trials because the applications were made after weed emergence. Hexazinone at the 0.25 lb ai/ac was adequate to control the broadleaf weeds but only provided partial control of downy brome. Paraquat at 0.375 lb ai/ac did not provide adequate control of either broadleaf or grass weeds.

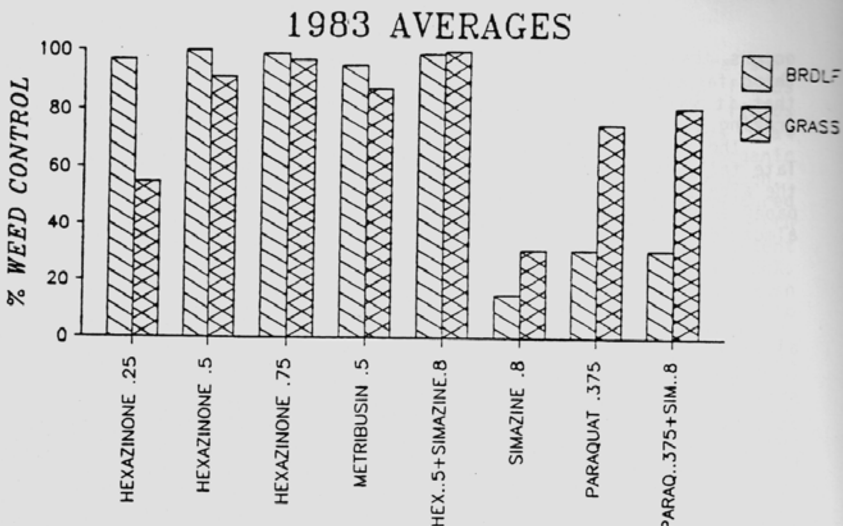

FIGURE 1. BROADLEAF WEEDS: SHEPARDSPURSE, PRICKLEY LETTUCE, AND TANSY MUSTARD. GRASS WEEDS: DOWNY BROME.

Figure 2 shows the average efficacy ratings for the 1984 trials. The broadleaf weeds were shepardspurse, and the grass was downy brome. These trials were applied approximately two weeks after the alfalfa had broken dormancy in the spring. The general trend for all the treatments to have less grass control than the 1983 trials can be attributed to the more mature weed stage of development at the time of application.

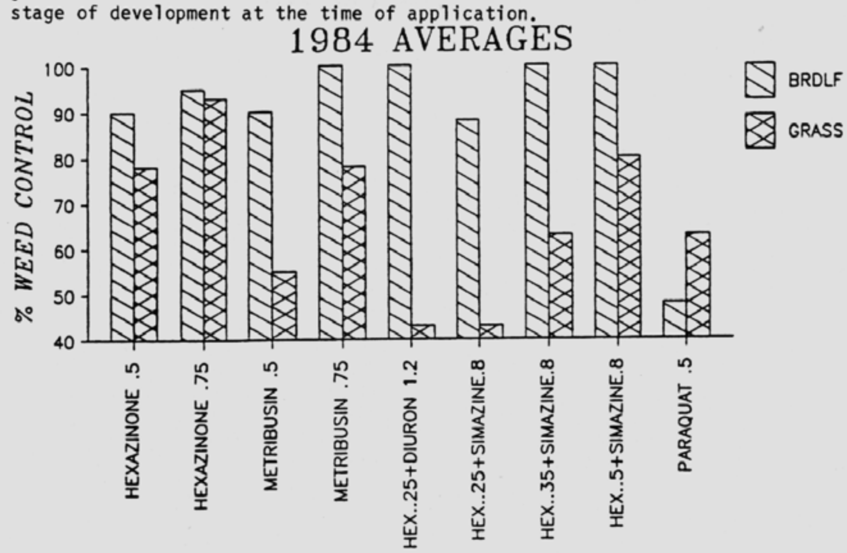

FIGURE 2. BROADLEAF WEEDS: SHEPARDSPURSE
GRASS WEEDS: DOWNY BROME

Figure 3 shows the average efficacy ratings for the 1985 trials. The broadleaf weeds were yellowflower pepperweed, shepardspurse and tansy mustard. The grass weeds were downy brome, wild barley and bulbous bluegrass. The general lack of adequate weed control is once again attributed to application after the alfalfa had broken dormancy and the more mature weed stage of growth. Even at this late date, the tank mix of hexazinone at 0.5 lb ai/ac plus paraquat at 0.5 lb ai/ac provided excellent weed control with comparable crop phytoxicity to paraquat alone at the 0.5 lb ai/ac rate. The hexazone 0.5 lb ai/ac plus 2,4D-B Ester 0.5 lb ai/ac tank mix gave better weed control than either of the herbicides alone at those rates.

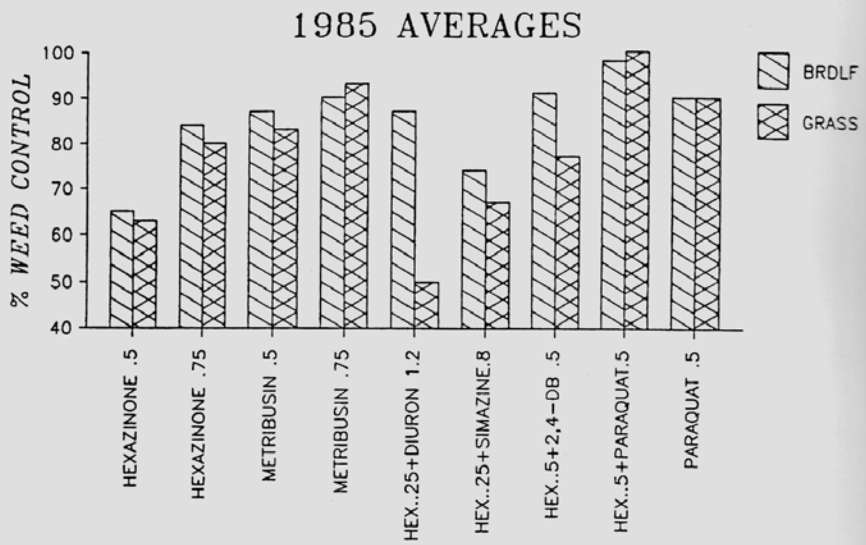

FIGURE 3. BROADLEAF WEEDS: YELLOWFLOWER PEPPERWEED, SHEPARDSPURSE, AND TANSY MUSTARD. GRASS WEEDS: DOWNY BROME, WILD BARLEY, AND BULBOUS BLUEGRASS.

When comparing all three years, some general conclusions can be made. Soil type, herbicide, rate of application, precipitation after application, weed spectrum and weed stage of growth all have interactive effects on the efficacy of the various herbicides. When tank mixing hexazinone and simazine, there is increased efficacy at lower rates when compared to the hexazinone applied by itself. The hexazinone/simazine tank mix seems to be more effective in controlling downy brome than the hexazinone/diuron tank mix. Hexazinone at 0.75 lb ai/ac and metribusin at 0.75 lb ai/ac both provided adequate weed control in most all cases.

Table 1 lists comparable prices for the herbicides used. Figure 4 is a graph using the dollar per acre amounts in Table 1. Rating weed control efficacy is only part of the information needed for an alfalfa grower to

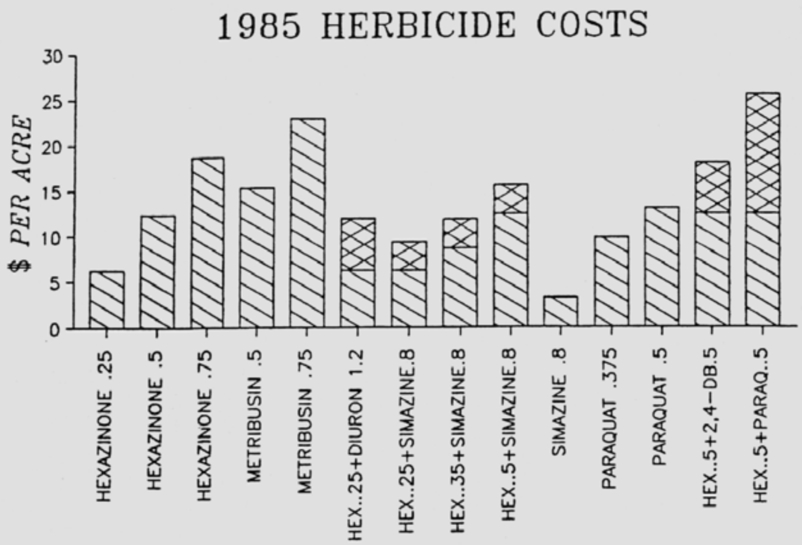

FIGURE 4. 1985 HERBICIDE LIST PRICES, SUSANVILLE, CALIFORNIA.

decide which herbicide and rate to use. In these times of extreme farm financial stress, the economic factor of applying herbicides is definitely a consideration. Figure 4 shows relative costs of herbicides. Obviously, when considering economics as a decision factor, a grower would want to choose a herbicide or herbicide tank mix that gave adequate weed control for the least amount of dollars invested. When looking at the costs of hexazinone at 0.75 lb ai/ac or metribusin at 0.75 lb ai/ac, even though these treatments provide quite satisfactory weed control, the cost of these treatments is not satisfactory when compared to other treatments with similar efficacy and a lower cost.

Conclusion

There were many of the tested herbicides that were effective at controlling the target weeds at the proper rates for the conditions. However, the cost of applying these herbicides at the proper rates for the conditions are often prohibitive to growers. Several of the tank mixes tested, when applied at lower than the normal rates of a singularly applied herbicide, showed equivalent efficacy in controlling weeds while substantially lowering the cost of the application. One such tank mix was a combination of simazine at 0.8 pound ai per acre and hexazinone at 0.35 pound ai per acre. At the rates used for the conditions present, this tank mix was as effective in controlling the target weeds as was hexazinone by itself at 0.75 pound ai per acre. The cost of the tank mix in this instance was $11.82 per acre compared to $18.56 per acre for the hexazinone. Tank mixing currently registered herbicides could be an economically viable alternative in a weed control program for alfalfa.

Table 1. 1985 Herbicide Prices, Susanville, California.

HERBICIDE	RATE LBS. A.I./AC.	ALONE $/AC.	TANK MIX $/AC.
HEXAZINONE	.25	6.19	6.19
HEXAZINONE	.5	12.38	12.38
HEXAZINONE	.75	18.56	18.56
METRIBUSIN	.5	15.23	15.23
METRIBUSIN	.75	22.84	22.84
HEXAZINONE DIURON	.25 1.2	6.19 5.75	11.94
HEXAZINONE SIMAZINE	.25 .8	6.19 3.15	9.34
HEXAZINONE SIMAZINE	.35 .8	8.67 3.15	11.82
HEXAZINONE SIMAZINE	.5 .8	12.38 3.15	15.53
SIMAZINE	.8	3.15	3.15
PARAQUAT	.375	9.74	9.74
PARAQUAT	.5	12.99	12.99
HEXAZINONE 2,4-DB ESTER	.5 .5	12.38 5.49	17.87
HEXAZINONE PARAQUAT	.5 .5	12.38 12.99	25.37

AC-263,499 A POTENTIAL HERBICIDE FOR WEED CONTROL IN ALFALFA

Stephen D. Miller[1]

Abstract. Alfalfa (*Medicago sativa* L.) is an important forage crop in Wyoming with over 400,000 acres of irrigated and 100,000 acres of non-irrigated alfalfa in the state. Weeds continue to be a serious problem in the production of quality alfalfa in the state. Several herbicides and/or herbicide combinations are registered for weed control in new seeding and/or established alfalfa; however, results often have not been satisfactory because of poor weed control and/or crop damage. AC-263,499 (5-ethyl-2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)nicotinic acid is an experimental herbicide which has shown promise for broad spectrum weed control in small seeded legume crops.

Field experiments were conducted at Laramie and Torrington, Wyoming during 1985 to evaluate weed control and crop tolerance with AC-263,499 applications in both new seeding and established alfalfa stands. The soil type was a sandy loam at both locations. Treatments in established alfalfa were applied as a dormant treatment March 15 at Torrington and April 4, 1985, at Laramie. Treatments in new seeding alfalfa were applied preplant and incorporated April 15, 1985, at Torrington prior to seeding Apollo II alfalfa. All treatments were applied in water with a 6-nozzle knapsack sprayer delivering 40 gpa at 40 psi. The experimental design for all studies was a randomized complete block with three replications and experimental units were 9 by 30 ft.

Both new seeding and established alfalfa tolerance to AC-263,499 was excellent at rates up to 0.125 lb/A. AC-263,499 applications increased yield of new seeding alfalfa 800 to 1200 lb/A and established alfalfa 600 to 1100 lb/A compared to the untreated control. Kochia (*Kochia scoparia* (L.) Schrad.), tansy mustard (*Descurania pinnata* L.), common lambsquarters and skeletonleaf bursage (*Ambrosia tomentosa* Nutt.) control was excellent (90 to 100%); yellow foxtail (*Setaria glauca* (L.) Beauv.) and downy brome (*Bromus tectorum* L.) control fair (70-80%) and stinkgrass (*Eragrostis cilianensis* (All.) E. Mosher) control poor (<50%) with AC-263,499 at rates of 0.06 to 0.125 lb/A.

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[PURSUIT(AC 263,499), WEED CONTROL IN ALFALFA IN CALIFORNIA

D. Colbert, L. Whatley[1]; H. Agamalian, M. Canevari and J. Orr[2]

AC 263,499 ((5-ethyl-2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)nicotinic acid is a soybean and alfalfa herbicide which provides excellent control of many annual grass and broadleaved weeds. It belongs to

[1]American Cyanamid Company
[2]University of California Cooperative Extension Service

a new class of herbicides being developed by American Cyanamid called imidazolinones.

The imidazolinone herbicides are absorbed by both the roots and foliage, providing both preemergent and postemergent control. These herbicides are absorbed quickly and translocated through both the xylem and phloem with accumulation in the growing points.

The imidazolinones appear to kill plants very slowly. Treated leaves remain green for one to two weeks after application. This lack of immediate symptoms is due to the way in which the herbicide disrupt the functions of the plant. The ability to photosynthesize is unaffected, thus the plant remains green and translocation of the herbicide continues.

What the imidazolinones do is disrupt the ability of the plant to make proteins. The herbicide does this by preventing the production of three essential amino acids through the inhibition of acetohydroxyacid synthase. Once the level of these amino acids drop, protein synthesis slows down greatly and growth stops. With no further production of these amino acids, the plants eventually use up their supply and essentially starve to death. Since the growing points have the highest demand for new proteins, these points die first. The mature green tissue has a lower demand for proteins so the effects take longer before they can be seen.

We hypothesize that this specific mode-of-action that disrupts a metabolic pathway common only to plants explains in part the low toxicity of AC 263,499 to nontarget organisms. AC 263,499 has been found to be nonteratogenic and nonmutagenic as well as low in toxicity to mammals, fish, birds, insects and microorganisms. It does not accumulate in fish or mammals and is excreted rapidly if injested.

AC 263,499 has been tested postemergence in seedling and established alfalfa. Field research trials have been conducted from 1983-85, and these results are in Tables 1, 2, 3 and 4.

Table 1. Weed control in seedling alfalfa from postemergence herbicide applications. Sacramento County, CA 1983

Treatment[1/]	Rate lb/A	%-Control BG	%-Control M	%-Crop Injury 7/9	%-Crop Injury 8/1
AC 263,499 (PURSUIT)	.1	93	100	17	0
	.3	97	100	20	0
	.5	100	100	40	0
Fluazifop-butyl (Fusilade)	.3	93	0	20	0
	.5	97	0	23	0
Sethoxydim (Poast)	.3	100	0	14	0
	.5	100	0	19	0
Control	0	0	0	0	0

1/ Treatments applied postemergence 5/17/83. Alfalfa 1-4 trifoliate, barnyardgrass= 1-3 leaf, wild mustard= 2-4 leaf. Surfactant X-77 added to AC 263,499 .25% by volume. Other treatments 1 qt/A of non-phyto oil.

Table 2. Postemergence weed control in seedling alfalfa. San Joaquin County, CA 1984.

Treatment[1/]	Rate lb/A	%-Crop Injury 1/9	4/3	%-Control 3/5/84 WO	M	ML
AC 263,499 [2/] (PURSUIT)	.05	8	1	74	90	96
	.1	14	1	88	97	95
	.2	33	13	88	98	97
Pronamide (Kerb)	1.0	9	4	76	60	76
Sethoxydim [2/] + Bromoxynil	.25 .25	9	10	89	100	99
Control	0	0	0	0	0	0

1/ Treatments applied postemergence 12/4/83. Alfalfa 1.5 to 2 trifoliate. Wild oats= 2-4 leaf, wild mustard= 3-5 leaf, miner's lettuce= 2 leaf.

2/ Surfactant X-77 added .25% by volume.

Table 3. Cheeseweed control from postemergence herbicide applications in seedling alfalfa. Monterey County, CA 1984.

Treatment[1/]	Rate lb/A	%-Cheeseweed Control 25 DAT[2/]	61 DAT	%-Crop Injury 25 DAT	61 DAT
AC 263,499 (PURSUIT)	.03	83	87	13	3
	.06	80	94	10	8
	.12	83	98	10	6
	.25	88	100	20	19
Bromoxynil	.5	50	48	18	25
2,4-DB	1.0	48	60	24	48
Control	0	0	0	0	0

1/ Treatments applied postemergence on 12/29/83. Alfalfa 6-8 trifoliate. Cheeseweed= 12-15" in height. Surfactant added to each treatment .25% by volume.

2/ = Days after treatment

Table 4. Yellow foxtail control in established alfalfa from pre-emergence herbicide applications. Sacramento County, CA 1985.

Treatment[1/]	Rate lb/A	%-Yellow Foxtail Control 117 DAT[2/]	239 DAT	%-Alfalfa Injury 89 DAT	127 DAT
AC 263,499 (PURSUIT)	.125	100	56	1	0
	.25	100	92	10	0
	.5	100	96	8	0
Trifluralin (Treflan 10G)	2.0	100	82	0	0
Control	0	0	0	0	0

1/ Treatments applied 1/16/85. Preemergence to Yellow foxtail.

2/ Days after treatment.

In summary, AC 263,499 has shown good alfalfa tolerance with excellent activity on a number of grass and broadleaved weeds. Some of the weeds controlled by the herbicide were: miner's lettuce (Montia perfoliata), wild mustard (Sinapis arvensis L.), cheesweed (Malva sp), yellow foxtail (Setaria lutescens Weigel Hubb), and wild oats (Avena fatua). Continued field research will hopefully lead to the labeling of the herbicide AC 263,499 for use in California alfalfa production.

PRAIRIE CUPGRASS (ERIOCHLOA CONTRACTA HITCHC) CONTROL IN ESTABLISHED ALFALFA WITH EPTC

C.E. Bell[1]

Abstract. EPTC (S-ethyl dipropylthiocarbamate) has been used for many years for control of weeds in alfalfa. In the Imperial Valley of California, the primary weeds that EPTC is meant to control are summer annual grasses. Of these grasses, the most common was junglerice (Echinochloa colonum (L) Link). In recent years, a new grass [prairie cupgrass (Eriochloa contracta Hitchc.)] has been increasingly important in alfalfa fields, especially in fields where EPTC has been used frequently.

It is suspected that the increasing levels of prairie cupgrass is an example of a population shift caused by repeated use of one herbicide. These shifts are known to occur when one weed is more tolerant to the herbicide than another. Laboratory tests by Stauffer Chemical Co. indicate

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that 3.4 Kg/H of EPTC is required to kill prairie cupgrass as compared to 2.2 Kg/H for control of junglerice.

Experiments were conducted on two fields in the Imperial Valley during the spring of 1985 to test various levels of EPTC for control of prairie cupgrass. Test 1 compared four levels of EPTC (0, 3.4, 4.5, 5.6 Kg/H). Test 2 compared one level of EPTC (4.5 Kg/H) applied in two regimes against an untreated control. There were three replications in each test. Application of the herbicide was of undiluted chemical, metered out of the original container through a constant flow device into the irrigation water.

The first alfalfa cutting of the year in this area is usually from mid-February to mid-march. Prairie cupgrass starts germinating at this time of the year. Alfalfa fields are flood irrigated twice between harvests. In Test 1, application of the herbicide was made in the irrigation following the first three alfalfa harvests of the year starting on February 24, 1985. In Test 2, EPTC was either applied after the first three harvests at 4.5 Kg/H or applied at 2.2 Kg/H in each irrigation for a total of 4.5 Kg/H per harvest.

Weed control efficacy was determined by counting prairie cupgrass seedlings as they germinated. Approximately ten days after each irrigation, 18 -1 square meter sample areas were counted in each treatment. One half of these sample areas had been lightly tilled before the irrigation and flagged for later counting. The purpose of the tilling was to encourage prairie cupgrass germination and to help see how effective the EPTC was without the competitive assistance of the alfalfa. The two tests were also evaluated on a visual scale of 0-10 at the conclusion of the experiment. Results indicate that EPTC can assist in the management of prairie cupgrass in alfalfa under certain conditions. These conditions are that the alfalfa stand is strong and competitive against the grass (shading of young seedlings seems to be very significant) and that the EPTC is applied at a sufficient rate.

Introduction

The use of EPTC (S-ethyl dipropylthiocarbamate) for control of weeds in alfalfa has become a standard practice in the Imperial Valley of California. Alfalfa is usually irrigated by flooding between raised borders twice per cutting. EPTC is applied at the rate of 2.2 Kg/H into the irrigation water after the alfalfa has been cut. This application is usually made with the first spring cutting in February or March and continued for the next three cuttings. The target weed for this application has been junglerice [*Echinochloa colonum* (L.) Link]. In recent years, alfalfa growers and their pest management consultants have been noticing an increased in the level of grass infestation. This increase has been attributed to several causes, including resistance by the grass and building-up high levels of EPTC-consuming bacteria in the soil. What had actually happened was that a new weed, prairie cupgrass (*Eriochloa contracta* Hitchc.), had become widespread in the valley.

After the weed was properly identified, Stauffer Chemical Company, a manufacturer of EPTC, initiated greenhouse tests to determine if EPTC would kill prairie cupgrass. These tests indicated that 3.4 Kg/H would kill prairie cupgrass. Therefore, an apparent species shift has taken place from junglerice to prairie cupgrass because of the regular use of EPTC at a rate (2.2 Kg/H) that was too low to kill the more tolerant grass. The following experiments were designed to determine the level of EPTC required under field conditions to kill prairie cupgrass.

Materials and Methods

Two experiments were conducted to determine the rate of EPTC required to kill prairie cupgrass.

Experiments were conducted to determine the rate of EPTC required to kill prairie cupgrass.

Experiment 1 compared four rates of EPTC (0, 3.4, 4.5 and 5.6 Kg/H). The alfalfa field was going into the fifth year of production. Plot size was approximately 2.1 hectares, with three replications in a randomized complete block design. Application of the herbicide was with a commercial-type constant flow device that meters the chemical into the irrigation water from the original container. Calibration of the constant flow device is based upon the area being irrigated and the time required to irrigate.

The first herbicide application was on February 24, 1985, after the first alfalfa cutting of the spring. Subsequent application were made with the same rate of herbicide to the same plots after the second and the third cuttings, except in the case of the 5.6 Kg/H rate. This rate was only applied after the first and second cuttings.

Experiment 2 compared one level of EPTC (4.5 Kg/H) applied in two regimes against an untreated control. Plot size was 2.1 hectares with three replications in a randomized complete block design. The EPTC was applied using the same type of constant flow device as in the first experiment. EPTC application was either 4.5 Kg/H in the irrigation after the cutting or at 2.2 Kg/H in the same irrigation plus 2.2 Kg/H in the irrigation between cuttings for a total of 4.5 Kg/H per harvest period. Applications were made to the first three cuttings of the year starting on March 22, 1985.

Measurement of weed control achieved on both experiments was determined by counting prairie cupgrass seedlings as they germinated. These counts were taken in one meter square sampling areas approximately ten days after each irrigation. Eighteen samples were counted per plot. Nine of these sample areas were lightly tilled before the irrigation and flagged for later counting. The other nine were undisturbed. At the irrigation between cuttings, the sample areas that were tilled were also mowed to a height of approximately eight cm. The purpose of tilling and mowing was to encourage prairie cupgrass germination and to diminish the effect of the alfalfa competition. Therefore, the efficacy of the EPTC might be more apparent. The dependent variable (# of weed seedlings per square meter) could have been affected by several factors and the interactions of these factors. The following table summarizes these factors:

Table 1. Sources of variation affecting weed counts in both experiments.

Source	# of Variations	Comment
Block	3	3 replications
Treatment	3 or 4	3 or 4 herbicide levels
Month	3	Application of the same treatment to the same plots for 3 months
Day	2	Weed counts made on 2 days each month (approx. 10 & 24 days after treatment)
Tillage	2	Sample areas either tilled or not tilled before counting

The analysis of variance for these data includes these factors and their interactions. Because of the variation in the numbers, analysis of variance was done on square root transformation of the data. Other data collected on these fields were height of the alfalfa and bales of hay produced per plot (both these were measures of EPTC phytotoxicity) and a visual rating of weed control at the conclusion of the experiments.

Results

The weed counts (plants/sq.m.) for the untilled samples and tilled samples are presented graphically in Figures 1 and 2. The numbers are the mean of nine samples.

Figure 1. Data from Experiment 1, using mean value of nine samples.

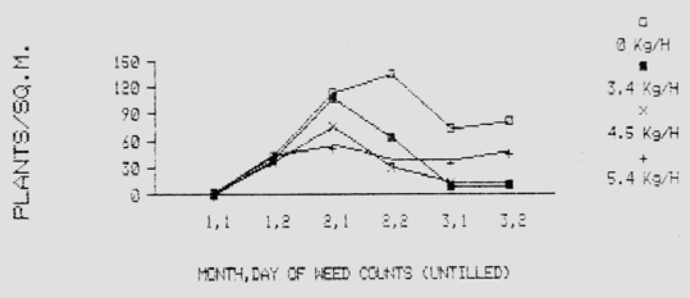
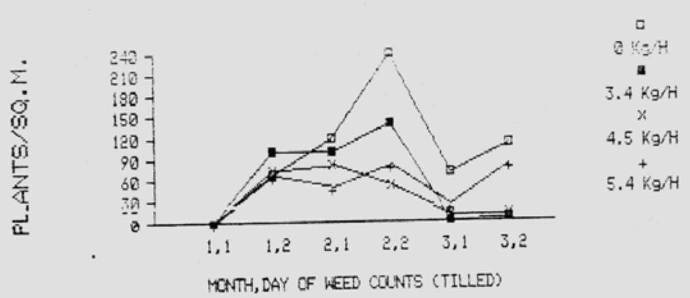


Figure 2. Data from Experiment 2 using mean value of nine samples.



Since the analysis of variance included 22 effects, only those that are significant for Experiment 1 are shown in Table 2.

Table 2. Significant effects, Experiment 1.

Source	df	MS	F_1	F_2
Month	2	3289.26	9.75 ***	
Day by Month	2	1212.93	14.66 **	
Month by Treatment	6	330.41	7.65 ***	
Day by Tillage	1	340.20		19.43 *
Month by Tillage	2	43.29	6.27 **	

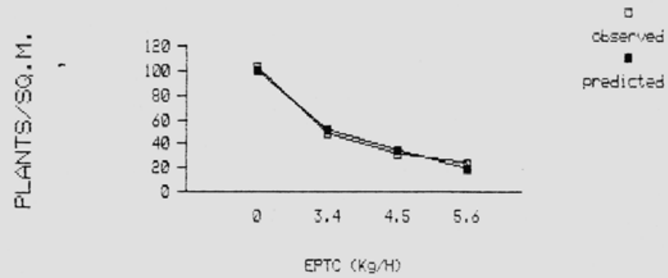
The analysis of variance shows that treatment by itself was not a significant factory in this experiment. However, the two sources of variation, Month and Month by Treatment, suggest that climatic or seasonal changes during the course of the experiment had an effect on the activity of the herbicide and the weed counts. The effect of season is evident when the data from each month are analyzed separately.

Table 3. Experiment 1, ANOV by Month

Source	df	MS	F
Month 1			
Treatment	3	2.70	0.08 ns
Tillage	1	84.45	13.92 **
Day	1	4039.45	193.61 **
Day by Tillage	1	103.06	14.54 **
Month 2			
Treatment	3	548.61	9.11 *
Tillage	1	226.78	34.25 ***
Day by Tillage	1	226.78	36.78 ***
Month 3			
Treatment	3	856.04	14.58 **
Day by Tillage	1	45.37	10.28

When the data from months 2 and 3 are average (using only the numbers from the untilled samples) and an estimated value for the 5.6 Kg/H rate is used, a linear regression can be developed. Figure 3 shows the observed and predicted values for these data at a 5% level of significance.

Figure 3. Linear regression, Experiment 1.



$$y = 9.0943 - 1.0764\ x$$

$$r^2 = .980$$

These data show a strong inverse relationship between the level of herbicide and the number of weeds. Normally we would expect a curvilinear relationship between number of weeds and herbicide level. In the case of this experiment, the relationship could be linear, or we could still be on the straight portion of the curve at these herbicide levels.

Data from Experiment 2 was analyzed in the same fashion as Experiment 1. Figure 4 shows the data from Experiment 2. Only data from untilled samples are shown because there was no significant differences between tilled and untilled weed counts.

Figure 4. Data from Experiment 2 using mean value of nine samples.

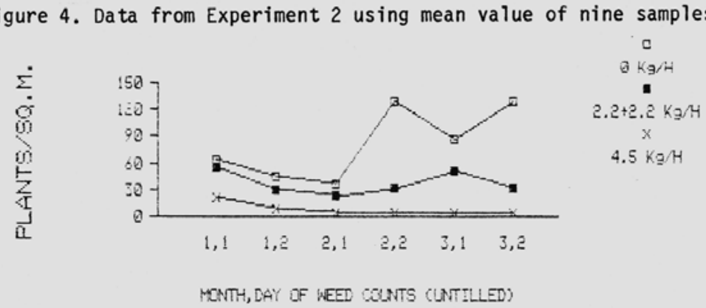
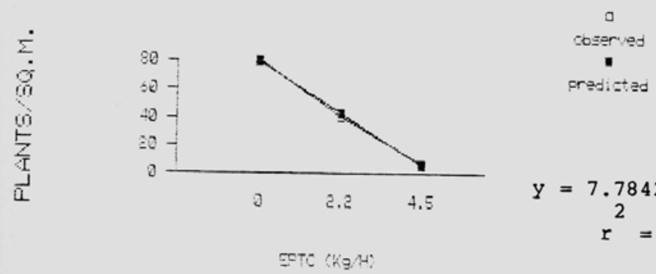


Table 4. Experiment 2, Significant Effects

Source	df	MS	F
Month	2	12523.73	<1 ns
Treatment	2	286914.95	99.02 ***
Day by Tillage	1	3104.08	15.05 ***
Day by Tillage by Treatment	2	784.28	3.80 *

A linear regression of these data, shown in Figure 5, demonstrates the same inverse relationship between herbicide level and weed counts as in Experiment 1. Significance is at the 0.1% level.

Figure 5. Linear regression for Experiment 2.



$$y = 7.7842 - 1.4789\,x$$
$$r^2 = .9891$$

There were no significant differences between the treatments with regard to height of the alfalfa or the numbers of bales produced per plot in either experiment. A visual evaluation of these experiments is presented in Table 5.

Table 5. Visual evaluation of weed control.

	EPTC Level	Rating
Experiment 1	0	0
	3	9.3
	4	9.9
	5	9.6
Experiment 2	0	0
	2+2	6.2
	4	9.2

0 = no control, 10 = all weeds dead

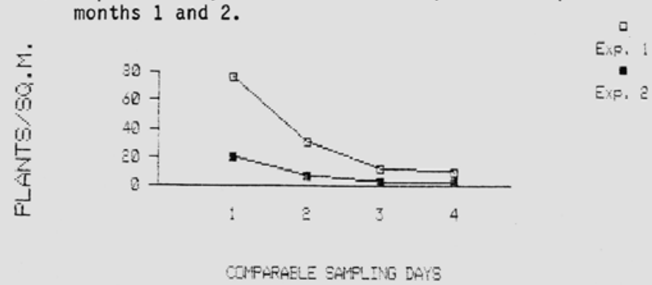
Discussion

The basic purpose of this experiment was to see what level of EPTC is required to control prairie cupgrass. In this regard, the results show that the more herbicide that is used, the higher the degree of control. At the rates used, we did not reach 100% control. However, the control achieved at 3.4 Kg/H (Table 5) would probably be considered commercially acceptable, especially when compared to 2.2 Kg/H.

In Experiment 1., the treatment effect became more important as the experiment progressed. In contrast, the treatment effect in Experiment 2 was significant throughout. This apparent discrepancy is because Experiment 2 started one month after Experiment 1. If the data from months 2 and 3 of

Experiment 1 are compared to months 1 and 2 of Experiment 2 at one herbicide rate (4.5 Kg/H), there is a good degree of similarity (Figure 6). Evidently there is an effect of time (month) on the efficacy of this herbicide or the susceptibility of the weed.

Figure 6. Experiment 1, months 2 and 3 compared to Experiment 2, months 1 and 2.



Tillage, as expected, had an effect on the number of weeds that germinated after each irrigation. In Experiment 1, the general effect of tillage was to increase the number of grass seedlings. This was especially true on day 2 of each month where tillage was accompanied by mowing of the hay to 8 cm. In Experiment 2, tillage was not a significant effect on weed counts. The difference between the two experiments is probably because the alfalfa stand in Experiment 1 appeared to be much thicker and more vigorous than Experiment 2.

Another important aspect of this experiment was the natural mortality of the weed seedlings. Every weed count was of new seedlings. These new seedlings were not surviving until the next irrigation, even in the untreated portions of the fields. Data was not collected to explain or to substantiate this observation. The most likely explanation is that death was from shading from the alfalfa. This cause would support the widely accepted belief in the importance of the alfalfa stand to alfalfa weed management.

GLYPHOSATE CONTROLS ATTACHED DODDER SELECTIVITY IN ALFALFA

J.H. Dawson[1]

Results of several field experiments at Prosser, Washington, have demonstrated that extremely low rates of glyphosate [N(phosphonomethyl)-glycine] control largeseed dodder (*Cuscuta indecora* Choisy) and field dodder (*Cuscuta campestris* Yuncker) selectively in alfalfa when applied after the parasite is established on the host. Phytotoxic quantities of glyphosate reach the dodder both by direct uptake and by systemic translocation from the alfalfa shoots.

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[1]USDA-ARS, Irrig. Agric. Res. and Ext. Center, Prosser, WA.

Glyphosate has been most effective if applied when alfalfa is more than 20 cm tall, when dodder shoots are 15 to 50 cm long and still vegetative and before symptoms of injury to the alfalfa from dodder parasitism are evident. A rate of 75 g ae/ha (1.1 oz ae/A) usually stops all growth of dodder within two days of application. Dodder late recovers to varying degrees from haustoria imbedded in the host, from tendrils wrapped on host stems, and to a much lesser degree from terminal and axillary buds on the exposed shoots. A rate of 150 g ae/ha (2.2 oz ae/A) usually kills all exposed shoots, and recovery from imbedded haustoria and wrapped tendrils is much less than at the lower rate.

Shade from alfalfa foliage suppresses dodder and augments control from glyphosate. When a uniform, full stand of established alfalfa is growing vigorously, glyphosate at 75 g ae/ha has usually controlled dodder satisfactorily because shade from the alfalfa retards regrowth of the dodder. In newly seeded alfalfa or in stands of established alfalfa in which shade from the host is incomplete, the more complete suppression of dodder by a rate of 150 g ae/ha is needed for satisfactory control.

We have not killed alfalfa plants at any growth stage with glyphosate at 75 or 150 g ae/ha. An application of 300 g ae/ha has killed 50% of alfalfa plants when applied to seedlings with only three trifoliolate leaves. This rate has never killed seedling with eight or more trifoliolate leaves or any established plants. Glyphosate at 150 g ae/ha may suppress established alfalfa sufficiently to reduce forage yield slightly. Uncontrolled dodder reduces alfalfa yield much more than glyphosate does. The greater the dodder infestation, the less the glyphosate injures the alfalfa, evidently because the dodder's parasitic activity diverts the herbicide to itself and away from the alfalfa.

One application of glyphosate per season has not protected newly-seeded alfalfa from destruction by dodder, regardless of when applied. When alfalfa was seeded in April, dodder control was good from two applications of glyphosate and excellent from three applications two or three weeks apart. Dodder control was always more complete, and consequently, alfalfa vigor was always better when the rate of glyphosate was 150 g ae/ha than when the rate was 75 g ae/ha.

Dodder almost never injures the first cutting of alfalfa and is not likely to injure the last cutting if it has been controlled in previous cuttings. For full-season protection of alfalfa from devastation by dodder, a glyphosate application would probably be needed in all cuttings of the season except the first and last.

METRIBUZIN RATE AND TIMING FOR POTATO TOLERANCE AND SEASON-LONG WEED CONTROL

D.K. Harrington, L.C. Haderlie[1] and P.J. Petersen[2]

Abstract. Metribuzin (4-amine-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one) was applied preemergence and postemergence to potatoes (*Solanum tuberosum* cv Russet Burbank) under field conditions at or near

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[1]University of Idaho, Research and Extension Center, Aberdeen, ID.

Aberdeen and American Falls, Idaho, at different rates to determine crop injury and season-long weed control in 1984 and 1985. Metribuzin was applied at rates 0.12 to 2.0 lb ai/A late preemergence (early June) and postemergence (late June or early July) by a tractor-mounted compressed air sprayer on plots that were 12 by 40 ft. Each treatment was replicated four times in each experiment. Potato injury was determined by visual integration of the size, vigor and injury symptoms of plants when compared to untreated checks. Potato injury did occur at the higher rates of metribuzin (1.0 to 2.0 lb ai/A) when applied late preemergence and was generally two times more pronounced than at the lower treatments (0.12 and 0.25 lb ai/A). Most of the plants had outgrown the injury by the time a second evaluation was made in late July except at the highest rate. Early overall weed control was excellent (90% or better) except at the lowest rate of metribuzin (0.12 lb ai/A). Metribuzin applied postemergence at the highest rate (2.0 lb ai/A) had much higher injury than at the 0.25 lb ai/A rate (up to 28%) with similar weed control. Green foxtail (Setaria viridis) and hairy nightshade (Solanum sarachoides) were most difficult to control in these experiments. However, green foxtail was controlled 88% and 93% at rates 0.25 lb ai/A and 0.5 ai/A, respectively, compared to 97% at the highest rate (2.0 ai/A) preemergence or postemergence. There was no significant difference in yield between preemergence or postemergence over the two years; however, there was a noticeable rate response. Reduction in yield, when comparing the highest rate (2.0 lb ai/A) to a lower rate (0.25 lb ai/A), was as high as 70 cwt/A but the difference averaged only 11 cwt/A over the two years. These data suggest that metribuzin rates could be decreased to provide better safety to the potato crop and environment while maintaining excellent weed control.

[2]E.I. DuPont, Clarkston, WA.

RESPONSES OF POTATO (CV. RUSSET BURBANK) TO TWO RATES OF MALEIC HYDRAZIDE APPLICATION

P.W. Leino and R.B. Dwelle[1]

Abstract. Maleic hydrazide (1,2-dihydro-3,6-pyridazinedione) is used in the potato industry as a storage sprout inhibitor and is applied preharvest to growing potatoes near the end of the growing season. Experiments were conducted at the University of Idaho, Aberdeen to document the effects of excessive rates of maleic hydrazide on foliage and on tuber yield and quality.

Two experiments were conducted in a field in a randomized complete block statistical design with six replications each. The two experiments differed only in the amount of water maintained in the soil during growth. The 'normal' irrigation experiment was maintained at 65% available soil moisture (asm) or above and the 'wet' experiment was maintained at 85% asm or above. Two rates of maleic hydrazide were used in each experiment, 5.6

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[1]University of Idaho, Research and Extension Center, Aberdeen, ID.

and 11.2 kg ai/ha (5 and 10 lb ai/A), 1 2/3 X and 3 1/3 X the recommended rate respectively. Applications were made ten days before recommended time, at the recommended time and ten days after the recommended time. The recommended time of application on potatoes is two to three weeks past the full bloom when the primary and secondary inflorescences have lost most of their flowers and a few third order inflorescences and buds are present. The Russet Burbank variety tubers should be 3-5 cm (1 1/5 to 2 in) in diameter and elongating.

Foliar symptoms of maleic hydrazide at lower rates include: thickened green leaflets with brittle petioles, leaflet cupping [i.e. leaf margins elevated], interveinal puckering and brittle stems; at higher rates: thick leathery cupped leaflets with marginal chlorosis and necrosis, puckered interveinal area, brittle stems and petioles and a cessation of growth of the terminal areas.

Some of these symptoms can be confused with similar symptoms from other herbicide injuries, such as obtained with dicamba (3,6-dichloro-2-methoxybenzoic acid), 2,4-D (2,4-dichlorophenoxy)acetic acid), bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) and glyphosate (N-(phosphonomethyl)glycine) or with diseases such as leaf roll virus. Drift from dicamba and 2,4-D have produced similar cupping and puckering symptoms as MH produces but such drift also produces stem epinasty. Bromoxynil produces leaf chlorosis with necrosis occurring at higher rates but shows no cupping. Glyphosate symptoms include chlorosis of younger leaves and cupping without thickening. Leaf roll virus symptoms usually include chlorosis and leaf cupping but do not usually include any leaf puckering symptoms. The most striking tuber symptoms of maleic hydrazide injury include a cracking or splitting of the tuber with deep "V"-shaped cracks. Some 'elephant hide' can also occur as with dicamba. Dicamba and glyphosate injury includes cracking but the bottoms of the cracks are more rounded and broader and have the appearance of creases.

Significant yield reductions occurred at the 11.2 kg ai/ha rate at the early and normal application times under the 'normal' irrigation practices. Under the 'wet' irrigation, no significant yield differences were noted (see Table 1). The wet irrigation had a significantly higher proportion of US #1 potatoes with the 5.6 and 11.2 kg ai/ha rates at the early and normal application times. However, under the 'wet' irrigation, all applications showed significant chemical cracking damage except at the 5.6 kg ai/ha rate at the early application time. Under the 'normal' irrigation experiment chemical cracking damage was limited to the normal application time of 5.6 kg ai/ha and the normal and late application times at the high 11.2 kg ai/ha rate (see Table 2).

The greatest damage occurred at the normal application timing with the 11.2 kg ai/ha rate under both irrigation levels with nearly one-fourth of the potato tubers showing symptoms.

Foliar and tuber symptoms of maleic hydrazide injury are unique and can be separated from potatoes that have herbicide drift damage. Yield and quality reductions can occur with excessive rates of maleic hydrazide, the degree of symptom expression depending on the application timing and rate and the irrigation management of the field.

Table 1. Tuber yield -- tons/ha (cwt/a).

MH Rates	Timing	Irrigation Normal	Irrigation Wet
1. - -	Check	42.4 (378)	37.2 (332)
2. 5.6 Kg a.i./ha	Early	40.8 (364)	36.3 (324)
3. "	Normal	41.9 (374)	36.7 (328)
4. "	Late	43.3 (386)	38.2 (341)
5. 11.2 Kg a.i./ha	Early	35.1 (313)	31.2 (279)
6. "	Normal	36.8 (329)	35.0 (312)
7. "	Late	40.1 (358)	38.0 (339)
LSD 5%		3.7 (33)	n.s. (n.s.)

Table 2. Percent MH tuber damage.

MH Rates	Timing	Irrigation Normal	Irrigation Wet
1. - -	Check	0.0	0.0
2. 5.6 Kg a.i./ha	Early	0.0	1.8
3. "	Normal	7.5	6.0
4. "	Late	4.2	6.5
5. 11.2 Kg a.i./ha	Early	3.3	6.5
6. "	Normal	24.3	23.0
7. "	Late	10.2	20.0
LSD 5%		7.2	3.0

USE OF LACTOFEN WHEN APPLIED PREEMERGENCE TO DRY EDIBLE BEANS

Thomas C. DeWitt and Thomas M. Cheney[1]

Abstract. At this time, there are very few herbicides applied for preemergence use in dry or succulent beans that provide adequate control of broadleaf weeds. Lactofen ((±)-2-ethoxy-1-methyl-2-oxoethyl 5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoate) has shown weed control efficacy and selectivity to many of the bean classes when applied preemergence. Field studies were conducted in 1984 and 1985 to evaluate preemergence applica- tions of lactofen in the dry and succulent bean growing areas of the western U.S. Preemergence rates of 0.25 to 0.30 labs ai/A afforded good to excellent control of wild mustard, nightshade species and redroot pigweed. Several classes of beans were evaluated for tolerance to preemergence applications of lactofen. Differences in tolerance between the bean classes tested were observed. Navy beans, pinto beans, kidney beans, great northern and snap beans all appear to be tolerant to rates of 0.2 to 0.6 lbs ai/A of lactofen. Although some initial injury to the crop was observed, by 60 days after treatment the injury was not significant. Injury appears to be influenced by soil type and the environmental conditions following treatment. Yield measurements show no reduction in yield from lactofen applications at 0.25 to 0.3 lbs ai/A. Dry peas and lima beans were not tolerant to preemergence applications of lactofen. These crops exhibited a high degree of initial crop injury that appeared to last throughout the growing season.

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

BAS 517H: A NEW POSTEMERGENCE GRAMINICIDE IN BROADLEAVED CROPS

G.R. Oliver, G.C. Cramer, L.C. Darlington, C.E. Osgood,
W.J. McAvoy and J.O. Pearson[1]

Abstract. BAS 517H is a new postemergence graminicide from BASF Aktiengesellschaft for the control of annual and perennial grasses in all broadleaved crops. The chemical name is 2-[1-(ethoxyimino)butyl]-3-hydroxy-5-(2H-tetrahydrothiopyran-3-yl)-2-cyclohexen-1-one and the proposed chemical name is cycloxydim. BAS 517H is currently formulated as a 200 g/L emulsifiable concentrate. It translocates rapidly to the meristematic regions of grass plants. Initial symptoms are evident in a few days; however, three weeks may be needed for complete control. Single applications are effective for annual grasses and volunteer cereals whereas double applications may be needed for perennial grasses, depending on the grass species and the competitiveness of the crop. BAS 517H is approximately twice as active than sethoxydim on all grass weeds. Effective

[1]BASF Wyandotte Corporation, Parsippany, NJ.

rates range from 0.084 to 0.224 ai kg/ha with the addition of 2.34 l/ha oil concentrate. Other adjuvants are also being evaluated. Maximum activity has been found with low rates at early stages of growth and under good growing conditions.

A TRANSPLANTING METHOD FOR STUDYING WEED COMPETITION IN CROPS

P.W. Stahlman and S.D. Miller[1]

Abstract. Weed density, time of weed establishment and removal in crops, and weed species themselves are major factors influencing the degree to which weeds compete with crops for moisture, nutrients and light. An understanding of these and other factors for individual weed species is needed to determine economic threshold density levels in crops and to design appropriate control procedures. Competition studies are difficult to conduct, largely because consistently uniform weed densities are difficult to obtain, especially at desired times.

We have developed a system of germinating downy brome (*Bromus tectorum* L.) in soil-filled paper pots (2 by 2 by 5 cm) in the greenhouse, then transplanting individual seedlings in the field at the desired density and time of establishment in winter wheat (*Triticum aestivum* L.). Overwinter survival and growth of the transplants has been excellent. This system is more accurate and less physically damaging to crop plants than thinning natural populations and should facilitate studies on the competitiveness of many weed species with crops.

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[1]Plant Science Division, University of Wyoming, Laramie, WY.

DEMOGRAPHY OF BULL THISTLE IN SHEEP PASTURES AND ITS CONTROL WITH DICAMBA

Frank Forcella[1] and Helen Wood[2]

Abstract. Bull thistle [*Cirsium vulgare* (Savi) Ten.] is a serious biennial weed only in heavily grazed pastures. To identify reasons for such preferential infestation and to isolate sensitive stages in the life history of bull thistle, comparative demographic analyses were conducted in grazed, ungrazed and herbicide-treated Mediterranean pastures in southeastern Australia. Sheep grazing was found to influence bull thistle by (1) reducing competition from neighboring plants, (2) increasing bull thistle growth, flowering and seed productio and (3) promoting survival of bull thistle seedlings. The most sensitive period in the life of this thistle

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[1]North Central Soil Cons. Res. Lab., USDA-ARS, Morris, MN.
[2]School of Applied Science, Riverina-Murray Inst., Wagga Wagga, NSW, Australia.

appeared to be the transition from the seedling-to-rosette life stages, where an average survival rate of less than 1% occurred over a period of three years. In contrast, average success rates for transitions from the seed-to-seedling life stages and the rosette-to-adult life stages were about 10-15% and 49-51%, respectively. Control of bull thistle with dicamba (3,6-dichloro-*o*-anisic acid) was attempted at several life history stages. Control was most effective if dicamba was applied after the initiation of autumn rains, when naturally high seedling mortality in bull thistle is induced by competition from neighboring plants.

RYE AND WHEAT CONTROL WITH FLUAZIFOP AND SETHOXYDIM FOR WINDBREAKS

C.E. Bestel[1]

Abstract. Wind damage to vegetable crops can delay or reduce yields, and cereals can be utilized as windbreaks. Wheat (*Triticum aestivum* L.) and rye (*Secale cereale* L.) as 6 to 12-inch strips between each row of vine crops are more effective as windbreaks than 10 ft. wide strips drilled 60 to 80 ft. apart. Selective control of the cereals at 20 to 40 inch heights for optimum wind protection is required, since the vine crops are planted early while the grains are increasing in height for better wind protection.

Sethoxydim (2-[1-(ethoxyimino)butyl]-5[2-ethylthio)propyl]-3-hydroxy-2-cyclohexene-1-one) or fluazifop-*p*-butyl(butyl(R)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoate, code PP 005) were applied postemergence at 0.095, 0.188 and 0.285 lb/A tank-mixed with 1 qt/A crop oil concentrate to wheat and rye on April 29, 1985, at a spray volume of 22 GPA. The air temperature was 85^{o} with low soil moisture. The wheat stage of growth was 20 inches tall without head emergence, and the rye was 48 inches tall with anthers protruding from 1% of the ears indicating the start of anthesis. The prevention of seed formation was desirable to avoid cereal growth in succeeding crops and at maturity, a rating of empty or partially-filled grain heads was obtained.

The interruption of the floral process caused the cereals to revert to vegetative growth as shoots from the basal nodes which also formed heads. This vegetative regrowth did not occur in the controls. The percent regrowth based on numbers of new shoots per plot was obtained, and these shoots formed normal grain heads, but grain viability was not determined.

The suppression of grain development was correlated with the chlorosis and necrosis of wheat, but not rye, probably due to differences of growth stages at the time of treatment. This indicates that sethoxydim and fluazifop-*p*-butyl have a gameticidal effect uniquely separate from the herbicidal aspect. Sethoxydim was more effective than fluazifop-*p*-butyl for the suppression of seed development in rye. Wheat seed development was suppressed slightly better by fluazifop-*p*-butyl than sethoxydim. Apparently wheat was slightly more tolerant to sethoxydim than rye, but for fluazifop-*p*-butyl, wheat was the most susceptible.

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[1]Department of Horticulture, University of Maryland, College Park, MD.

Table 1. The effect of postemergence broadcast sethoxydim and fluazifop on the growth of wheat and rye.

Treatment[1/]		Growth Effects					
		% chlorosis and necrosis[2/]		% suppression of seed in heads[3/]		% basal regrowth[3/]	
Herbicide	lb/A	rye	wheat	rye	wheat	rye	wheat
Sethoxydim (1.53E)	0.095	42	60	99	86	50	7
Sethoxydim	0.188	57	93	100	92	48	15
Sethoxydim	0.285	73	97	100	98	40	14
Fluazifop (1E)	0.095	43	93	87	96	33	17
Fluazifop	0.188	42	97	90	98	37	8
Fluazifop	0.285	53	97	100	100	33	2
Untreated control		0	0	0	0	0	0

1/ Tank mixed with crop oil concentrate at 1 qt/A rate. Spray volume was 22 GPA. The height of wheat was 20 inches and rye was 50 inches when sprayed on April 29, 1985.
2/ Rated May 29, 1985.
3/ Rye rated on July 3, 1985 and wheat on June 16, 1985.

Basal regrowth could be related to the stage of growth at treatment or species susceptibility. The basal regrowth was not rate responsive; however, fluazifop was slightly more effective than sethoxydim for suppression. The lack of regrowth with sethoxydim at 0.095 la/A was due to the partial development of grain in the heads which induced normal plants senescence. Seed development appeared normal in the regrowth; however, the heads were less than half normal length on stems of 16 to 20-inch height. If the seed were viable, they should be a minor problem in most vegetables.

Rye stem elongation continued after treatment to 66 inches in height as erect stems because the lack of grain weight in the head did not bend the stems to the 40-inch height in the controls. This higher plant stem would improve wind protection. Sethoxydim and fluazifop-p-butyl appear effective for selective control of 2 to 4 ft. tall rye and wheat in vegetable crops for optimum wind protection.

PRODIAMINE: A BROAD SPECTRUM PREEMERGENCE HERBICIDES FOR TREE AND VINE CROPS

Steven J. Bowel

Introduction

Prodiamine (N3, N3-di-n-propyl-2,4-dinitro-6-(trifluoromethyl)-m-phenylenediamine) is a long residual, broad spectrum, preemergence herbicide with excellent selectivity in thee and vine crops.

[1]Velsicol Chemical Corporation, Paso Robles, CA.

Prodiamine is typically used as a surface applied preemergence treatment during the fall and winter months. It should be incorporated within several weeks to be effective. In corporation may be accomplished through rainfall, irrigation or mechanical means.

Extensive field testing has revealed that prodiamine can provide good long-term control of many grass and broadleaf weeds, at rates of 2.2 to 4.5 kg ai/ha. These field tests have also demonstrated that prodiamine is safe to tree and vine crops, at rates in excess of 9.0 kg ai/ha. Prodiamine has shown excellent safety to tree and vine crops across different soil types.

History

Prodiamine has been tested in tree and vine crops since 1975. Velsicol Chemical Corporation purchased the rights to prodiamine, from US Borax, in 1982, and give it the tradename of Endurance during the fall of 1985.

Velsicol obtained a federal experimental use permit for large-scale field testing of prodiamine 50WP during the 1984-85 season. A 65WDG formulation of prodiamine is currently being tested under a federal experimental use permit for the 1985-86 field season.

Weeds Controlled. Prodiamine has been tests in over 200 tree and vine field trials since 1975. Results from these trials show that prodiamine at 2.2 kg ai/ha controls many annual grasses such as barnyardgrass (Echinochloa crus-galli), large crabgrass (digitaria sanguinalis), yellow foxtail (Setaria glauca) and bearded sprangletop (Leptochloa fascicularis); and many broadleaves such as prickly lettuce (Lactuca serriola), pigweed (Amaranthus sp.), common purslane (Portulaca oleracea), and prostrate spurge (Euphorbia maculata). Prodiamine will also control weeds such as black nightshade (Solanum nigrum) and annual sowthistle (Sonchus oleraceus) at 4.5 kg ai/ha.

Weeds such as mustard (Brassica sp.), common groundsel (Senecio vulgaris), and horseweed (Conyza canadensis) are tolerant of prodiamine at normal use rates. These weeds can be controlled by tank mixing prodiamine with herbicides such as diuron, simazine or oxyfluorfen.

Length of Control. A summary of field trials performed between 1975 and 1985 revealed marked difference between prodiamine and currently used tree and vine herbicides such as napropamide and oryzalin. Table 1 provides a general summary of grass and broadleaf weed control during early (<16 WAT*) and late season (<15 WAT). Both susceptible and tolerant weeds were averaged together as grass or broadleaf weeds for the summary.

Table 1. Comparison of Early and Late Season Broadleaf and Grass Control Provided by Prodiamine, Napropamide and Oryzalin.

		-----Percent Weed Control[1] -----			
		Broadleaf		Grass	
Treatment	Rate(kg ai/ha)	Early[2]	Late	Early	Late
Prodiamine	2.2	73	77	90	90
Prodiamine	4.5	82	83	93	94
Napropamide	4.5	68	62	79	69
Oryzalin	2.2	65	38	78	40
Oryzalin	4.5	76	60	80	76

1. Percent control data are an average of all broadleaf and grass weeds evaluated in 1975-85 field trials.
2. Early evaluations were made less than 16 WAT; late evaluations were made more than 16 WAT.

Early in the season, prodiamine provided slightly better control of all broadleaf weeds than oryzalin or napropamide; prodiamine at 2.2 kg ai/ha gave 73 percent control, while oryzalin at 2.2 kg ai/ha gave 65 percent control and napropamide at 4.5 kg ai/ha gave 68 percent control. This difference in control increased as the season progressed. Late season evaluations showed that prodiamine at 2.2 kg ai/ha gave 77 percent control of all broadleaves, while oryzalin's control had decreased to 38 percent and napropamide's decreased to 62 percent.

Field trials during 1985 confirmed the long residual activity of prodiamine on several individual weed species including: pigweed, large crabgrass, common purslane and annual sowthistle. Results from trials involving large crabgrass and common purslane appear in Table 2.

*WAT = Weeks after treatment.

Table 2. Comparison of Large Crabgrass and Common Purslane Control Provided by Oryzalin and Prodiamine.

		Percent Control						
		Crabgrass			Purslane			
		WAT			WAT			
Treatment	Rate(kg ai/ha)	16	23	29	12	17	23	30
Prodiamine	2.2	83	80	97	90	84	86	90
Prodiamine	4.5	93	95	97	94	90	95	95
Oryzalin	2.2	70	48	15	82	73	69	42
Oryzalin	4.5	85	65	40	89	88	79	45

Prodiamine at 2.2 and 4.5 kg ai/ha provided 97 percent control of large crabgrass at 29 WAT; while oryzalin gave only 15 and 40 percent control at the same rates. Similarly, 2.2 and 4.5 kg ai/ha of prodiamine gave 90 and 95 percent control of common purslane at 30 WAT; while oryzalin showed 42 and 45 percent control at the same rates.

Prodiamine at 2.2 and 4.5 kg ai/ha provided 97 percent control of large crabgrass at 29 WAT; while oryzalin gave only 15 and 40 percent control at the same rates. Similarly, 2.2 and 4.5 kg ai/ha of prodiamine gave 90 and 95 percent control of common purslane at 30 WAT; while oryzalin showed 42 and 45 percent control at the same rates.

Conclusion

Prodiamine demonstrates three characteristics that would make it an excellent herbicide for use in newly planted or established tree and vine crops. These characteristics are : 1) good control of many annual grass and broadleaf weeds; 2) long residual weed control; and 3) excellent crop safety.

THE EFFECT OF SPRAY VOLUME ON THE POSTEMERGENCE ACTIVITY OF OXYFLUORFEN AND GLYPHOSATE COMBINATIONS

L.D. West, B. Mitsui and T.C. Tillett[1]

The use of low volume spray equipment in orchards has several advantages over conventional equipment. These include the use of smaller equipment which results in reduced soil compaction, the ability to spray when conventional equipment could not, and the reduced water volumes required for application. Glyphosate [N-(phosphonomethyl)glycine] is effective when applied postemergence in low carrier volumes. However, the activity of oxyfluorfen [2-chloro-1-(ethoxy-4-nitrophenoxy)-4-trifluoro-methyl)benzene] is dependent upon spray volume to provide adequate spray coverage for contact activity, particularly with large weeds or dense weed canopies. Volume studies involving oxyfluorfen, glyphosate and the tankmix combinations were initiated in 1984 and 1985.

Oxyfluorfen (0.56 kg ai/ha). glyphosate (1.12 kg ai/ha), and the tankmix combination of oxyfluorfen with glyphosate (0.56 + 1.12 kg ai/ha) were applied at four different spray volumes (23, 94, 374 and 935 l/ha). The lowest spray volume treatments were applied with a controlled droplet applicator ("Herbi"). All other treatments were applied with a CO_2 backpack sprayer equipped with flat fan nozzles. Plot size was 9.3 x 22 meters and replicated three or four times.

Oxyfluorfen, alone or tankmixed with glyphosate, provided better postemergence weed control as spray volume increased from 23 to 935 l/ha. The influence of spray volume on weed control varied by weed species; spray volume was not as critical on oxyfluorfen sensitive weeds or on seedling weeds. However, the trend favoring higher gallonage was still observed. Glyphosate, applied alone, was less sensitive to spray volume than oxyfluorfen.

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[1] Rohm and Haas Company, Fresno, CA.

PHYTOTOXICITY TRIALS WITH TRICLOPYR AND 2,4-D ON SELECTED TRANSITIONAL ZONE TURF GRASSES

Glenn McCourty[1], Vanelle Carrithers[2], William Carrithers[3] and Wendy Robinson[4]

Abstract

Greenhouse trials for phytoxicity were conducted on bermudagrass (*Cynodan* sp. 'Tifway'), St. Augustine grass (*Stenotaphrum secundatum*) and tall fescue (*Festuca arundinacea*). Amine and ester formulations of

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[1]Cal Poly, San Luis Obispo, CA.
[2]Dow Chemical, Davis, CA.
[3]Statistical Consultant, Sacramento, CA.

triclopyr ([3,5,6-trichloro-2-pyridinyl)oxy]acetic acid) and 2,4-D [2,4-dichlorophenoxy)acetic acid] were tested. Rates for the ester formulation of triclopyr were: 0.4 lb. ae/A (0.4 kg/ha), 1.5 lbs ae/A (1.7 kg/ha), and 3.0 lbs ae/A (3.4 kg/ha). Rates for the amine formulation were: 0.5 lb ae/A (0.5 kg/ha), 1.9 lbs ae/A (2.2 kg/ha) and 3.85 lbs ae/A (4.4 kg/ha). Phytotoxicity was observed on the bermudagrass and St. Augustine at all rates. Tall fescue was not effected at the low rate but some phytotoxicity was observed at higher rates.

Fertilizer at various rates applied as ammonium sulfate (21-0-0) one week prior to herbicide treatments did not stimulate recovery or increase phytotoxicity of any of the turf grasses except tall fescue recovery was more rapid at the highest fertilizer rate.

The amine formulation of triclopyr causes the same phytotoxic response on bermudagrass and St. Augustine grass observed with the ester formulation. Fertilizing one week prior to application did not aid in turf recovery or increase phytotoxicity.

ARSENAL HERBICIDE (AC 252,925): ENVIRONMENTAL FACTORS INFLUENCING BEHAVIOR

A.M. Van Cantfort, A.R. Hegman, R.M. Herrick, J.B. Dobson,
D.R. Colbert, M. Mallipudi and K. Umeda[1]

AC 252,925 (2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-pyridinecarboxylic acid with 2-propanamine (1:1) salt) is a broad-spectrum herbicide registered for the control of vegetation in noncrop areas. It controls a wide variety of species, including annuals, perennials, grasses, broadleaved weeds, vines and deciduous trees. AC 252,925 is absorbed by both roots and foliage for both preemergent and postemergent activity. It is translocated throughout the plant through both the xylem and the phloem, accumulated in the growing points. Lateral and vertical movement in soil has been found to be limited.

These characteristics have practical considerations in actual usage. AC 252,925 has been found to be absorbed quickly into plants, approximately 85% within two hours. This is combination with the root absorption reduces the effect of rainfall on the application. In several trials, rain has occurred between four and twelve hours after the treatment with no effects on the degree of control observed. Field studies conducted with radiolabeled material have shown that there is little lateral or downward movement of the active ingredient when the material is applied either to bare soil or to actively growing plants. After one year, 80-90% of the remaining material has been found in the top six inches of the soil. No active ingredient has been found outside a 3-inch perimeter of the treated area. Under typical field conditions AC 252,925 has been observed to remain where it is applied. Treatments located on steep slopes have retained sharp plot outlines despite heavy rainfall. Treatments in two trials which have accidentally flooded have provided excellent weed control in the treated areas with no effect on surrounding vegetation.

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[1]American Cyanamid Company, Princeton, NJ.

WSWS BUSINESS MEETING

March 20, 1986
Town and Country Hotel-San Diego, CA

The meeting was called to order at 7:26 a.m. by President Harvey Tripple. He thanked Elanco for the breakfast. President Tripple asked for the reports of the various committees:

The Nominations Committee Report was give by Pete Fay. New officers for 1987 are: John Evans-President; Larry Mitich-President-Elect; Paul Ogg-Secretary; Bart Brinkman-Chairman, Research Section; Steven Miller-Chairman-Elect, Research Section; Robert Callihan-Chairman, Education and Regulatory Section; and Sheldon Blank-Chairman-Elect, Education and Regulatory Section. It was moved and seconded to accept the Nominations Committee report. Motion passed.

The Program Committee Report was given by John Evans. The poster section was a success in 1986, and members were encouraged to participate in the paper and poster sessions in 1987. Eighty papers were presented in 1986. It was moved and seconded to accept the Program Committee report. Motion passed.

John Evans moved that the WSWS donate $200 research gift to Scripps Institution of Oceanography for the participation of Jacqueline Parker-Director of Public Affairs- as luncheon speaker. Motion was seconded and passed.

The Education and Regulatory Section Report was given by Phil Olson. It was reported that the WSWS has agreed to give $1,000 to CAST to support their Science and Agriculture Magazine. At the Regulatory and Education section of the meeting, about 50 individuals attended. Discussion was helped by Len Richardson, Editor, Agrichemical Age. Len guided the group into thought-provoking ideas on how the agrichemical industry can defend itself. Good public relations was deemed critical, with the suburban public as the main audience. The 1987 Chairman of the Education and Regulatory Section is Robert Callihan. It was moved and seconded to accept the Education and Regulatory Section report. Motion passed.

The Local Arrangements Committee Report was given by Nelroy Jackson. He thanked his committee members for their help. The 1987 local arrangements chairman in Boise, Idaho, is Oakford Bain. It was moved and seconded to accept the Local Arrangements Committee report. Motion passed.

The WSSA Representative Report was given by Alex Ogg, Jr. The 1986-87 President of the WSSA is Jean Dawson-USDA-Prosser, WA, and member-at-large is Larry Mitich-University of California, Davis, CA. The WSSA will raise their dues in 1987 from $25 to $40 (regular members); $10 to $20 (graduate students); and $35 to $50 (institutionals). The WSSA has stopped support of the "Weeds Today" magazine, but will begin publishing a new journal, "Weed Technology." the 1987 meeting of the WSSA will be held February 4-6 in St. Louis, MO. It was moved and seconded to accept the WSSA Representative report. Motion passed.

The CAST Report was given by Lowell Jordan. It was reported that CAST is financially sound. The American Association of Cereal Chemists joined CAST in 1985. CAST would like to support the Extension Service, and Lowell desires inputs from WSWS members on how this and other support functions CAST might provide. It was moved and seconded to accept the CAST report. Motion passed.

The Placement Committee Report was given by Phil Leino. Indications are that job opportunities are not as plentiful as they were a few years ago. It was moved and seconded to accept the Placement Committee report. Motion passed.

The Public Relations Committee Report was given by Jack Schlesselman. Pictures of new officers were taken at the meeting for inclusion in the WSSA newsletter. Attendance at the meeting has been approved as credit toward PCA licenses. Jack will be the 1987 Public Relations Chairman. It was moved and seconded to accept the Public Relations Committee report. Motion passed.

The Student Paper Committee Report was given by Clyde Elmore. Winners of the student paper contest were announced: First place: Gwen Fleming, Washington State University - Advisor, Frank Young; second place, Dwayne Martin, University of Wyoming - Advisor, Steve Miller; third place, Don Morishita - University of Idaho - Advisor, Don Thill.

Dave Cudney, University of California, will be the Chairman for this committee in 1987. It was moved and seconded to accept the Student Paper Committee report. Motion passed.

Member-at-Large Report was given by Pete Fay. It was reported that all three WSWS Constitutional amendments proposed to the voting membership passed:

Old: Article VII-Standing Committee, Section 6; The Nominations Committee shall consist of a Chairperson and two members.

New (Amended): The Nominating Committee shall consist of a Chairperson, Immediate Past-President and two rotating members.

Old: The Committee for Nominations of Fellows and Honorary Members shall consist of the three most Immediate Past-Presidents of the Society.

New (Amended): The Committee for Nominations of Fellows and Honorary Members shall consist of three Fellows of the WSWS appointed by the President with advice and consent of the Executive Committee.

Old: The Society Representative to the WSSA shall serve three years beginning at the WSSA Business meeting in the year following the WSWS meeting at which the election is announced.

New (Amended): The Society Representative to the WSSA shall serve three years beginning at the WSSA Business meeting in the year following their appointment by the President with advice and consent of Executive Committee.

It was moved and seconded to accept the member-at large report. Motion passed.

The Research Section Report was given by Ralph Whitesides.

Research Section Report

Ralph E. Whitesides

The 1986 Research Progress Report is 371 pages in length, contains 197 individual reports and represents contributions from 106 different authors. No papers were received for Project 3: Undesirable Woody Plants. The quality of the camera-ready copy for the Progress Report is generally good; however, authors must pay careful attention to margins, clarity of type and timely submissions of reports.

The Research Chairman for 1986-87 is Bart Brinkman, Velsicol Chemical Corp., 5130 2nd Ave., SE., Salem, OR 97302 (503-363-1934). Chairman-elect is Steven Miller, Plant Science Division, University of Wyoming, Laramie, WY 82071 (306-766-3112).

Chairman and chairman-elect of the Research Projects for 1986-87 follow:

Project 1: Perennial Herbaceous Weeds

Chairman: Donn Thill, Dept. of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83843
Chairman-elect: Phil Westra, Colorado State University, Fort Collins, CO 80524

Project 2: Herbaceous Weeds of Range and Forest

Chairman: Celestine Lacey, Dept. of Agriculture and Agriculture and Livestock Building, Helena, MT 59620
Chairman-elect: Tom Whitson, University of Wyoming, Laramie, WY 82071

Project 3: Undesirable Woody Plants

Chairman: Diane White, Oregon State University, Forest Science Dept., Corvallis, OR 97331
Chairman-elect: Vanelle Carrithers, Dow Chemical Co., Davis, CA 95616

Project 4: Weeds in Horticultural Crops

Chairman: Lee Darlington, BASF Wyandotte Corp., 4609 Englewood Ave., Yakima, WA 98902
Chairman-elect: Rick Boydston, ARS-USDA, IAREC, Prosser, WA 99350

Project 5: Weeds in Agronomic Crops

Chairman: Ron Vargas, University of California, 128 Madera Ave., Madera, CA 93637
Chairman-elect: Doug Ryerson, Monsanta, Co., Twin Falls, ID 83301

Project 6: Aquatic, Ditchback and Non-Crop Weeds

Chairman: Win Winkyaw, Weed Control Program, P.O. Box 1980, Salt River Project, Phoenix, AZ 85801
Chairman-elect: Barbara Mullin, Montana Dept. of Agric., Agriculture/Livestock Bldg., Capitol Station, Helena, MT 59620-0205

Project 7: Chemical and Physiological Studies

Chairman: Fred Ryan, USDA/ARS, University of California, Davis, CA 95616
Chairman-elect: Jodie Holt, Dept. of Botany and Plant Sciences, University of California, Riverside, CA 92511

The reports from individual project sections are as follows:

Project 1: Perennial Herbaceous Weeds

Chairman - Galen Schroeder, Chairman-elect - Donn Thill

The research project meeting was called to order by Chairman Schroeder at 1:15 p.m. There were 69 people in attendance. Phil Westra, Colorado State University was elected to serve as chairman-elect in 1987. Rod Lym, Lloyd Haderlie and Galen Schroeder made opening remarks. Schroeder discussed the differences between annual weed and perennial weed control research techniques, the need for a multi-year approach to perennial weed research, and the concept of control versus eradication versus weed management. Lym discussed the need for a large main plot size at the onset of a perennial weed field experiment and how this relates to encroachment problems form one plot to another. Changes in forage production due to harvesting techniques was discussed. He also discussed the problem of nonuniform weed populations and visual control estimates versus quantitative-type measurements. Haderlie discussed the need for root versus top growth or year-to-year control measurements, selection of field plot locations, and greenhouse or growth chamber research versus field experiments. At this point, the discussion was opened to the audience. Many of the above topics were further discussed. For example, it was felt that visual estimates of perennial weed control were as reliable, or in some cases, more reliable than actual stand counts, biomass measurements, etc. It was suggested that plot size should be at least 15 by 50 feet and that plot location be selected one year in advance of establishing a field experiment in order to reduce experimental variation. Other topics discussed were long-term control of established perennials and seedlings that emerge after the initial treatment(s), genetic variation within a population of perennial weeds, the acceptable level of probability for perennial weed experiments (e.g. 90 versus 95%), and the weed to monitor environmental condition at the experimental site for the duration of the experiment, experimental design, the need to precisely define experimental objectives, weed thresholds, allelopathy, integrated biological and chemical control of perennial weeds, and weed seed viability and longevity. The session adjourned at 2:50 p.m.

Project 2: Herbaceous Weeds of Range and Forest

Chairman - Mark Ferrell, Chairman-elect - Celestine Lacey

Mark Ferrell chaired the session and Celestine Lacy recorded the proceedings of Project 2. Approximately 40 people attended this discussion session. Nominations were opened for chairman-elect for 1987. Dr. Tom Whitson, University of Wyoming and Doug Johnson, Cascade County Weed and Pest Administrator were nominated for the position. Tom Whitson won the election.

Subject 1: Livestock Grazing as a Method of Weed Control - moderated by Dr. John Brock, Arizona State University.

The purpose of this discussion was to review the use of livestock as a biological component in integrated weed/brush management on pasture and rangeland. For livestock to be effective as biological control agents, the following four conditions must be met:

1) Effect control of livestock is necessary
2) Target plants must be accepted by the livestock as forage
3) Presence of other forage plants than can replace the target species
4) Differential susceptibility of the target plants to grazing at some time of the year to aid in the control strategy

The differential classes of livestock (cattle, sheep, and goats) and their impact as biological control agents was reviewed. Cattle grazing appears to offer the least potential as biological agents for pest plants. However, studies indicate that they have effectively controlled aspen and Johnson grass in controlled grazing situations. Sheep have been shown to utilize leafy spurge and keep the plant from going to seed. Other examples of sheep grazing as a weed management tool include: the use of sheep to control reduction of slender thistle, tansy ragwort and barley grass. Goats have been successfully utilized as brush management tools in Texas and Southern California chaparral. The major brush species in this area that were controlled were scrub oak, mountain mahogany, and less specifically, chamise, manzanita and California buckwheat.

Based on the results of published research, it appears that mixed livestock grazing holds potential for vegetation management, and biological control of weedy species may be achieved. The discussion group concluded that well-defined research is needed to begin to document the role of livestock grazing in the integrated pest management approach for pasture and rangeland improvement.

Subject 2: Herbaceous weed control in forests: Moderated by Jack Warren, Dow Chemical Company (retired)

The importance of herbaceous weed control in forest situations was reviewed. Mike Newton, Oregon State University, listed several advantages to weed control in forest regeneration:

1) Minimize animal damage especially of small rodents due to an increase of exposure and subsequent predation
2) Weeds increase stress of young tree seedlings especially under drought conditions
3) Releases tress from competition
4) Trade-off between herbs and shrubs and tree competition

Diane White, Oregon State University, discussed the results of research conducted in Oregon which measure tree survival and growth in weeded and unweeded plots. The data indicated that herbs had more of an effect on the trees than the large woody species such as manzanita.

Subject 3: How to confront anti-pesticide groups in an effort to deal effectively with misinformation concerning pesticide use. Moderator - Dr. Wendell Mullison.

The discussion centered around the need for public relation programs that would involve the urban public. Dr. Mullison noted that only 2% of the American public was involved in farming, yet most of our educational programs were targeted toward this group. We must educate the non-agricultural public about the impact of weeds on recreation, such as fishing, hunting, rafting and sight-seeing, and wild life populations. Without the urban population, we cannot obtain legislative support for pest control programs.

Project 3: Undesirable Woody Plants

Chairman - Bruce Kelpsas, Chairman-elect - Diane White

Three broad discussion topics were addressed:

1) How do disturbances, such as grazing, cutting or burning alter a plant's susceptibility to herbicides?
2) How rapidly do herbicides translocate in woody plants, and how does top removal after application affect sprouting?
3) What long-term trends are emerging from brush control in forests?

Little formal information was presented for topics one and two above, although much fragmented empirical information was discussed. Effects of phenology, age of plant, season of disturbance and application were determined to play a role in plant response. Herbicide movement into plants was generally regarded as rapid, and translocation sufficient to inhibit or prevent sprouting was completed by a few weeks after application.

The long-term effects of weed control in forests was discussed in a crop tree performance context. It was observed that brush and herb control shifted the trajectory of a number of tree growth parameters resulting in growth gains.

Elections were held for chairman for the 1987 meeting and chair-elect for the Fresno, California meeting in 1988. Diane E. White, Oregon State University, was elected chair for 197. Vanelle F. Carrithers, Dow Chemical, Davis, California, was elected chair for 1988.

Project 4: Weeds in Horticultural Crops

Chairman - Ron Brenchley, Chairman-elect - Lee Darlington

1. The comparative strengths and weaknesses of Poast, Fusilade, Select, Assure, BAS-517, Verdict, Whip and Ro 17-3668 were discussed for controlling foxtail, annual bluegrass, barnyardgrass, rabbit foot, wild oats, annual ryegrass, bromus sp., quackgrass, bermudagrass and Johnsongrass. For control of Setaria sp. Poast = Assure = BAS 517 = Verdict = Ro 17-3668 > Fusilade. All compounds were ineffective for control of annual bluegrass except Verdict which gave partial control. For control of barnyardgrass Poast = Fusilade = BAS-517 = Verdict = Ro 17-3668 > Assure. Rabbit foot grass control was excellent with Poast, Fusilade and Assure. Wild oats control was Fusilade = Assure = BAS-517 = Verdict = Ro 17-3668 > Poast = Select > Whip. Annual ryegrass control was Poast = Fusilade = Select = Assure = Verdict = Ro 17-3668 > BAS-517 >>> Whip. *Bromus tectorum* control was greatest with Assure = BAS-517 = Verdict = Ro 17-3668 > Fusilade > Poast = Select. Dallasgrass control was good with Fusilade. Quackgrass control was best with Assure = Verdict > Fusilade > BAS-517 > Poast. Johnsongrass control was best with BAS-517 ≥ Fusilade > Verdict > Poast = Assure. Surfactant preferences were as follows: Poast needs crop oil, Fusilade needs non=ionic surfactant X-77 etc. Select needs crop oil or oil concentrate. Assure needs non-ionic toxicology problems which cloud the future of this compound.

II. Living Mulches in Horticultural Crops
Various grass species are being evaluated to determine which are best suited as candidates for a cover crop in various crops. Oregon State University reports Elka perennial ryegrass shows promise. The purposes of living mulches are for erosion control, traffic ability, and weed suppression. Studies are being conducted at the University of California by Clyde Elmore to determine moisture and nutrient losses in crops due to living mulches. They are also studying water penetration and disease, insect and rodent interactions with crop plants grown under living mulches. Concern was voiced as to the shift of annual plant communities to perennial weed types which could offer severe management problems. Chemical mowing of grasses using low rates of Poast, Fusilade or other graminicides as a tool to reduce competition of living mulches to crop plants was discussed. Concept was highly practical. Again much research is needed to determine the optimum plants (grasses or legumes) to be used as living mulches in any given crop. It was concluded that with certain crops, bare ground vegetative control was highly desirable (example: citrus, almonds, etc.).

III> General discussions initiated for unresolved problems in horticultural crops included:

a) Black nightshade control in Solanaceous crops
b) Nutsedge control in all crops
c) Legume control in grassy cover crops
d) Dodder control in tomatoes
e) Field bindweed in all crops

Generally no solutions which have not been tried already were offered to resolve the above problems. Solutions are still being sought.

The Chairman for 1987 is Lee Darlington and the Chairman-elect is Rick Boydston. Forty-two people registered for the session and 60 people were present.

Project 5: Weeds in Agronomic Crops

Chairman - Steve Miller, Chairman-elect - Ron Vargas

Doug Ryerson, Monsanto Chemical Co. was elected as chairman-elect for the 1987 meeting.

Subject 1: Weed spectrum change with reduced tillage.

Weed spectrum changes were discussed under a no-till wheat culture. In general, there appeared to be a feeling that annual weed populations were generally reduced and perennial weed populations increased under a no-till wheat culture. Examples were expressed as follows:

Wyoming: Less wild oats and mustard but increases of Canada thistle and kochia. Wild oats populations were also reduced when nitrogen fertilizer was banded as opposed to broadcast.

Tennessee (humid areas of the East): No-till systems cannot be maintained for much more than three years because perennial weed population increased to such an extent that plowing was necessary.

Iowa: All perennials increased under reduced tillage, except for field bindweed. Canada thistle has also been a problem. No-till will only last three to five years before perennials take over.

Kansas: Same experience as Iowa with field bindweed. In a study comparing continuous wheat, wheat-fallow, and wheat-sorghum-fallow; all reduced tillage programs reduced field bindweed populations compared to a continuous wheat system. Tillage plots have had a trend for increasing field bindweed populations.

Washington: Southeast Washington has experienced annual grasses such as bromes and jointed goatgrass, being a major problem in no-till systems.

Southeast U.S.: Johnsongrass becomes a major perennial weed problem in a no-till system.

California: No-till systems do not fit into the irrigated and cropping sequences of the arid west.

Little information is available on modeling of no-till systems, but Robert Norris (University of California) is working on a model to predict shifts of weed species under different cropping patterns.

Plot size to research no-till systems was discussed. Plots will need to be large. Discussed the possibility of using set aside acreage, but because a crop will be harvested from land, ASCS office will not allow land to be used for this purpose.

Overall objective of no-till systems.

Growers will not adopt unless a yield increase is realized. There also has to be a low per unit cost of production.

Soil conservation and soil moisture conservation are also benefits to a no-till system, but the growers main concern is profitability.

Subject 2: Herbicide Persistance in Soil

Robert Norris (University of California) has done plant back studies after three years of hexazinone applications to alfalfa. Paper presented in the agronomy research section.

Discussion centered around the problem of predicting if a problem may arise in subsequent crops after herbicide application.

Methods discussed:

1. Modeling: models available in England that will predict rate of herbicide breakdown in soil, but none are available in U.S.
2. Bioassay: can be useful but needs to be used with caution. Factors that determine results include soil sampling technique, soil type, rainfall, type and variety of bioassay plant used.

   Disadvantage of this method is the approximate lag time of 4-6 weeks between sample and results.

3. Chemical test: rapid analysis for triazine available. DuPont is developing methods of determining chlorsulfuron levels in the soil.

Plants back restrictions and information can usually be found on product labels. California Department of Food and Agriculture is going to begin enforcing plant back restrictions.

Herbicide persistence and subsequent crop injury is becoming more important due to the new herbicide chemistry of sulfonylureas and imidazalinones.

Project 6: Aquatic, Ditchback and Non-crop Weeds

Chairman - Dave Spencer, Chairman-elect - Winn Winkyaw

The chairman for next year is Winn Winkyaw, Salt River Project, P.O. Box 1980, Phoenix, Arizona 85801. Barbara Mullin, Montana Department of Agriculture is chairman-elect. Thirty-one people attended Project 6. The discussion centered on weed control practices in rice.

Project 7: Chemical and Physiological Studies

Chairman - Phil Peterson, Chairman-elect - Fred Ryan

Dr. Jodie Holt (Dept. of Botany and Plant Sciences, University of California at Riverside) is the new chairman-elect.

Approximately 90 people were in attendance. A lively discussion took place on the impact of chemical control of weeds on the environment. The role of weed scientists in the formulation of public opinion on this topic was questioned. The responsibility of weed scientists to educate people on the risks and benefits of herbicide usage was discussed.

It was moved and seconded to accept the Research Section Report. Motion passed.

The Site Selection Committee Report was given by Paul Ogg. The 1990 meeting of the WSWS will be held March 13-15 at Ascuaga's Nuggett in Sparks, Nevada. It was moved and seconded to accept the Site Selection Committee report. Motion passed.

The Treasurer and Business Managers Report was given by J. LaMar Anderson. The Society netted $2,993.57 in 1985 and now possesses a net worth of in excess of $42,000.

Western Society of Weed Science

Financial Statement
March 8, 1985 - March 8, 1986

Income		1985-86
Registration, Annual Meeting		$8,885.00
157 X $30	$4,710	
Preregistration, 167 X $25	4,175	
Graduate Students (22)		
Guests (3)		
Tour		190.00
Dues, members not attending annual meeting (97)		485.00
Extra luncheon tickets (28 X $10)		280.00
Current Research Progress Report Sales		3,592.69
Current Proceedings Sales		4,417.72
Page Charges, review aritícles		910.00
Sale of back issues of publications		323.26
Payment of outstanding invoice, previous year		223.50
Advance order payments		
Coffee Break donations		1,025.00
Refunds		
Total fiscal year income		$20,332.17

Expenditures	
Annual Meeting incidental expenses, last year	1,683.62
Annual Meeting incidental expenses, current year	574.74
Luncheon, annual meeting	4,061.07
Guest Speaker expenses	264.00
Graduate Student room subsidy	620.00
Graduate Student paper awards	304.05
Business Manager honorarium	1,000.00
Cast dues	571.20
Research Progress Report publication costs	2,703.58
Proceedings publication costs	3,444.76
Postage	866.60
Newsletters, printing costs	281.63
Office Supplies	281.53
Refunds	70.00
Program, printing costs	611,82
Total fiscal year expenditures	$17,338.60
Fiscal Year operational profits	2,993.57
Interest on checking	388.06
Interest on saving certificates (matured)	2,913.79
	$6,295.42

Assets	
Savings certificates	$30,500.00
Check Account balance	12,137.97
Cash on hand	50.00
	$42,687.97

The Finance Committee Report was given by Sheldon Blank. An audit of finances showed excellent records and soundness of WSWS assets. The society now possesses in excess of 2 1/2 years operating capital. It was moved and seconded to accept the Business Managers and Finance Committee report. Motion passed.

The Necrology Report was given by Pete Fay. He reported that Lee Burge and Ray Meyer had recently passed away. It was moved and seconded to accept the Necrology report. Motion passed.

Raymond Warren Meyer, who served as the Whitman County Weed Specialist for several years died May 21, 1985. He was 64. He was born on January 1, 1921 at Weeping Water, Nebraska. He served with the U.S. Army Air Force from December of 1942 until October of 1945. His military service included a stint in Europe. In 1946 he moved to Pullman to study at Washington State University. After receiving his bachelor's degree in wildlife management in 1949, he worked for the school's agronomy department and the U.S. Soil Conservation Service.

Meyer was employed with the Soils Conservation Service at Goldendale from 1949 until 1957 and then at Ellensburg for one year. He then returned to Pullman in 1958 and entered graduate school at WSU working part-time with the agronomy department. In 1964 he received a master's degree in botany and soil science. After working with the university's agronomy department for a year, he was employed as a weed specialist with the Whitman County Extension Service at Colfax. Meyer retired in 1980 and worked as a private consultant until last summer, when he discontinued the service because of poor health. Meyer was a member of the Weed Science Society of America and of Sigma Xi, a scientific honorary fraternity. He was also a member of the Western Society of Weed Science.

Lee M. Burge died September 30, 1985. He was born in San Francisco, California October 1, 1906. Lee graduated from the University of Nevada in 1929 with a bachelor of science degree in animal husbandry and biological sciences. Lee began his career with the State Board of Stock Commissioners in 1928, which later became the Nevada State Department of Agriculture. He served as supervising inspector of the Plant Division until 1957 when he was named director of the division. In 1960, Lee was appointed Executive Director of the Department of Agriculture, serving until his retirement in 1972.

Lee gained national recognition in 1951 when he was honored with the "Man of the Hoe" award. In 1970 he was made an honorary life member of the Western Society of Weed Science. Lee was also involved in national and regional, as well as local, agricultural associations and fraternal organization. During the last six years, he had been engaged in successfully breeding and showing West Highland White Terrier dogs which produced a number of show champions under the name of Lee Burge Westies. He is survived by his wife, Florence, two daughters and two grandchildren.

The meeting was opened for New Business from the floor. Elaine Hale moved that the WSWS Executive Committee in conjunction with CAST set aside a contingency fund of $2500 to investigate the physical and financial feasibility for producing a children's television program. The purpose would be to further educate elementary children about agriculture in general. The motion was seconded and discussed. Motion passed. Lowell Jordan indicated that CAST would consider the motion at their summer meeting. He will put together a letter for the WSWS to CAST containing Elaine Hale's motion and information. No further new business was brought to the floor.

President Tripple presented his closing remarks and thanks to the WSWS membership. He called up John Evans and passed the gavel and responsibility to the new President. John Evans presented an appreciation plaque to Harvey on behalf of the WSWS. It was moved and seconded that meeting be adjourned. Motion passed and meeting was adjourned at 8:37 a.m.

Respectfully submitted,

Sheldon Blank-Secretary WSWS

Dwight V. Peabody and Robert L. Zimdahl were elected Fellows at the Western Society of Weed Science.

Dwight Van Peabody worked at the Northwestern Washington Research and Extension Center for 34 years serving the agricultural community in western Washington. During his tenure as a weed scientist, he developed weed control programs for virtually every crop grown in western Washington. This includes some 40 crops ranging from green peas and field corn to seed crops and Christmas tree production.

Dwight's contribution to research and extension are well documented, as he has authored over 150 extension and journal publications. He has been active in and served as president of the Washington State Weed Association. In addition, he has been active in the WSSA and WSWS. He was awarded the 'Weed Warrior Award' by the Washington State Weed Association in recognition of his contributions to Weed Science. Last year Dwight was the first recipient of the Robert 'Bob' MacDonald award by the Puget Sound Seed Growers Association in recognition of his contributions to the seed industry. Dwight's contributions to weed control research, extension and technology transfer have been of a very high level. He has had an excellent rapport with researchers, extension and industry personnel as well as the farmer. He is recognized in the Pacific Northwest and southwestern Canada as one of 'the' weed scientists.

Robert L. Zimdahl was born in Buffalo, New York, is married and the father of four children. His Bachelor's Degree in Dairy Husbandry is from Cornell University (1956). He obtained and Master's of Science Degree from Cornell in Agronomy in 1966 and the Ph.D. from Oregon State University in Agronomy and Agricultural Chemistry in 1968. He has been employed at the Weed Research Lab, Colorado State University since 1968. In addition to teaching the undergraduate weed science course, Dr. Zimdahl does research on soil degradation of herbicides and is particularly interested in the kinetics of herbicide degradation in soil. He has served as major professor for 19 graduate students in Weed Science at Colorado State University.

During his career at Colorado State University, he has written three books, chapters in five other books and been author or co-author of 45 scientific papers. In 1984 he was elected a Fellow of the Weed Science Society of America and received the Outstanding Paper Award (with E.E. Schweizer) in 1985 from the Weed Science Society of America. He is a member of the UN/FAO Expert Panel on Weeds. In addition to his duties in Weed Science, he has a quarter time appointment as CSU's Director of International Education and teaches a class on world population and food.

FELLOWS OF WSWS

Robert B. Balcom 1968
*Walter S. Ball, 1968
Alden S. Craft, 1968
F.L. Timmons, 1968
D.C. Tingey, 1968
Lambert C. Erickson, 1969
*Jesse M. Hodgsen, 1969
*Lee M. Burge, 1970
Bruce Thornton, 1970
Virgil H. Freed, 1971
W.A. Harvey, 1971
*H. Fred Arle, 1972
Boysie E. Day, 1972
Harold P. Alley, 1973
K.C. Hamilton, 1973
William R. Furtick, 1974
*Oliver A. Leonard, 1974
Richard A. Fosse, 1975
Clarence I. Seeley, 1975
Arnold P. Appleby, 1976
J. LaMar Anderson, 1977
Arthur H. Lange, 1977
David E. Bayer, 1978
Kenneth W. Dunster, 1978
Louis A. Jensen, 1979
Gary A. Lee, 1979
W.L. Anliker, 1980
P. Eugene Heikes, 1981
J. Wayne Whitworth, 1981
Bert L. Bohmont, 1982
Lowell S. Jordan, 1982
Richard D. Comes, 1983
Clyde L. Elmore, 1983
Larry C. Burrill, 1984
Jack Warren, 1985
Dwight V. Peabody, 1986
Robert L. Zimdahl, 1986

HONORARY MEMBERS OF WSWS

*Dick Beeler, 1976
Dale H. Bohmont, 1978
R. Phillip Upchurch, 1982
Virgil H. Freed, 1983
Warren C. Shaw, 1984

*Deceased

Membership List of the Western Society of Weed Science, May 1, 1986

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