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**Presidential Address**  
**It's Time to Make Our Move**  
**Donald L. Burgoyne<sup>1</sup>**

When one looks at the membership list of the Western Society of Weed Science, he is impressed with the high quality of personnel and the expansive scope of technological expertise found in these people.

Further, when one examines the Constitution and By-laws of this Society he is further impressed with the benevolent intentions of the group.

How then could such a fine group of people with such good intentions be included among many similar groups as irresponsible poisoners of the earth's environment?

There is no easy answer to this question. The fact remains that the unenlightened world does believe to a considerable degree that all those who advocate the use of pesticides do so with an irresponsible attitude.

In this country, many self-appointed protectors of their fellowman have dedicated themselves to stopping the pesticide pushers. When I say dedicated themselves, I mean it.

With a short-sighted attitude, few, if any, facts and exaggerated claims of malpractice, these people sought out the unenlightened press, provided them with sensational headlines and succeeded in blasting us right out of our fat and happy little nests.

Their effectiveness was and still is seated in the minds of millions of ordinary citizens who depend on the media to frame their attitudes. The public has neither the time nor the inclination to seek out the real truth.

Stunned at learning that some of their neighbors would poison their environment, the public reacted favorably to suggestions for getting it stopped.

There's no need to go through all the things that have happened in that regard. You know them as well as I. We've had the banning of certain pesticide users and the hurried passage of legislative rules and regulations to protect the people. We even have a Federal Environmental Protection Agency. What a title! How could John Q. Public believe that such an agency with such a beautiful name could be anything but good for him.

Now that John Q. Public has gotten some action to protect him from the pesticide menace, he's beginning to relax a little. He's beginning to worry about the energy shortage and the integrity of his elected leaders. He's curious as to why food costs so much.

But what about us? The good guys! What have we been doing while our accusers so graciously included us in the "bad-guy" list and poured the heat on us? The answer to that question is fairly easy. We've done little.

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<sup>1</sup> Du Pont Company, Palo Alto, California

Even though we've accomplished little doesn't mean we've been idle. We've been busy talking. Talking to each other, that is. Talking about how our friends turned on us, when all we were guilty of was trying to be helpful to them.

We've been very busy lately trying to find out what rules and regulations must be followed if we are to continue to have useful pesticides available.

There have been a few isolated cases where some of our people have successfully defended us from some vicious attacks which could have robbed us of more of our useful pesticides.

What next? Are we to be satisfied with tokenism?

Our adversaries knocked us off our feet with a crunching offensive action. When do we launch our offensive? When do we go to the press with our story? When do we go to our legislature for help?

The answer is; Now! It's time to make our move! Now!

This Society has been in existence for over 25 years and until very recently, has never had a public relations program. Your Executive Committee is working toward correcting that omission.

A careful screening of the most recent list of WSWS members failed to turn up a single magazine editor or member of the daily press, radio, or television. This needs to be corrected.

How can we expect help in carrying our message to the masses if we don't make it easy for the reporters to witness and write about what we're doing.

How are we going to show the public what their Environmental Protection Agency is going to do for them? We need to tell them that the EPA regulations are becoming so strict and cumbersome, that the costs of pesticide development and marketing will double or triple. The cost of necessary pesticides to the food and fiber producer will go up, and he will be forced to charge the consuming public more for his produce.

And, who gets to be included in paying the higher cost for food and clothing? We do!

Last month at the WSSA meeting in Las Vegas one of the principal speakers, who is a leader in the field of Home Economics, told us that our image in the eyes of the American household was badly tarnished. She explained that this prevailing attitude had been planted in the minds of the householders by the constant bombardment provided by the media.

Her advice to us was to change our image to its rightful lustre by using the same approach. Constant bombardment, via the media, aimed at the American household with our side of the pesticide controversy.

She challenged the members of her WSSA audience to make a personal pledge to do something positive toward educating the people. I accepted the challenge.

I personally pledge to you that I will work long and hard at removing the tarnish from our image. And, I challenge you as a member of the WSWS to make your own pledge.

Now is the time to make our move.

## Toxicity of Several Nitrite-Bearing *Astragalus* Species

M. Colburn Williams and L. F. James<sup>1</sup>

**Abstract.** Several species of nitrite-bearing *Astragalus* were examined for toxicity to sheep. Species tested, with nitrite content expressed as mg NO<sub>2</sub>/g of dried plant, were: *A. convallarius* Greene, 6.2; *A. diversifolius* Gray, 6.4; *A. canadensis* var. *brevidens* (Gand.) Barneby, 36.0; *A. pterocarpus* Wats., 7.8; and *A. cibarius* Sheld., 16.3. Of these, only *A. canadensis* was known to poison domestic livestock.

Dosages were calculated as mg NO<sub>2</sub>/kg of body weight and administered orally as an aqueous slurry. The toxicity of the plants was compared with the oral toxicity of two known organic nitro compounds found in *Astragalus*, 3-nitro-1-propanol (3-NPOH) and 3-nitropropanoic acid (3-NPA). Blood samples were collected hourly for methemoglobin determinations.

Fatal doses (mg NO<sub>2</sub>/kg body wt) were: *A. pterocarpus*, 37.5; 3-NPOH, 50; *A. diversifolius*, 62.5; *A. convallarius*, 62.5; 3-NPA, 125; *A. cibarius*, 200; and *A. canadensis*, 275.

Nitrites were rapidly absorbed from 3-NPOH, *A. convallarius*, *A. diversifolius*, and *A. pterocarpus*, but slowly absorbed from 3-NPA, *A. cibarius*, and *A. canadensis*.

From the standpoint of livestock poisoning, the chemical structure of the nitro compound, and therefore its capacity to be absorbed into the circulatory system, is more important than the concentration of nitrite within the plant. Nevertheless, *A. canadensis* may contain up to 60 mg NO<sub>2</sub>/g of dried leaf and be as toxic, per gram of plant, as *A. convallarius* or *A. pterocarpus*.

<sup>1</sup>Western Region, Agr. Res. Serv., U.S. Dept. of Agr., Logan, Utah 84322.

## Mesquite Control With Repeated Herbicide Treatments

W. L. Gould<sup>1</sup>

**Abstract.** The degree of control on the sand-dune type of mesquite commonly found in New Mexico varies from nearly zero to over 50 percent on similar sites in different years. Sometimes poor control is obtained after two applications of 2,4,5-T are made. Consequently, a study was initiated to determine the effectiveness of repeated treatments applied at various intervals after the initial treatment.

Over a seven-year period, single applications of 1/2 lb/A of 2,4,5-T at four locations killed from 5 to 43 percent of the mesquite with an average of 16 percent control. When two applications of herbicide were made, the average degree of control decreased as the number of years between treatments increased from one to three years or more. The average degree of control when the second treatment was 1, 2, or 3 years after the initial treatment was 46, 39 and 33 percent, respectively. With three applications of 2,4,5-T, the average degree of control was 57 percent when two of the three treatments were in successive years, but the control was lower when two or more years occurred between each treatment.

This study indicates that generally treatments with 2,4,5-T on mesquite in New Mexico should be applied in successive years until the desired level of control is obtained.

<sup>1</sup>Agronomy Department, New Mexico State University, Las Cruces, New Mexico 88003.

## "KRENITE" – A New Brush Control Agent

A. A. Baber – G. L. McCall<sup>1</sup>

The discovery of ammonium ethyl carbamoylphosphonate<sup>2</sup> had introduced a new concept for the control of brush. Undesirable brush can be eliminated efficiently by foliar sprays without unsightly discoloration or undue loss of leaves other than through the normal seasonal maturation process. Application of this growth regulator, after the main flush of annual growth has hardened, causes only a slight visible effect on the foliage. Normal seasonal leaf drop occurs during the fall, but leaf bud development the following spring is either severely limited or is prevented entirely. Stems and roots eventually die.

Ammonium ethyl carbamoylphosphonate has other attributes which minimize its impact upon the environment. Mammalian toxicity is extremely low with an LD<sub>50</sub> of the four pound per gallon formulation of 24,400 mg/kg. Fish and other wildlife species are tolerant to the compound.

Ammonium ethyl carbamoylphosphonate, although extremely soluble in water, is readily absorbed by the soil. It has a Freundlich K equilibrium constant on Keyport silt loam greater than 20, which indicates high absorption on soil. It is also decomposed quickly by soil microorganisms. This material poses no problem of runoff into surface waters or leaching into subterranean aquifers.

Based on tests conducted to date, effective applications of ammonium ethyl carbamoylphosphonate can be made during August, September, and early October. Leaf necrosis may take place if treatment is applied at high temperatures. Generally, only the more susceptible species show this effect. The usual response, if any, is merely an earlier appearance of fall coloration of the foliage.

Most testing has been focused in areas with rainfall of 30 inches or more per year and with cold winter temperatures. More recent tests have been applied in areas of the Far West.

Effective rates for aerial applications range from 4 to 8 pounds active per acre depending on the species to be controlled. Ground applications in sufficient volume to give good coverage are effective at 2 to 6 pounds per acre. The addition of an effective wetting agent such as Du Pont Surfactant WK will enhance activity. The wetting agent will also increase the probability of leaf discoloration if, as previously stated, air temperatures are higher than normal.

<sup>1</sup>Contribution of the Biochemicals Department, E. I. du Pont de Nemours & Co., Inc., Wilmington, Delaware.

<sup>2</sup>Ammonium ethyl carbamoylphosphonate is the active ingredient in "Krenite" Brush Control Agent (formerly designated DPX 1108). "Krenite" is a Du Pont trademark.

Applications designed to get the spray into the canopy of the brush appear to be most effective. It is essential that the leaves and branches in the top of the tree be covered thoroughly. Spray coverage of these upper limbs and subsequent inhibition of the buds is essential for best results.

The response of woody plants to applications made before the optimum period varies considerably. Treatments made when leaves are expanding usually injure the plant. Symptoms are leaf necrosis and chlorosis with some marginal puckering. The terminal branch and sometimes numerous laterals may defoliate often accompanied by tip dieback. Very little if any elongation takes place.

The following year many species will begin growth again so that the final result is a retardation of the normal growth rate. This can be accomplished at rates of 1 to 3 lbs./100 gallons on some species such as the maples, without serious injury symptoms. On mixed brush, significant retardation is seldom accomplished without excessive injury showing on some species such as alder. Higher rates of 4 to 8 lbs./100 gallons will be required to obtain broad spectrum brush control.

Brush treated after the heavy flush of spring growth has been completed, but before the leaves and new stems have hardened, may not produce symptoms until the following spring. The response then is similar to the first year symptoms produced by early applications.

There is possibly a critical physiological or anatomical stage in the annual growth cycle of a deciduous tree relative to the effect of ammonium ethyl carbamoylphosphonate. All buds are suppressed or killed if the chemical is applied after that stage is reached and the plant eventually dies. Earlier applications affect the leaves and suppress growth but the plant eventually recovers. If such a critical stage does exist, it has not yet been identified.

Herbaceous plants do not respond significantly to ammonium ethyl carbamoylphosphonate. Perennials are sometimes repressed depending on the timing of the application. The undercover, including low shrubs protected by the canopy, takes over immediately so that there is no erosion problem. Broadleaf evergreens, if present, also continue unharmed.

The unique response of plants to this growth regulant makes possible the management of brush so that transmission and transportation arteries can be efficiently and aesthetically maintained with a minimum undesirable effect on the environment. Much remains to be learned in order to completely attain the results of this brush management concept. Studies are required to determine the best time of treatment at different latitudes. Dormant applications have shown some promise but methods of application and methods to increase penetration need attention. Suppression of root suckering takes place, suggesting the combination of chemical treatment and cutting for some brush problems. The selective weeding of commercially important species is a possibility but needs more researching.

A few species in the Far West have been treated with ammonium ethyl carbamoylphosphonate. Early indications of susceptibility or tolerance of species is listed as follows:

### Susceptibility to ammonium ethyl carbamoylphosphonate<sup>3</sup> brush control agent.

Species		Tolerant	Intermediate	Susceptible
Maple (Big Leaf)	Acer macrophyllum		X	
Maple (Vine)	Acer circinatum			X
Alder	Alnus ruera			X
Blackberry	Rubus sp.		X	
Douglas Fir	Pseudotsuga menziesii		X	
Salmonberry	Rubus spectabilis			X
Tan Oak	Quercus sp.			X
Eucalyptus	Eucalyptus sp.			X
Willow	Salix sp.	X		
Redwood	Sequoia sempervirens			X

T = Tolerant 0 - 50% retardation or control.

I = Intermediate 50 - 80% retardation or control.

S = Susceptible 80 - 100% retardation or control.

<sup>3</sup>"Krenite" evaluated at 2 to 6 lbs. active ingredient per 100 Gallons.

### Origin of Mountain Whitehorn Brushfields on Burns and Cuttings in Pacific Northwest Forests

H. Gratkowski

#### Introduction

A good understanding of ecology of native shrubs is necessary in Pacific Northwest silviculture, for brush species affect regeneration and growth of valuable coniferous trees. Small, scattered shrubs can ameliorate harsh microclimatic conditions and favor establishment of tree seedlings on many sites. On the other hand, dense stands of mature brush can hinder reforestation and reduce growth of young trees by shading and competing with the trees for limited soil moisture during the dry summer season. A knowledge of the origin and optimum habitat of native shrubs is vital in developing silvicultural practices that will create conditions unfavorable for brush species but favorable for germination and growth of young conifers.

Mountain whitethorn (*Ceanothus cordulatus* Kell.) is one of the more abundant and troublesome shrubs on commercial forest land in California and southwestern Oregon. This spiny, erect shrub is an important component of many high-elevation brushfields from the southern end of the Sierra Nevada northward to the Siskiyou Mountains and Cascade Range in Oregon.

Sunny, open habitats appear most suitable for development and growth of mountain whitethorn. Dense stands of

mountain whitethorn more than 8 feet tall occupy many new cuttings near the crest of the Cascade Range northwest of Crater Lake (Fig. 1), although shrubs of seed-bearing size are not usually present under the trees before logging. A similar occupation of disturbed and burned areas occurs in California's Sierra Nevada (1), but the shrubs are only 2 to 5 feet tall. Mountain whitethorn shrubs in Siskiyou Mountain brushfields also attain heights of only 2 to 5 feet at maturity.

Several botanists and foresters have noted an abundant germination of mountain whitethorn seeds on new burns and cuttings following wildfires or prescribed burning of logging slash (1, 4). In the Siskiyou Mountains, prescribed burning of chemically-desiccated brushfields for site preparation produced more than 10,000 new brush seedlings per acre; 87 percent were mountain whitethorn seedlings (3). Those observing such seedlings have speculated that the fires stimulated germination of dormant *Ceanothus* seeds in the soil.

Quick (6) found 1.8 million mountain whitethorn, deerbrush *Ceanothus* (*C. integerrimus* H. & A.) and little-leaf *Ceanothus* (*C. parvifolius* Trel.) seeds per acre in soil under virgin mature stands of mixed conifers in the Sierra Nevada. He also learned that either boiling mountain whitethorn seeds or soaking them in hot water would cause the seeds to germinate if heat treatment was followed by stratification (7). Earlier, Wright (8) had determined that heating *Ceanothus* seeds in an electric oven at air temperatures up to 260° F resulted in germination of seed from three other *Ceanothus* species.

Such treatments, however, do not resemble natural conditions that induce germination of dormant mountain whitethorn seeds in forest soil. Forest fires or prescribed burning of brushfields or logging slash heats soil to a wide range of temperatures from slight warming to soil temperatures in excess of 1,000° F (538° C), and buried seed may be encased in hot soil for periods of a few minutes to several hours (5). Maximum temperatures attained, duration of high temperatures, and speed of cooling depend to a great extent upon fuel type, fuel volume and arrangement, and soil characteristics.

Two laboratory-greenhouse experiments were designed to more nearly simulate conditions that occur in nature. One experiment was designed to determine the effect of high soil temperatures and duration of heating on germination of buried mountain whitethorn seeds. The second experiment was designed to determine stratification requirements of heat-treated seeds.

## Materials, Methods, Results and Discussion

Seeds used in the experiments were collected during August, 1958, 3,200 ft. above sea level in the Cascade Range near Crater Lake, Oregon. Mature capsules were stripped from the shrubs and stored in paper sacks at room temperature for several months before extraction. Capsules were then cracked by rubbing between soft cedar boards and dark brown, mature seeds were manually separated from the chaff. Cleaned seed was stored in

dry paper containers at 3° C in a refrigerator until used in the soil temperature experiment in 1963 and the stratification study in 1971. The long period of cold storage should not have appreciably reduced viability or germination percentage. Quick and Quick (7) obtained germination percentages of 71 to 90 percent for five seed lots after dry cold storage for periods of 12 to 15 years.

### Germination Induced by Heated Soil

Replicates of 50 seeds each were buried for periods of 4, 13, 22, 31, or 40 minutes in fine, dry sand preheated in an electric oven to soil temperatures of 30°, 45°, 60°, 75°, 90°, 105°, or 120° C. Each treatment was replicated four times in a 5 x 7 factorial experiment in a randomized block design. Thermocouples and a recording potentiometer was used to control soil temperatures during treatment. Each replicate was stratified in moist vermiculite at 3° C for 12 weeks after heat treatment and then germinated in separate flats in a greenhouse. A 3:1 sterile mixture of perlite (exploded pumice) and vermiculite (expanded mica) was used instead of soil as a germination medium. This insured that all mountain whitethorn seedlings were from seed heat-treated in the experiment.

Soil temperatures of 30° and 45° C did not induce germination of mountain whitethorn seeds (Fig. 2). A small percentage germinated after exposure to 60° C soil temperatures, but maximum germination was obtained from seeds that had been buried in soils preheated to 90° or 105° C. The 120° C soil temperature was lethal to most mountain whitethorn seeds of this seed lot.

Although seed coats became permeable to moisture within 4 minutes in soils heated to 90° or 105° C, viability was not reduced by allowing the seeds to remain in the hot soil for as long as 40 minutes. This remarkable ability to withstand high soil temperatures is an important survival mechanism. It permits mountain whitethorn seeds to endure long exposure to high soil temperatures during wildfires and then germinate and occupy the burned areas.

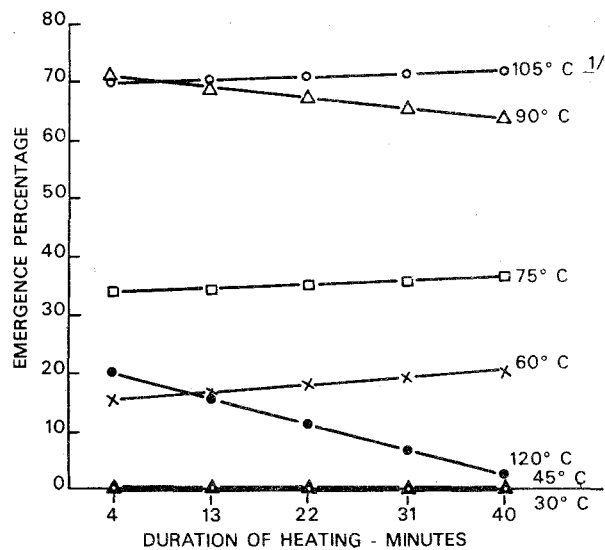
Soil temperatures within the range that will induce germination are produced under burning logging slash in forest cuttings (5). Burning light slash or small accumulations of logging debris is most favorable for heating soil to these temperatures at depths of ¼ to 1½ inches from which mountain whitethorn seedlings can emerge. Large accumulations of slash and decayed logs raise soil temperatures far above lethal levels at this depth and may even burn out all organic matter including seeds to depths of a foot or more below the soil surface.

### Stratification Requirement

Most *Ceanothus* seeds have dormant embryos as well as impermeable seed coats and will not germinate unless stratified in a cold, moist, aerated medium after the seed coats are made permeable to moisture. Stratification is generally required for seeds of species that grow at high elevations (2). Stratification allows after-ripening of the embryo and other seed contents.



**Figure 1.** Stand of mountain whitethorn near the crest of the Cascades in southwestern Oregon.



<sup>1/</sup>Slopes of the 90° and 105° regression lines not statistically significant, indicating average number of seeds that germinated after 40 minutes was same as number germinating after 4 minutes.

**Figure 2.** Emergence of mountain whitethorn seedlings heated in dry sand at soil temperatures ranging from 30<sup>o</sup> to 120<sup>o</sup> C for periods of 4 to 40 minutes.

The *Woody Plant Seed Manual* (2) does not provide pregermination treatments for mountain whitethorn seeds, but Quick and Quick (7) determined that mountain whitethorn seeds collected in the Sierra Nevada required stratification for approximately 3 months at 0 to 2.2° C. It seemed advisable to learn whether mountain whitethorn seeds collected in Oregon require stratification and to determine if 12 weeks after-ripening is sufficient for maximum germination.

At intervals of 2 weeks, four 50-seed replicates of the same seed lot used in the 1963 experiment were heat-treated, then stratified for periods of 12, 10, 8, 6, 4, 2, and 0 weeks. Heat treatment consisted of burying each 50-seed replicate for 10 minutes in fine sand preheated to 90° C in an electric oven. Sand temperature was measured with thermocouples buried at seed level in the sand. After heat treatment, each replicate was placed in moist vermiculite in a separate container and allowed to absorb moisture at room temperature overnight. They were then placed in a refrigerator at approximately 3° C, for the desired stratification period. The day after the unstratified (0 week) replicates were heat treated, all samples were moved into the greenhouse for germination. Each 50-seed replicate was planted in a separate numbered flat filled with a 2:1 mixture of perlite and vermiculite and covered with a ½-inch layer of perlite.

Mountain whitethorn seeds of this seed lot unquestionably require stratification after heat treatment. Few seeds germinated with less than 8 weeks stratification (Table 1). Maximum germination was obtained in samples stratified for 10 weeks and 12 weeks, but the low total germination percentage (48 percent) indicates that a longer period of stratification may be more effective. This test is being repeated with stratification periods of up to 18 weeks duration. Present test results, however, indicate that mountain whitethorn seeds from Oregon should be stratified for at least 12 weeks after heat treatment.

**Table 1. Germination of heat-treated mountain whitethorn seeds after stratification for periods of 0 to 12 weeks.**

Sample number	Duration of stratification—weeks						
	0	2	4	6	8	10	12
	Percent						
1	0	0	4	4	14	58	64
2	0	0	0	8	34	56	32
3	0	2	2	12	80	40	50
4	0	0	2	22	20	38	46
Means	0	0	2	12	24	48	48

### Conclusion

Origin of many mountain whitethorn brushfields evidently can be attributed to fire-induced germination of dormant mountain whitethorn seeds in the soil. The experiments show that heated soil can stimulate germination of

buried seeds if followed by a cold, wet period suitable for after-ripening to overcome embryo dormancy.

The necessary sequence of fire and natural stratification is common at high elevations in the Cascade Range, Siskiyou Mountains and Sierra Nevada, where mountain whitethorn is abundant. Most logging slash is burned and wild-fires generally occur during late summer and early fall. Autumn rains and snow fall soon afterward at high elevations. Seeds rendered permeable by the fires imbibe moisture and after-ripening naturally in the cold, wet soil during winter, then germinate the following spring.

This new information, coupled with Quick's finding large number of mountain whitethorn seeds in forest soil (6), adds weight to earlier investigators' speculations that mountain whitethorn seedlings on burns resulted from fire-induced germination of dormant seeds in the soil.

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### Status of Glyphosate for Use in Western Agriculture

E. C. Spurrier and W. D. Carpenter<sup>1</sup>

The present status of labeling and field performance of glyphosate, the promising new postemergence herbicide from Monsanto, will be reviewed in general terms. Extensive field performance data is being generated; this will be utilized in Environmental Protection Agency (EPA) label petitions as well as for developing commercial programs. To date, experimental evaluations related to potential industrial and agricultural uses are in progress.

Monsanto has applied for an industrial use label for glyphosate. The EPA registration is expected in the first quarter of 1974. This label will permit the use of glyphosate

<sup>1</sup>Monsanto Company, St. Louis, Missouri

for control of annual and perennial weeds along highways, railroad, fuel and power transmission rights-of-way, airport runway areas and other similar areas with problem vegetation. In 1974 limited quantities of glyphosate will be available commercially for the above uses in selected areas of the United States.

Monsanto has also applied for an experimental permit and the establishment of temporary tolerances to treat small acreages of four crops, namely corn, cotton, soybeans and wheat. The glyphosate used in this program will not be sold. The experimental permit program will be the responsibility of Monsanto's Agricultural Market Development Department and will be closely coordinated with the cooperation of various university, experiment station and extension workers. This experimental permit is expected in the late first quarter or early second quarter 1974.

Work is also proceeding on other crops leading to label registration. These crops include barley, oats, rice, sorghum, citrus and coffee. Work is also underway for label registration of water. The label requirements have been completed and have been submitted to the EPA for both the industrial and experimental label permit. The toxicology requirements are complete and all appear favorable. The 70-15 environmental impact studies have also been completed and appear favorable.

The metabolism and residue methodology studies are completed for corn, cotton, soybeans and wheat. In addition, the residue analyses for the experimental permit for these crops are complete. Further, the necessary studies for the four crops to support a full label are in progress and the data appear promising. Additional studies are underway to evaluate long term efficacy, as well as fundamental physiological responses.

In terms of field performance, much of the work and data submitted for label registration deal primarily with control of perennial species of herbaceous weeds such as bermudagrass, johnsongrass, quackgrass and certain perennial broadleaf weeds. 1973 results and reports discussed here and reports presented to other conferences confirm that glyphosate is an effective herbicide for a broad range of both perennial and annual vegetation. Therefore, no attempt will be made at this time to make a detailed report in this area.

It appears that glyphosate holds promise for control of woody plants. A number of trials conducted in 1972 and 1973 suggest that a range of species such as oak, sweetgum, aspen, ash, maples and others can be controlled with over-the-top applications of glyphosate. Results from Scandinavia show certain deciduous hardwoods can be selectively removed from conifer stands at rates ranging from one to six lb/A acid equivalent of glyphosate. Limited data indicate that the injection technique may also be effective. As is true with perennial vegetation, it appears that glyphosate is more effective for woody brush control when applied during the later summer period.

Control of certain aquatic weed species, such as pragmites, water hyacinth, tules and cattails, with glyphosate shows promise. These species include weeds emersed in water as well as ditchbank species. Further trials are

planned to evaluate the potential of glyphosate in this very important area.

Glyphosate is also being evaluated as a tank mix with certain soil residual herbicides such as triazines, substituted ureas and others. When mixed with certain of these residuals the performance of glyphosate is reduced in some situations. However, the performance of the residual apparently is not affected. Control of perennial grasses such as bermudagrass and johnsongrass is generally better when glyphosate is used alone than when tank mixed with a residual. Reduced glyphosate activity has been more of a problem when mixed with residual materials at industrial rates than when mixed with residuals at lower agricultural rates such as would be used in no-tillage or minimum tillage concepts.

One of the more interesting application techniques for glyphosate has been the recirculating sprayer. This sprayer concept, developed at the Delta Branch Experiment Station, Stoneville, Mississippi under the direction of Dr. Chester McWhorter, may be an excellent method for applying glyphosate in a range of crops where a differential height of weeds and crops will allow its use. Control of johnsongrass in soybeans is effective. Other potential uses range from controlling volunteer corn in soybeans to controlling pigweed in cotton, and shattercane in several crops.

#### Progress Report on Crop Tolerance, Weed Control and Drift Control with LO-DRIFT™ Spray Additive

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K. W. Dunster<sup>2</sup>

LO-DRIFT Spray Additive is a polyvinyl polymer which increases the size and stability of spray droplets. Drift studies have established that the polymer contained in LO-DRIFT decreases the drift of agricultural sprays applied by aerial and ground equipment. The current product label recommends using the polymer with non-crop herbicides and cotton defoliant. Crop selectivity and performance trials indicate that LO-DRIFT has only minor effects on the weed and crop activity of herbicides. The physical properties, ease of mixing, and low rates required for effectiveness make this drift control agent an attractive tool for reducing herbicide spray drift.

#### Legume Selectivity

Spray mixtures of LO-DRIFT Spray Additive with several herbicides were applied to alfalfa; alsike, ladino, and red clover; birdsfoot trefoil; garden peas; mustard and pigweed at Manteca, California. Legumes were in the two to three trifoliolate leaf stage. Mustard and pigweed had four to six true leaves. Sprays of 2,4-DB dimethylamine salt at 1.5 lb/A, 2,4-DB butoxyethanol ester at 1.5 lb/A and MCPB dimethylamine salt at 1 lb/A were applied with and without LO-DRIFT at 8 fl oz/100 gallons of spray mixture. All herbicides were applied in water at a volume of 25 gallons per acre on April 15, 1973. Plots were evaluated on May 10 and percent injury on each crop and weed species

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was recorded (Table 1). Adding LO-DRIFT increased herbicide injury and weed control slightly. Injury of alfalfa alsike, ladino and red clover took the form of necrotic leaf spots; injury to garden peas, mustard and pigweed was epinasty of the petioles and leaves. Subsequent growth of the legumes was normal.

The LO-DRIFT formulation used in the study contained a surfactant in the formulation, and no other surfactant was added.

Table 1. Effect of herbicide/LO-DRIFT mixtures on legume selectivity and weed control. Manteca, Calif., 1973

Treatment <sup>1</sup>	Percent injury <sup>2</sup>		Percent weed control <sup>2</sup>	
	Alfalfa	Alsike	Ladino	Red clover
2,4-DB amine 1.5 lb/A	10	10	5	5
2,4-DB amine 1.5 lb/A + LO-DRIFT	10	15	5	10
2,4-DB ester 1.5 lb/A	10	5	0	5
2,4-DB ester 1.5 lb/A + LO-DRIFT	20	20	5	20
MCPB amine 1 lb/A	15	5	0	0
MCPB amine 1 lb/A + LO-DRIFT	25	10	10	15
Control	0	0	0	0

<sup>1</sup>Treated April 15 when garden peas had 4-6 true leaves, other legumes 2-3, and weeds had 4-8 true leaves.

<sup>2</sup>Average of 2 replications. Evaluated May 10.

### Small Grain Selectivity

Mixtures of LO-DRIFT Spray Additive and several herbicides were applied to barley, wheat, oats, ryegrass and volunteer weeds consisting of knotweed (*Polygonum aviculare*), redmaid (*Calandrinia ciliata*) and others at Manteca, California. Treatments were applied on April 5, 1973 to small grain seeded on February 2. Spray mixtures of bromoxynil octanoate at 6 oz/acre, 2,4-D dimethylamine at 12 oz/acre, 2,4-D butoxyethanol ester at 12 oz/acre, and MCPA dimethylamine at 4 oz/acre were applied with and without LO-DRIFT at a rate of 8 fl oz/100 gallons of water in a volume of 20 gallons spray mixture per acre. Evaluations were made on May 10 (Table 2). Stunting of

grains and ryegrass and reductions in weed populations were recorded. The addition of LO-DRIFT did not significantly affect the height of small grains or weed control.

Table 2. Effect of herbicide/LO-DRIFT mixtures on small grains and weeds. Manteca, Calif., 1973.

Treatment	Percent injury (stunting) <sup>1</sup>				Weed Control <sup>1</sup>
	Barley	Wheat	Oats	Ryegrass	
bromoxynil 6 oz/acre	0	0	0	0	90
bromoxynil 6 oz/acre + LO-DRIFT	0	0	3	0	90
2,4-D amine 12 oz/acre	13	7	10	7	90
2,4-D amine 12 oz/acre + LO-DRIFT	3	3	7	0	90
2,4-D ester 12 oz/acre	10	13	7	7	90
2,4-D ester 12 oz/acre + LO-DRIFT	13	7	10	0	90
MCPA amine 4 oz/acre	0	0	0	0	80
MCPA amine 4 oz/acre + LO-DRIFT	0	0	7	3	80
Control	0	0	0	0	0

<sup>1</sup>Average of 3 replications. Treated April 5; evaluated May 10.

### Drift Control

Butler and Goering (2) reported that in various tests with a dual spray system using Spraying Systems 8002 flat fan spray nozzles mounted on a boom 20 inches from the ground, the polyvinyl polymer used in LO-DRIFT Spray Additive reduced drift beyond 16 feet from the spray swath by an average of 91%. Spray pressures of 40-50 psi and polymer rates of 8-16 fl oz/100 gallons were used in these studies.

In wind tunnel tests, Akesson and Yates (1) found that the polyvinyl polymer increased the VMD (volume mean diameter) of spray droplets produced by D6 jets pointed back to 1400 microns from 800-900 microns with water only. D6 jets pointed down gave a VMD of 700 microns with the polyvinyl polymer.



## Viscosity

LO-DRIFT Spray Additive stabilizes spray droplets and increases droplet size without extreme increases in the viscosity of the spray solution. A study (4) was conducted to compare the viscosity of a LO-DRIFT spray solution with that of a commonly used hydroxyethyl cellulose drift control agent. Emulsions containing 4 lb/100 gal of 2,4-D butoxyethanol ester were thickened with LO-DRIFT and with hydroxyethyl cellulose. Both agents were used at recommended rates (3). Results of the study are presented in Table 3.

**Table 3. Average viscosity values of LO-DRIFT and hydroxyethyl cellulose drift control agents at use rates.**

Thickener	Rate/100 gal	Viscosity
LO-DRIFT	16 fl oz	10.0 cps <sup>1</sup>
	32	29.6
	48	50.6
Hydroxyethyl cellulose	3.4 lb	109.0
	4.5	159.8
	5.7	off scale

<sup>1</sup>Viscosity in centipoise measured with Brookfield Viscometer, Model RVT, spindle No. 1, 50 RPM setting.

## Physical Characteristics

Applicator experience shows that LO-DRIFT can be used to stabilize and increase the droplet size of wettable powder, emulsifiable and water soluble herbicide sprays. Label directions provide mixing instructions and ranges of rates for various types of spray equipment. It is important to maintain agitation when using LO-DRIFT with wettable powders, since they are difficult to resuspend if they settle to the bottom of the spray tank.

High concentrations of emulsifiable concentrates (10% or more of the spray solution) or herbicide mixtures with extra oil will require one quart or more of LO-DRIFT per 100 gallons of spray solution.

Butler and Goering (2) reported that this polyvinyl polymer is not as salt-sensitive as other thickeners.

When mixing LO-DRIFT with herbicide solutions, it is important to allow 5 to 10 minutes of agitation time to insure polymer structure activation. When using the LO-DRIFT polymer with ground equipment, most applicators find it necessary to raise the boom pressure to maintain the required spray angle, since the drift control agent narrows the effective spray angle of most nozzles. Raising the height of the boom will also maintain the desired spray overlap with flat fan nozzles.

For aerial application, D-4, D-6 or D-8 jet nozzles with whirl plate removed will give the most satisfactory spray distribution with LO-DRIFT. For maximum drift control and resultant large droplets, point the nozzles straight back away from the direction of flight. Smaller droplets for greater coverage can be produced by turning the nozzles

45° or 90° down. Droplet size is more irregular when whirl plates are used.

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## Can Unsatisfactory Field Results be Traced to Spray Tank Incompatibility Problems?

William P. Long<sup>1</sup>

Have you ever wondered why the weed control and the injury in a test plot wasn't uniform? Perhaps, your compound gave excellent results in one part of the plot but poor results in another. Or perhaps, you failed to achieve any control with a compound that had shown good results in other places or at other times. Many factors can cause poor results in field tests. One factor, which we would like to direct your attention to today, is spray tank incompatibility.

The achievement of success in field testing leading to the establishment of new pest control methods is very gratifying. All of us involved in developing new pesticides, new pesticide formulations and new weed control practices are interested in avoiding poor results.

So that we don't place a disproportionate amount of importance to the problem of spray tank incompatibility we should recognize it as only one of the factors that can contribute to poor field results. Some, though admittedly not all of these factors, are:

- 1) incorrect selection of chemicals
- 2) failure to follow label instructions
- 3) incorrect application techniques
- 4) poor planting practices
- 5) poor weather
- 6) spray tank incompatibility problems

When an incompatibility problem occurs, it will take place probably unknown to you. This sinister effect will be hidden within the confines of your opaque spray tank. Too often it is not until we collect our field test data that we see the form in which this problem manifests itself. Incompatibility in the spray tank produces a non-uniform spray mixture that gives a non-uniform deposition of pesticide which causes poor results. Poor results can cost you money and precious time. An entire season's field experience may be lost. Poor results can also mean the rejection of a potentially beneficial new compound. And,

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they can provoke grower complaints.

Throughout our years of experience in developing pesticide formulations we have had occasion to observe many types of spray tank problems. For the purpose of today's presentation, we have attempted to categorize these problems. Exhibit I summarizes this list of categories. No one would claim that this list includes every possible problem. However, we offer it as a starting point for your consideration. Today, we would like to present laboratory tests run to demonstrate some examples of several categories of spray tank problems. Keep in mind, these problems are the exception rather than the rule. However, they can and do occur. We hope our presentation will convince you to evaluate the physical aspects of new pesticide formulations and tank mixes prior to field testing. Compatibility studies on a small scale can reduce the frequency of problems in the field. Remember, a great deal of what you see taking place in laboratory glassware takes place in spray tanks.

### Improper Preparation of Spray Mixture

The first category we will discuss is improper preparation of spray mixture. Problems we put in this class are not entirely caused by physical or chemical incompatibilities. They are primarily caused by the procedures used in preparing the spray mixture which may be an emulsion, a dispersion, a solution or some combination thereof. Fortunately, problems in this class can be avoided by using proper procedures or by re-formulation.

To help illustrate our laboratory examples of incompatibility problems, we assembled the glassware simulation of a spray tank you see in this slide. Realizing we could not scale down a spray tank exactly, we designed the following features into our simulation:

- a) good visibility of the tank mixture
- b) simplicity of construction
- c) essential components: a tank with bottom drain, a pump, a pressure gauge, and a T shaped nozzle outlet at the discharge end of recirculation line into the tank.

### Categories of Spray Tank Problems

- (1) Incompatible Mixtures of Pesticide Formulations
  - a) Physical Incompatibilities
  - b) Chemical Incompatibilities
- (2) Incompatibility Caused by Spray Tank Additives
- (3) Improper Preparation of Spray Mixture
  - a) Insufficient Agitation
  - b) Improper Order of Addition
  - c) Wettable Powder Caking
  - d) Incorrect Dilution Rate
- (4) Pesticide Formulation Abuse
  - a) Contamination
  - b) Temperature

### (5) Incompatibility with Liquid Fertilizer

Most importantly we designed the tank,

- a) to simulate the flow pattern of a field spray tank with a recirculation line, and
- b) to recirculate approximately the same percent of the spray tank volume as a field tank would.

These last two factors are those which most affect the consequences of a spray tank incompatibility because they control the degree of agitation of the tank mix. Some physical incompatibilities will not yield non-uniform mixtures.

To illustrate this, we have chosen a spray tank mixture that does yield an incompatibility. Into our simulated spray tank partially filled with tap water, one of my helpers adds a concentrated slurry of a carbamate insecticide. Formulation of the slurry is not required with most wettable powder formulations but is desirable to insure good initial dispersion. With our simulated spray tank we have a completely uniform dispersion of this wettable powder. Now, an emulsifiable concentrate of a phosphorothioate insecticide is added.

With good agitation, this wettable powder dispersion/emulsion mixture will remain uniformly dispersed for an extended period. However, with poor agitation—which in our simulation means a lower recirculation rate—this inherently incompatible mixture substantially separates. In the slide, you can see a demarcation line between a bottom phase containing the wettable powder dispersion and a top phase containing only emulsion. If this mixture were applied in a field test, the last part of the plot would receive little or none of the wettable powder pesticide. In this example, poor agitation corresponded to recirculation of about 17% of the liquid volume per minute; whereas, good agitation corresponded to 70% recirculation.

The next spray tank problem I will describe involves the failure to agitate tank mixtures immediately after addition of the pesticide formulation or formulations. This situation arises in the field when a farmer dumps pesticide into a spray tank of water but does not start circulation of the mix until he is ready to start spraying some time later. It also arises when a greenhouse researcher makes up a large series of test treatments but does not agitate them until he is ready to apply them.

Most pesticide formulations are insensitive to the time delay between addition to water and agitation. However, some are not and can cause problems. To illustrate this, we pipette an emulsifiable pesticide concentrate into a graduated cylinder of water. This emulsion is not agitated and is allowed to stand undisturbed for two hours.

After two hours we pipette an identical amount of the same concentrate into an identical cylinder of water. Immediately after addition of this second concentrate, both cylinders of emulsion are agitated equally and then allowed to stand undisturbed.

After standing 30 minutes, the emulsion that was not agitated immediately is beginning to separate, whereas the emulsion agitated just after addition shows no physical

separation. Separation is evidenced by the color difference from the top to the bottom of the emulsion and by the cream layer separated at the bottom of the cylinder. To facilitate detection of separation for the purposes of this presentation, a small amount of oil soluble dye of intense color had been added to the concentrate.

After 60 minutes the emulsion not immediately agitated has separated into a layer of oil with a dilute emulsion above it. The emulsion agitated immediately after addition shows no separation. The **only** difference between this excellent emulsion and the very poor quality, unusable one was the time delay between addition and agitation.

Another problem that can occur in the preparation of a spray mixture is wettable powder caking. Our simulated spray tank will be used to illustrate how deceptive and severe this problem can be. Into our glass tank containing water, we add a slurry of a triazine herbicide wettable powder. Using normal agitation (recirculation), a uniform dispersion of the wettable powder is easily formed and maintained.

If the agitation is well below normal or if the agitation is stopped, most all wettable powders will begin to come out of suspension. To show the extreme case, we have stopped the recirculation and allowed the dispersion to stand for about 24 hours. As you can see in this picture, the expected separation has occurred.

Now if we start recirculation again, we should re-form our uniform dispersion. Right? Well, from the looks of the tank mixture after 15 minutes recirculation, this appears to be the case. The deposit of spray on a leaf surface would tend to confirm this. However, if we inspect our tank after its contents have been sprayed, we see an entirely different situation. Over half the wettable powder originally added is caked on the bottom of the tank. In addition to decreasing the application rate of herbicide, caking represents a potential source of contamination of future sprays.

Allowing a wettable powder—or flowable—dispersion to stand for a long time without agitation is unadvisable. However, when it cannot be helped, use vigorous agitation (even a paddle) to break up the cake. If you know a dispersion must stand for a long time in a field spray tank, it is advisable to drain all dispersion from the lines to the pump and strainer to prevent clogging.

The uniformity of the spray tank mixture of some combinations of pesticide formulations is dependent on the order of addition. This predominantly occurs with combinations containing wettable powders. As the title of this problem implies, there is a correct order of addition that avoids the problem. To illustrate this we will prepare mixtures comparing the two orders of addition side by side. We also will show dispersions of the individual formulations. Into two graduated cylinders of tap water, we add a herbicide wettable powder. Here, the powder wets and sinks to the bottom of the cylinder.

Into two more graduated cylinders of tap water, we add a liquid water soluble contact herbicide. The four cylinders

are agitated to uniformly disperse the individual formulations. Leaving the dispersion and solution on the left to illustrate what is obtained with the individual formulations, we now add liquid herbicide to the wettable powder dispersion and—on the far right—we add wettable powder to the herbicide solution. All four herbicide dispersions are agitated equally (equality is obtained by inverting stoppered cylinders 180 degrees in a smooth motion and at a controlled rate of about one complete inversion every 3 seconds). The dispersions are allowed to stand undisturbed.

After 10 minutes the wettable powder/liquid herbicide mixture that was formed by adding the powder last has grossly separated (on the far right). Whereas, the same mixture formed by adding the wettable powder first is still uniformly dispersed. As expected, there is no separation of the straight wettable powder dispersion or of the liquid herbicide solution (in the tubes on the left). It is uncommon for wettable powder tank mixes with water soluble formulations to be sensitive to the order of addition. If it were not for the sensitivity to addition order, one might suspect a chemical rather than physical interaction in this example.

The more frequent combination that produces an incompatibility dependent on the order of addition is a mixture of a wettable powder with an emulsifiable concentrate. To the tube of water on the left, we add an emulsifiable selective herbicide. To the tube of water on the right is added a wettable powder formulation of a selective herbicide. Both tubes will be agitated equally. Then, wettable powder is added to the herbicide, emulsion and emulsifiable concentrate is added to the wettable powder dispersion. Both mixtures are agitated and allowed to stand undisturbed.

After 15 minutes, the wettable powder has flocculated in the tube on the left to which the emulsifiable concentrate had been added first. In the other tube where the emulsifiable concentrate was added last there is no apparent separation. The problem in the first tube occurred because the agglomerates of wettable powder became coated with oily emulsion droplets before they had a chance to completely wet out and disperse finely. This was avoided in the second tube because a fine dispersion of wettable powder particles was formed before the oily emulsion was introduced. A good rule of thumb when dealing with mixtures of this type is to add wettable powders first (preferably from a pre-formed slurry) then add any water soluble herbicides and last add the emulsifiable concentrates. The chances of an incompatibility problem occurring will be greatly reduced.

It is not at all uncommon to have a non-uniform distribution of pesticide in a spray mixture from the incorrect use of a well formulated pesticide. Those people unfamiliar with the art of formulation do not always appreciate that emulsifiable concentrates must be tailored to work within a definite range of end use conditions. The formulator must take into account the water hardness and temperature variations anticipated in the end uses of the concentrate.

Just as the field researcher optimizes application rates of active ingredient to be both effective and safe so must the formulator design the emulsifiable concentrate to perform well within a range of anticipated dilution rates.

To illustrate this point we have formulated an insecticide emulsifiable concentrate to give a thick creamy emulsion at typical field dilution rates of 2 to 4 quarts concentrate per 10 to 20 gallons of water. This normal dilution is shown by the emulsion on the left. Using this same formulation, on the right we form a much more concentrated emulsion of 1 gallon concentrate to 1 gallon water. Such concentrated emulsions are typically used in aircraft spraying. Initially, both emulsions are good.

However, after only 15 minutes the concentrated emulsion has broken. The deep color of the red dye in the water phase above the emulsion accentuates this. To show you this situation occurs also with commercial formulations, this slide shows an emulsion of a non-selective herbicide at its recommended dilution on the left and on the right as an emulsion more concentrated than recommended. After only 15 minutes the concentrated emulsion has completely broken. The herbicide, being lighter than water, is floating as an oil layer on top of the water. Problems associated with dilution rate are readily discovered by testing on a small scale prior to application.

#### Pesticide Formulation Abuse

Into this category we include those ways in which we can abuse a well designed formulation to the extent that it no longer provides the good service it was intended to. Sometimes this abuse affects the chemical stability of the active ingredient. We will limit our discussion, however, to effects on the physical characteristics of the formulation, especially as these effects produce non-uniform spray tank mixtures.

Now, no one in his right mind who knows pesticides would intentionally subject his material to suffer the punishment of Mother Nature. However, you may be assured of catastrophic effects with some emulsifiable concentrates should they become contaminated with water. For example, as little as 1% water contamination in an emulsifiable crop oil concentrate can cause precipitation of the emulsifier. To the concentrate on the right 1% water has been added. On the bottom of this sample you can see a layer of off-white emulsifier. To prove the separation is emulsifier, a sample from the top layer of the contaminated concentrate and a sample from the uncontaminated concentrate will be simultaneously pipetted into water.

As it goes into the water, the uncontaminated concentrate forms a white creamy emulsion. The top layer of the contaminated concentrate forms no emulsion upon entering the water. All that forms is an unstable dispersion of large oil droplets. Not all water contamination problems cause only emulsifier precipitation. One percent water added to this emulsifiable cotton defoliant sample on the right causes precipitation of considerably more material than emulsifier.

Water is not the only contaminant an emulsifiable concentrate would do well to avoid. Iron or rust contamination

can severely degrade the concentrate's emulsion characteristics. The thick white creamy emulsion on the left with good spontaneity was made with a phenoxy ester concentrate stored for two weeks at 50° C in a glass jar without a steel strip. Another sample of the same phenoxy emulsifiable concentrate was stored at 50° C for two weeks but had a steel strip submerged in it. The emulsion it gives is very poor quality. It is thin and off-colored and separates oil droplets from the emulsion while falling through the water.

If both emulsions are agitated thoroughly and allowed to stand in the tubes, the iron contaminated sample separates rapidly. After 30 minutes the emulsion of the uncontaminated concentrate shows no separation. The emulsion of the iron contaminated concentrate has separated into an oil phase and a very thin emulsion phase. Iron contamination should not normally occur because package testing is an integral phase of a pesticide development. However, should contamination accidentally occur—as for example, through breaks in a can lining—it may often be evidenced by a darkening of the concentrate. You should also realize from this emulsion example one of the reasons why a pesticide should never be transferred from its original container to another container.

Another way in which we can abuse a pesticide formulation is to subject it to exposure at extreme temperatures for an extended period. For numerous susceptible formulations, storage at low temperatures can cause crystallization of components, particularly the active ingredient. The two concentrates shown in this slide have been stored at 10° F. No non-uniformity can be seen in the darker concentrate on the right. And, were the concentrate on the left in a metal can rather than this glass jar, no separation would be seen in it.

However, when we turn these two concentrates upside down, a large layer of crystallized active ingredient can be observed in both. Were either of these two concentrates used in a field test a lower rate or a non-uniform rate of active would be applied. It is advisable to allow all emulsifiable concentrates to equilibrate with about 70° F before attempting to use them. Where a concentrate is suspected of having been subjected to cold storage, agitate it vigorously before using.

Physical and chemical instability at elevated temperatures has plagued many pesticide actives, especially chlorinated materials. While for the most part emulsifiers and solvents are stable, many active ingredients tend to rapidly degrade chemically at temperatures of 120° F and above. This degradation may be minor in terms of active ingredient assay but the acid produced greatly shifts the requirements for good emulsification. To illustrate this we have stored an emulsifiable chlorinated insecticide concentrate in glass jars for one month at room temperature (70° F) and at 120° F. The 70° F stored concentrate when poured into water gives a good white emulsion (on the left). The concentrate stored at the elevated temperature gives a poor quality emulsion as evidenced by separation of oil droplets from the emulsion cloud and by its darker color which indicates some oil is not being emulsified.

If these emulsions are agitated and allowed to stand for 15 minutes, we see a radical difference between them. The emulsion of the room temperature aged concentrate is uniform. The emulsion of the high temperature aged concentrate has completely broken into a water and a cream layer. The emulsifiable concentrate formulator can build physical stability into his product by his selection of emulsifier type and level. He generally aims for good long term 70° F stability with some, but limited, stability at elevated temperatures. If a concentrate is suspected of having been stored at an elevated temperature, a small scale compatibility test should definitely be run to determine usability from an emulsion standpoint.

#### Incompatible Mixtures of Pesticide Formulations

So far, we have discussed how non-uniform spray mixtures can result from improper preparation procedures or from our abusing a pesticide formulation. We now direct our attention to a category of spray tank problems that are inherent in the formulations used and that are unavoidable—sometimes even after re-formulation. The majority of individually well-formulated pesticides may be tank mixed without causing an incompatibility problem. However, problems definitely occur with some combinations. The problems may be broken down into physical incompatibilities and chemical reactions between actives. We will first consider physical interactions.

In this example, we have two commercial insecticide emulsifiable concentrates that when used alone produce excellent emulsions but when used together produce an incompatible mixture. Into the tube of water on the left we pour the emulsifiable concentrate of insecticide A. Into the center tube is poured the concentrate of insecticide B. The third tube contains only water. Both concentrates form good thick creamy emulsions. A small amount of red dye has been added to concentrate B to accentuate demarcation of the incompatibility we will produce.

Now, to the third tube of water we first add concentrate A then add concentrate B. At this point we might begin to suspect a problem because the mixed emulsion is neither white, like A, nor pink, like B. The mixture is yellow. The three emulsions are agitated equally. Initially, no separation or deficiency in quality can be observed in the mixed emulsion.

However, after only ten minutes the mixed emulsion has sharply broken. This spray tank mixture will definitely not be deposited uniformly on the crop. Therefore, insect control will vary throughout the application area. In this example, the problem is compounded by the fact that the incompatibility is not readily apparent initially; it takes a short but definite amount of time to be observable. Quite a bit of formulation time was devoted to this particular problem this past year. Fortunately, several solutions were found. One involved the use of a spray tank compatibility agent. One involved reformulating one of the concentrates. It was also learned that sufficiently dilute emulsions produced no incompatibility. So you see, the situation is not always hopeless. Often an incompatibility problem can be avoided by re-formulation. However, you should evaluate

new experimental mixtures on a small scale to avoid poor field test results. Also, you should relate these problems back to your formulation people.

This slide shows another example of a physical incompatibility between two emulsifiable concentrates. On the left is an emulsion of a cotton defoliant. In the center tube is a popular cotton insecticide. This combination might be applied for diapause control to reduce the insect population for the following year. Separately, each concentrate forms an excellent emulsion. But together they are incompatible giving rise to a very unstable emulsion. If applied to a cotton field, this combination spray will give spotty insect control and spotty defoliation. Also, injury or staining of the cotton in part of the field may result.

To emphasize a statement made before: these incompatible mixtures occur only infrequently. However, as these examples illustrate, they can occur.

A related physical incompatibility is one we choose to call salting out of an emulsifiable concentrate. This phenomenon occurs with some mixtures of water soluble and emulsifiable formulations. In the example shown on the slide is a water soluble non-selective herbicide on the left and in the center is an emulsion of a non-selective herbicide. The concentrate of this material was dyed blue to improve our observation of incompatibility. Alone it gives a good emulsion with good stability. However, when the emulsion is formed in the presence of the water soluble herbicide, stability is very poor. After 30 minutes the emulsion has separated into oil and dilute emulsion layers.

The water soluble material is a neutral salt. The nature of the active in the emulsifiable is such that a chemical reaction between the two is not expected. The explanation for the incompatibility lies in the ionic nature of the water soluble material. The principle of breaking an emulsion by electrolyte addition—or salting out—is well known. Fortunately, the effects on compatibility of water soluble ionic herbicides varies for different emulsifiable formulations. Even though our example involved commercial formulations that are used in the same control situations, we had to screen numerous combinations before an incompatible one was found.

Previously an example of incompatibility between a wettable powder and an emulsifiable concentrate was presented. In that case the incompatibility was dependent on the order of addition. This is not always the case. Some wettable powder/emulsifiable concentrate mixtures will flocculate regardless of how the spray mixture is prepared. Therefore, this becomes another category under physical incompatibilities between pesticide formulations.

Into the tube of water on the left we add an emulsifiable insecticide. Into the center tube we add a wettable powder insecticide. Into the tube of water on the right we will first add a slurry of the wettable powder. After agitating this dispersion, the emulsifiable will be added. All three tubes will be agitated and allowed to stand. After ten minutes, the mixed system has grossly separated despite our best efforts to avoid problems. In a field spray tank with good agitation, this incompatibility might cause

no problem.

Examples of incompatible mixtures presented thus far have been due to physical interactions. Chemical reactions between actives can also occur. Our example illustrating this involves a water soluble cationic contact herbicide, shown in the aqueous solution on the left, and a water soluble anionic selective herbicide, shown in the aqueous solution in the center. The aqueous solution of the two herbicides is shown in the tube on the right. Already, there are indications of incompatibility: note the darker color and haze.

After 15 minutes the reaction product of the two herbicides is evident as a heavy precipitate. Not only would this mixture deposit non-uniformly when applied, the chemical reaction probably has ruined the activity. You should be especially cautious when dealing with mixtures containing ionic pesticides. However, at least try these mixtures on a small scale as there are many that are compatible.

### Incompatibility with Liquid Fertilizer

The popularity of feed and weed practices has grown dramatically in the past decade. The simultaneous application of fertilizer and herbicide saves the farmer time, labor and fuel. With fuel no longer an abundant material that may be taken for granted, weed and feed applications become more advantageous. The one disadvantage to applying herbicides in fertilizer solutions is compatibility. Many herbicide formulations that form good stable mixtures in straight water form unstable mixtures in liquid fertilizer. However, many herbicide formulations have been registered for use in liquid fertilizer.

Under conditions of good agitation and with most of the many types of available liquid fertilizers, these registered herbicides form sufficiently uniform spray tank mixtures to cause no problems. However, if agitation is not vigorous during mixing and spraying—particularly with certain fertilizer types—the herbicide needs a small assist to achieve uniform distribution. In these cases, a spray tank adjuvant referred to as a compatibility agent frequently will provide the needed assist.

This slide shows an emulsifiable trifluralin being pipetted into water and into 9-9-9 clear mixed liquid fertilizer. The liquid fertilizer solution on the right contains 1% of a commercially available compatibility agent. It is apparent the emulsion forming in water is the best. It also appears the emulsion formed in liquid fertilizer with the compatibility agent is better than the emulsion in straight liquid fertilizer.

All three emulsions are agitated and allowed to stand 15 minutes. The emulsion in straight liquid fertilizer has separated as an oil layer. While the emulsion in straight water—as evidenced by its lighter color—is still the best, the emulsion in liquid fertilizer containing a compatibility agent is completely uniform. This same experiment is repeated using an emulsifiable concentrate of alachlor. Again, the emulsion in straight water is the best.

After agitation and then 15 minutes standing, the emulsion in liquid fertilizer without a compatibility agent has

separated. With a compatibility agent, the emulsion in liquid fertilizer is uniform.

Incompatibility in liquid fertilizer solutions is not limited to emulsifiable concentrates. The stability of wettable powder dispersions is often lower in liquid fertilizer solutions than in straight water. To graduated cylinders of water, 9-9-9 liquid fertilizer solution and liquid fertilizer containing a compatibility agent is added a wettable powder formulation of a selective herbicide.

After agitation and then standing 15 minutes, the dispersion in straight liquid fertilizer has separated. The dispersions in water and in liquid fertilizer containing the compatibility agent are still uniform. Compatibility agents will not work and are not needed with all herbicide formulations and all liquid fertilizers. Also, vigorous spray tank agitation should prevent all but the most severe problems. However, if an incompatibility problem does exist, compatibility agents are worth evaluation.

### Recommendations for Avoiding Problems

A number of incompatibility problems have been presented that could cause poor field results. While they do not occur frequently, the ones that do occur can be costly if they are not detected early. Let's review some recommendations for avoiding these problems.

(A) Evaluate on a small scale prior to field testing the physical compatibility of all new pesticide formulations and all new tank mixes. To run a small scale compatibility test, add one pint of the carrier (water or liquid fertilizer) to a quart jar. If water is the carrier, be sure to use the same water (i.e., hardness and temperature the same) as will be used in the field spray. Next, add each of the pesticides and additives. Add them in the same proportions as will be used in the final spray. For example, if the total spray rate is 25 gallons per acre.

- a) add 1 teaspoon of EC to the pint of carrier for each 1.0 quart/acre of EC required
- b) add 1½ teaspoon of WP to the pint of carrier for each 1.0 pound/acre of WP required
- c) add 1 teaspoon of spray tank additive to the pint of carrier for each 1.0% additive desired in the final spray

To make up this mixture add in the following order and shake the jar between each addition: wettable powders, flowables, water soluble pesticides, spray tank additives, emulsifiable concentrates. After all ingredients are added and well mixed, let the jar stand. Inspect it periodically for separation at either top or bottom. The allowable separation will depend on the intensity of agitation available in the field spraying equipment. Experience with your own equipment is the best determinant of the allowable stability. However, if the separation is minor after 30 minutes, the mixture should be safe to spray.

(B) When working with registered pesticides follow the label instructions on preparation of the spray mixture. Where the label specifies the volume of carrier, follow it—



remember the effect dilution rate can have. The label may warn against certain tank mixes with other pesticide formulations or with certain spray tank additives. The label may indicate the formulation may be applied with liquid fertilizer. The pesticide producer has gone to great trouble to develop these use recommendations to keep us out of trouble. It only makes good sense to follow them.

(C) Where possible provide good spray tank agitation. Many marginally stable mixtures will remain uniform if vigorously agitated.

(D) Do not delay agitation after pesticide addition to the spray tank.

(E) Disperse wettable powders prior to addition of liquid formulations. To get best results pre-slurry the wettable powder before addition to the spray tank. Remember, wettable powder dispersions need good agitation. Avoid letting a wettable powder dispersion stand overnight but if one does, use vigorous agitation to redisperse the cake.

(F) Avoid water contamination, contact with iron and storage at temperature extremes. Warm all cold-stored liquid formulations to room temperature and shake well before using. Evaluate on a small scale any formulation suspected of being contaminated or degraded.

(G) Use a compatibility agent where the dispersion uniformity of a formulation in liquid fertilizer is poor.

(H) Seek assistance when problems arise. Many incompatibility problems can be solved through reformulation. So, relate any field incompatibility problems back to the formulation group. Also don't hesitate to call on your raw material suppliers for help. That's what keeps us in business.

### Quackgrass Control and Crop Production with Herbicides<sup>1</sup>

J. M. Hodgson<sup>2</sup>

Quackgrass (*Agropyron repens* (L) Beau.) is an aggressive competitive weed distributed throughout the northern half of the United States (Raleigh et al., 1962). This weed produces a heavy growth of rhizomes in the upper 3-6 inches of soil (Derschied et al.) and competes seriously with most crops in its areas of adaptation. It causes major yield losses when it occurs in small grains, forages, row crops and gardens. Quackgrass grows during cool weather in early spring and late fall which contributes to its competitive nature (Raleigh 1962). It is also reported to produce a substance in its rhizomes that inhibits growth of several crops (Kommedahl et al., 1959).

It can be controlled by intensive cultivation which starves the plant and causes rhizome desiccation or exposes rhizomes to killing temperatures. One complete season of frequently repeated cultivations every 2-3 weeks may be required (Dunham et al., 1965), and some crop loss is usually involved.

<sup>1</sup>Cooperative research of the Western Region, Agr. Res. Serv., U. S. Dept. Agr. and the Montana Agr. Exp. Sta.

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Most chemicals that effectively control quackgrass are quite costly, some are limited to a single use, and others prevent the use of the land for one or more seasons after treatment. (Weed Control Manual 1973). Dalapon (2, 2 dichloropropionic acid) is registered for use on quackgrass before plowing and planting beans, corn, sugar beets, and potatoes (Buckholtz et al., 1959) but its effect is mostly in suppression at the rates permitted. There is a great need for a more effective herbicide treatment for control of quackgrass on all crop lands.

This report presents results of preplanting treatments with selected new herbicides for control of quackgrass.

### Materials and Methods

Herbicides were applied in late fall and early spring before seedbed preparation and planting of crops. Plots were established on a heavy uniform stand of quackgrass growing on highly productive farm land. The fall growth of quackgrass was quite mature and had been subjected to several cold nights (-5C) prior to the fall application of herbicides on November 20, 1972. Foliage was considered to be in poor condition for absorption and translocation of herbicides. However, 2 of the herbicides, dalapon and pronamide (N-(1,1-dimethylpropynyl)-3,5-dichlorobenzamide) were soil active.

Individual plots 9 x 12 feet were randomized in 4 blocks. Herbicide treatments included dalapon 15 lb/A, pronamide 2 and 4 lb/A, and glyphosate (N-(phosphonomethyl) glycine) 2 and 4 lb/A. Treatments were applied to some plots in the fall and to others on May 14, 1973, when spring growth of quackgrass was succulent and up to 8 inches tall. Rainfall was .46 inches between May 14 and May 21 when all treated and check plots were plowed and disced. After two harrowings we planted barley (Unitan), sugar beets (G. W. Monogerm), beans (U of I 136), and peas (Hyalite). Each crop was seeded in a single row across each plot with rows 18 inches apart. The plots were sprinkle irrigated on July 23, with 2 inches of water and 5.39 inches of precipitation fell between planting and harvest.

On August 28 and 29, 1973 when the barley was ripe an eight foot yield sample was obtained from the center of the row. Sugar beet tops and pea and bean forage was yield sampled on a similar basis. Quackgrass yield was also sampled on a 2.4 x .4m area (1m<sup>2</sup>) between the two center rows on each plot. The bean and pea forage and sugar beet tops, and quackgrass were oven dried and are reported as kilograms/ha of plant material. The barley samples were threshed and grain yields were determined.

### Results and Discussion

The herbicides were much more effective when applied in the spring than when applied in the fall (Table 1). Pronamide, a soil active herbicide, which was expected to be more effective when applied in the fall, actually controlled more quackgrass when applied in the spring. This was probably a result of limited penetration of this herbicide in the frozen soil in the fall application. Although spring applied pronamide gave only 44% control of quackgrass, bean yields were significantly increased. The other

Table 1. The Effect of Herbicides on Control of Quackgrass and Crop Yields. Bozeman, Montana 1973.

Treatments	lb/A	Quackgrass Control	Crop Yields <sup>a</sup>				
			Barley Grain	Bean Forage	Pea Forage	Sugar beet tops	
Fall applied 30 Nov. 1972			%	kg/ha	kg/ha	kg/ha	kg/ha
Dalapon	15	40	775 e	441 d	1173 de	108 d	
Glyphosate	1	0	2939 bc	323 d	796 e	161 d	
Glyphosate	2	0	3013 b	678 d	1141 de	506 d	
Glyphosate	4	35	2873 bc	1323 bcd	1356 de	355 d	
Pronamide	2	0	2378 bcd	560 d	968 de	161 d	
Pronamide	4	37	2991 b	1280 bcd	1765 de	678 d	
Spring applied 13 May 1973							
Dalapon	15	97	11 e	1087 d	1442 de	4003 a	
Glyphosate	1	90	6574 a	3314 a	3120 abc	2647 ab	
Glyphosate	2	99	6566 a	4810 a	3368 ab	2410 abc	
Glyphosate	4	99	6305 a	4153 a	3938 a	3206 a	
Pronamide	2	44	2496 bcd	2141 bc	2281 cd	872 cd	
Pronamide	4	44	2217 bcd	2335 b	1926 cde	1291 bcd	
Check			1629 d	635 d	947 de	334 d	

<sup>a</sup> Yields bearing different letters were significantly different at  $P = .05$ .

crops also showed a trend toward increased yield on pronamide plots. Pronamide in a previous set of plots applied in October 1971 gave much better control of quackgrass.

Fall and spring applications of dalapon at 15 lb/A gave 40 and 97% control of quackgrass respectively. The fall quackgrass growth apparently did not respond to the dalapon, possibly because of the poor condition of the foliage when sprayed. In an earlier experiment dalapon applied earlier in the fall gave 83% control of quackgrass. Fall applied dalapon residues in the soil seemed to be present throughout the soil in the plowed horizon the following spring as yields of all crops were reduced. The poorly controlled quackgrass was also partially responsible for depressed yield of all crops.

Sugar beets were almost eliminated in the fall dalapon plots indicating the probable distribution of dalapon into the soil where the seeds germinated. By comparison sugar beets in the spring treated plots seemed unaffected by dalapon or by quackgrass competition. Sugar beet foliage appeared healthy and normal and yields were among the highest of any of the treatments. However, barley in these plots was almost completely eliminated and beans and peas were also seriously inhibited.

Although glyphosate was quite ineffective as applied in

the fall in this experiment it was highly effective in quackgrass control from the spring applications. As stated previously the poor results in the fall were undoubtedly related to the lateness of application when the foliage had become partially desiccated. No control of quackgrass was found for the 1 and 2 lb/A rates and only 35 percent control for 4 lb/A rate of glyphosate in the fall. Glyphosate did not effect yields of beans, peas, and sugar beets but increased barley yields indicating some delay in the growth of quackgrass on these plots. Barley was the first crop to emerge and made rapid early growth.

The highest yields of all crops occurred on plots treated with glyphosate in the spring. Glyphosate at 2 or 4 lb/A controlled 99% of the quackgrass and at 1 lb/A gave 90% control. This evaluation was based on yield samples of quackgrass growth 15 weeks after treatment. In general crop yields on glyphosate plots were about 5x greater than on check plots which received no chemical treatment but which received the same cultural treatments. This emphasizes the extremely competitive effect of quackgrass on these crops.

#### Summary

The most promising treatments for control of quackgrass



in this experiment considering all crops was glyphosate applied to 8 inch tall vigorous new growth in the spring (Table 1). None of the four crops planted following the treatments indicated any residual effects from the glyphosate. Quackgrass control was over 99% and crop yields were excellent. Spring applied dalapon also effectively controlled quackgrass but soil residues severely limited beans and peas and killed out the barley. Sugar beets only were apparently not damaged. All fall applications of herbicides were limited in effectiveness because of conditions of the foliage and partially frozen soils.

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#### Subsurface Layering of Trifluralin for Field Bindweed Control in Cropland

L. C. Warner, W. R. Arnold and L. G. Peterson<sup>1</sup>

Trifluralin, first introduced as a preemergence soil incorporated herbicide for the selective control of annual broad-leaf and grassy weeds, has demonstrated effective control of field bindweed (*Convolvulus arvensis*) when applied as a subsurface layered (SSL) treatment. Excellent trifluralin tolerance has been observed in established trees and vines and a Federal registration for the SSL usage was obtained in 1972 for these crops in California.

Three types of equipment have been suitably adapted for subsurface layering of trifluralin. They are: 1) the straight blade, 2) the moldboard plow, and 3) various sizes of "V" shaped blades. In each case the technique involves placing the nozzles behind the cutting edge of the implement in such a manner as to spray a continuous horizontal subsurface layer parallel to the soil surface as it is pulled through the soil. The concentrated layer acts as a protective shield that prevents field bindweed shoots from

passing through it. If the trifluralin layer is not disturbed by soil cracking or tillage implements, inhibition of the developing shoots will occur. It appears the meristematic shoots of field bindweed are more sensitive to trifluralin than the roots of many crops, thus suggesting a possibility for selective bindweed control.

A number of studies were initiated in several western states utilizing the straight spray blade, the moldboard plow, or the "V" shaped blade to determine the tolerance of various agronomic crops to SSL treatments of trifluralin. Trial locations included both irrigated and non-irrigated sites and involved medium to heavy soil types. Depth of layering ranged from 6 to 12 inches. Most of the studies were located on grower's fields and following application the experimental sites were planted and handled in accordance with normal agronomic cropping practices. In most instances, the timing of the treatments and evaluations were tied to the respective cropping sequences.

Bindweed control evaluations were made from 9 to 12 months after treatment. Early and late crop injury ratings were made dependent on the maturity of the crop. Comparisons in weed control efficacy among the three pieces of equipment were not attempted because each was used under widely differing agronomic and geographical conditions. However, it was observed that excellent control of bindweed was obtained with each type of application equipment at all depths when they were operated properly.

Evaluations made 9 to 12 months after treatment showed that SSL trifluralin applied at 1 lb/A resulted in an average of 86 percent field bindweed control. Increased control of 93, 95, and 97 percent was obtained from the respective rates of 1.5, 2, and 4 lb/A (Table 1).

Table 1. Field Bindweed Control from SSL Trifluralin

Trifluralin (lb/A)	Number of Locations	% Bindweed Control 9-12 Months after Applic.
1	17	86
1.5	15	93
2	17	95
4	17	97

Alfalfa, dry beans, peas, cotton and safflower, which are tolerant to preplant incorporated trifluralin, also demonstrated tolerance when planted over trifluralin treatments of 2 lb/A SSL to a depth of 6 to 12 inches. Whereas, wheat, barley, oats, and sorghum were less tolerant to SSL treatments at comparative rates (Tables 2 and 3).

<sup>1</sup> Plant Science Representatives, Eli Lilly and Company, Greenfield, Indiana.

**Table 2. Preharvest Crop Response to SSL Trifluralin**

Trifluralin (lb/A)	Average Crop Injury Rating <sup>a</sup>				
	Alfalfa	Dry Beans	Peas	Cotton	Safflower
1	5	15	0	2	0
1.5	<u>b</u>	—	10	0	0
2	0	17	15	25	0
4	5	20	30	43	5
Number of Locations	3	2	2	3	2

<sup>a</sup>Rating Scale of 0-100 where 0 = no injury; 10-30 = slight; 40-60 = moderate; 70-90 = severe; 100 = death.

<sup>b</sup>Rate not included in the trials.

**Table 3. Preharvest Crop Response to SSL Trifluralin**

Trifluralin (lb/A)	Average Crop Injury Rating <sup>a</sup>			
	Wheat	Barley	Oats	Sorghum
1	39	20	82	83
1.5	57	43	<u>b</u>	—
2	76	60	100	88
4	87	81	100	92
Number of Locations	9	3	1	1

<sup>a</sup>Rating Scale of 0-100 where 0 = no injury; 10-30 = slight; 40-60 = moderate; 70-90 = severe; 100 = death.

<sup>b</sup>Rate not included in the trial.

Injury to the more sensitive crops was generally observed to be most evident during the later stages of growth. During the seedling and early growth stages, only slight crop injury could be observed. This suggests that as the roots came into contact with the treated zone, root development was inhibited. In contrast, the root systems of the more tolerant crops were less inhibited and consequently resulted in little or no reduction in the vegetative growth of these plants. The minimal crop injury resulting from the SSL treatments at 2 lb/A in the more tolerant plants was considerably less than caused by the field bindweed competition in nontreated controls.

In summary, trifluralin SSL 6 to 12 inches deep at 2 lb/A provided an average of 95 percent field bindweed control when evaluated 9 to 12 months after application. The straight blade, moldboard plow, and "V" shaped blades were all effective means of subsurface layering trifluralin. Alfalfa, dry beans, peas, cotton, and safflower all demonstrated acceptable tolerance to SSL trifluralin at 2 lb/A. Wheat, barley, oats, and sorghum showed less crop tolerance at the same rates.

### The Regeneration of Field Bindweed Root Fragments

D. G. Swan and R. J. Chancellor<sup>1</sup>

*Abstract.* Field bindweed (*Convolvulus arvensis* L.) is a perennial weed that spreads vegetatively and by seed. Objective of this study was to determine if seasonal variation occurred in the regenerative ability of field bindweed root fragments.

Field bindweed roots were freshly dug each month from a five year old planting at the Weed Research Organization farm in England. The roots were cut into 6 cm long fragments and grown in the dark on moist filter paper at 23<sup>o</sup> C. New shoot and root growth were measured at 8, 11 and 14 days.

Number and length of new shoots varied with the season. The mean number of shoots per fragment was greatest in April, with a lesser peak in September and was least in

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November and December. This correlated in the field with spring and autumn growth and with complete winter dormancy. Mean number of shoots per fragment over the year ranged from 2.0 to 6.4. Mean shoot lengths ranged from 24 to 43 mm.


Although most fragments produced shoots, very few produced roots. The greatest number of new roots was produced in May when 29% of the fragments rooted, while 0-17% rooted in the other months. After their initial growth the root tips tended to deteriorate and the greatest mean root length was 22 mm (in March). Regenerative capacity was therefore poor throughout the year.

### Tebuthiuron for Noncropland Vegetation Control

D. H. Ford, F. O. Colbert, L. C. Warner<sup>1</sup>

#### Introduction

Tebuthiuron has been tested throughout the United States and Canada for total vegetation control on railroad, highway and powerline rights-of-way, and industrial sites. Results from trials conducted by Eli Lilly and Company, state and federal scientists, and commercial applicators have shown that tebuthiuron provided effective, sustained control of most herbaceous weeds and many woody plants present in noncropland areas.

After four years of research, federal registration has been requested for the use of tebuthiuron as a total vegetation control herbicide. Eli Lilly and Company's present plans are for Elanco Products Company to market tebuthiuron in 1974, formulated as an 80 percent wettable powder under the trademark SPIKE .

#### Chemical Characteristics

Tebuthiuron, previously known as EL-103, is a thiazolylurea with the chemical name: 1-(5-*tert*-butyl-1,3,4-thiadiazol-2-yl)-1,3-dimethylurea. The compound is a colorless solid with a water solubility of 2.5 mg/ml at 25°C. Tebuthiuron is not readily decomposed by sunlight and is stable on the soil surface for extended periods of time. Under field conditions with adequate rainfall, vertical leaching of tebuthiuron is slow and very little lateral movement has been observed. At high rates of application the compound is persistent in the soil and dissipates primarily through microbial degradation.

Tebuthiuron exhibits limited foliar activity, but is readily absorbed through the plant root system. Plant toxicity symptoms suggest that the herbicide is an inhibitor of photosynthesis.

Toxicology studies have shown that tebuthiuron is safe under normal use conditions and poses no hazard to wildlife, birds, or fish.

#### Methods and Materials

Field trials in the western United States were first established with tebuthiuron in 1970. Initial experiments

<sup>1</sup>Plant Science Representatives, Eli Lilly and Company, Fresno, California.

with tebuthiuron 80% wettable powder were replicated trials utilizing small plot research equipment. Application rates are given in terms of active ingredient. Total vegetation control evaluations were expanded in 1973, when demonstration-type trials were established with commercial spray equipment under an Environmental Protection Agency experimental permit program. Trials were conducted throughout the western United States to obtain efficacy data under a broad range of environmental conditions.

#### Results and Discussion

Weed control observations from railroad trials in Arizona, California, and Oregon are presented in Table 1. Tebuthiuron at 4 lb/A provided 95 to 99 percent bare ground at these sites. At comparable rates, tebuthiuron was more efficacious than bromacil at the California and Oregon locations, when observed 16 and 14 months after herbicide application, respectively. These results substantiate the sustained weed control possible with tebuthiuron from a single application at relatively low rates.

Table 1. Percent Bare Ground on Railroad Rights-of-way Following a Single Treatment of Tebuthiuron.

Treatment	Rate lb/A <sup>a</sup>	Percent Bare Ground		
		AZ. 8/73	CA. 7/73	OR. 6/72
Tebuthiuron	2	80	87	— <sup>c</sup>
	4	95	100	100
	6	100	100	100
Bromacil	2	— <sup>b</sup>	77	— <sup>c</sup>
	4	—	62	—
	6	—	82	78
Control	0	50	11	8

<sup>a</sup>Spray application with a high-rail tractor sprayer in California 3/72, Arizona 3/73, and Oregon 4/71.

<sup>b</sup>Bromacil was not included in this trial.

<sup>c</sup>Treatment rate was not included in this trial.

In these western trials, tebuthiuron at 2 lb/A gave 90+ percent control of the annual weeds shown in Table 2.

Table 2. Weeds Controlled (90+ Percent) with Tebuthiuron at 2lb/A on Railroad Rights-of-way.

Ripgut bromegrass	<i>Bromus rigidus</i>
Wild oat	<i>Avena fatua</i>
Plains lovegrass	<i>Eragrostis intermedia</i>
Side oats	<i>Boutelous curtipendula</i>
Filaree	<i>Erodium</i> sp.
Yellow starthistle	<i>Centaurea solstitialis</i>
Shortpod mustard	<i>Brassica incana</i>
Horseweed	<i>Conyza canadensis</i>
Panicum willowweed	<i>Epilobium paniculatum</i>

Table 3. Weeds Controlled (95+ Percent) with Tebuthiuron at 4 lb/A on Railroad Rights-of-way.

Western wheatgrass	<i>Agropyron smithii</i>
Arizona threeawn	<i>Aristida arizonica</i>
Russian thistle	<i>Salsola kali</i>
Telegraphplant	<i>Heterotheca grandiflora</i>
Fivehook bassia	<i>Bassia hyssopifolia</i>
Poison hemlock	<i>Conium maculatum</i>
Burweed	<i>Haplopappus tenuisectus</i>
Velvetgrass	<i>Holcus lanatus</i>
Red clover	<i>Trifolium pratense</i>
Black medic	<i>Medicago lupulina</i>
Spotted catsear	<i>Hypochoeris radicata</i>
Italian ryegrass	<i>Lolium multiflorum</i>
Annual bluegrass	<i>Poa annua</i>
Buckhorn plantain	<i>Plantago lanceolata</i>

In the California trial, one-half the initial treatment rate was applied over the original rate nine months later and percent bare ground results are shown in Table 4.

Table 4. Percent Bare Ground on Railroad Rights-of-way Following a Single Application and After Retreatment of One-half Initial Rates Applied.

Treatment	Rate lb/A	Percent Bare Ground <sup>a</sup>	
		Single Applic.	Double Applic.
Tebuthiuron	2	87	
	2+1		92
	4	100	
	4+2		99
Bromacil	2	77	
	2+1		72
	4	62	
	4+2		85

<sup>a</sup>Single application made on 3/72 and retreatment on 1/73; trial observed on 7/73.

Results from this trial and others indicate that the frequency and rates of reapplication of tebuthiuron for maintenance purposes may be reduced and still provide commercially acceptable control.

Tebuthiuron applied at 5 lb/A on previously nontreated electric powerline rights-of-way near Seattle, Washington, provided 95+ percent control of many herbaceous annual and perennial weeds and a number of tree and brush species present at this site. Woody species controlled 8 to 10 months following tebuthiuron application are shown in Table 5.

Table 5. Woody Plants Controlled (95+ Percent) with Tebuthiuron at 5 lb/A on a Powerline Right-of-way 8 to 10 Months After Application.

Salal	<i>Gaultheria shallon</i>
Black cottonwood	<i>Populus trichocarpa</i>
Bitter cherry	<i>Prunus emarginata</i>
Bigleaf maple	<i>Acer macrophyllum</i>
Vine maple	<i>Acer circinatum</i>
Douglas fir	<i>Pseudotsuga menziesii</i>

In general, results of total vegetation control trials conducted under widely differing climatic conditions have shown that tebuthiuron provides effective control of most annual weeds and many woody species at rates of 2 to 6 lb/A. Control of most deep-rooted perennial species normally requires rates of 4 to 8 lb/A; however, control of some perennial grasses, such as johnsongrass and bermudagrass, may require 10 lb/A and above.

#### Summary

In summary, tebuthiuron has been evaluated extensively throughout the western United States in replicated experiments as well as in large, commercial trials. It has proven to be a highly effective herbicide for total vegetation control. Tebuthiuron has shown several desirable performance characteristics which include: controls a broader spectrum of herbaceous and woody plants than currently available herbicides; demonstrates good stability on soil surfaces; and provides extended herbicidal activity reducing the rate and frequency of re-application required for effective maintenance weed control.

#### Making Weed Control Recommendations in California

Clyde L. Elmore<sup>1</sup>

Prior to October 29, 1971, the University of California issued weed control recommendations as booklets covering control measures for crop, non-crop, brush and turfgrass weed problems. The information for these recommendations required efficacy data and crop residue information. These data were developed by farm advisors, Extension specialists, and Agricultural Experiment Station workers throughout California. It was required under the University's Communication 18 that crop residue data be obtained from University of California trials and be analyzed in University of California laboratories. Later, coded samples collected from University trials and analyzed by chemical companies were acceptable.

In July, 1972, Senate Bill Number 1021 was made law which required the licensing of pest control advisors. The bill also defined a "recommendation" as "... the giving of any instruction or advise on any agricultural use as to any particular application on any particular piece of property." This legislation usurped the University of California's weed

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control recommendations as previously known. Additionally, "agricultural use" was defined as, "the use of any pesticide or method or device for the control of plant or animal pests." Thus all recommendations are made for a particular pest or a particular parcel of land and are made in writing, whether the method of control was with a pesticide, a disk or a hoe.

The University of California is now working under a revised "Communication 18" which gives responsibility to the Agricultural Experiment Station and Cooperative Extension to develop and promulgate **guidelines** for pest management. These guidelines are defined as, "a generally applicable procedure that serves to inform or guide in the acceptance of a practice."

Research to develop guidelines includes three types of information: 1) efficacy, 2) residues in plants, and 3) residues in soil. Efficacy is determined by uniform trials throughout California in the major growing areas for a particular crop. Residue samples can still be analyzed in University of California laboratories, or coded samples are submitted to chemical company laboratories for analysis. In addition it is acceptable to use data from company analyzed residue samples which are obtained in California trials if such samples are approved by the Department of Environmental Toxicology and the Weed Science Group.

Soil residue information is developed by the weed science group since the herbicide is continuously being evaluated in field or greenhouse trials.

Although it is desirable to make umbrella guidelines for the entire state, these are often difficult to implement because of the diversification of crops, cropping procedures, soils and climatic conditions. A single guideline may be applicable to only one area because of this diversity. Thus guidelines are proposed to inform growers in those areas where data are available and in other areas where the same information would be applicable. This implies several guidelines for a single crop or area in some cases while in others no guidelines may be available.

In a recent survey of California's farm advisors who work in weed control it was determined that 96.5% found the weed control recommendations (prior to SB 1021) useful.

When asked "What percent of the time can a farmer's weed control problem be answered with the current University of California weed control recommendations?", the answers were not as encouraging.

<u>% answerable problems</u>	<u>% of time have answers</u>
90-100	26
80-90	13
70-80	17
60-70	6
50-60	20
<50	17

It was also asked, "What percent of time have the recommendations, when followed correctly, proven successful?"

<u>% success</u>	<u>% of time successful</u>
90-100	67
80-90	18
70-80	9
60-70	0
50-60	2
<50	4

Some complaints of recommendations were: not current enough, incompleteness and they did not spell out cultural and biological controls as well as chemical methods. It is also because of these problems that new weed control guidelines are being written.

In the farm advisor poll only 9% had made **written** recommendations as defined by Senate Bill 1021 on weed control. These farm advisors have only averaged 1.6 recommendations in six months indicating a very low level of activity in this regard.

The University of California weed control guidelines are being formulated with several objectives in mind. The principal objective is to incorporate all methods of weed control into a growing guide by crop or a natural grouping of crops. These guides will include preventive, biological, cultural, and chemical control when each is applicable. As far as chemicals are concerned, methods of application, timing, influence of other management practices, rotation and effects on the environment will be included. It is also the intention to not revise these routinely each year but make revisions when applicable information is available.

Although University of California weed scientists currently are making few recommendations as defined by Senate Bill No. 1021, an active role will continue for providing both research information and the guidelines for weed controlling practices in California.

### Soil Moisture Content and the Rate of Trifluralin Degradation

R. L. Zimdahl<sup>1</sup>

*Abstract.* The rate of degradation of 2 ppmw of trifluralin was studied at 0, 25, 50, and 100% of field capacity in weld silty clay soil. Analyses performed over a six month period show a positive correlation between moisture content and rate of degradation.

<sup>1</sup>Associate Professor, Colorado State University, Ft. Collins.

## Fate and Metabolism of BAS 290-H

Gary M. Booth<sup>1</sup>, Kuo Mei Chang<sup>2</sup>, Duane Ferrell<sup>3</sup>,  
and J. R. Larsen<sup>4</sup>

*Abstract.* Under the conditions of these experiments, the data shows that BAS 290-H will not persist as a microchemical pollutant in the environment.

The parent compound, 290-H, was mainly metabolized to IBA, 2-OH, 2-Oxo, and polar metabolites.

The Concentration Factor for metabolites and 290-H show that the fish (25 X), snail (59 X) and algae (35 X) concentrated the parent compound more than any other metabolite or unknown compound. However, these values were considered to be quite low when compared with classic microchemical pollutants. The rest of the organisms did not concentrate any of the chemicals to any significant degree.

Most of the activity was found in the water, rendering the chemicals harmless to living tissues. The complete lack of activity in the fish, the organism at the top of the food chain, suggests that 290-H could be used around aquatic ecosystems without endangering components of food chains.

### Introduction

The use of chemicals to control economic pests has grown in this century both in the amount and the diversity of materials used (Headley and Lewis, 1967). About ten billion pounds of pesticides have been used in the United States since 1945 (Matsumura, 1972). It is estimated that there are 340 million acres of cultivated lands in the Continental United States. Of this amount, approximately 119 million acres were sprayed with herbicides, 97 million acres were treated with insecticides, and 25 million acres were treated with fungicides and other minor pesticides.

In recent years the scientific community and the general public have become greatly concerned about pesticide residues in the environment (Brady, 1972). The majority of pesticides used in agriculture eventually reach the surface of the earth, and hence, the soil generally acts as a reservoir for the pesticides from which they degrade or are gradually spread to other parts of the environment. Water and air are two major physical factors which facilitate the movement of pesticides. Other means of transportation are mainly of biological origin, e.g., plants, soil invertebrates, and microorganisms can absorb pesticides directly from the soil, which in turn can be taken up by other animals in the environment (Matsumura, 1972). Since pesticides are purposeful contaminants, it is important to understand the metabolism, movement, and degradation of these compounds in the environment. This information will insure that only safe and biodegradable pesticides will be marketed.

Metcalf et al. (1971) devised a simple laboratory model ecosystem to facilitate the evaluation of pesticide biodegradable and magnification in food-chain organisms. A determination then can be made whether a new pesticide is safe to apply in the environment. About 30 pesticidal materials have been studied by using this approach (Metcalf, 1971). The herbicide studied herein, BAS 290-H, 2-chloro-N-(1-methyl-2-propynyl)-acetanilide, has been used on corn and soybeans to control broadleaf weeds. The metabolism and degradation of 290-H in soil and several species of plants and animals have been previously reported (Otto and Drescher, 1970; Cannon Laboratories, 1972; Gilman and Joseph, 1972; and Putman, 1973). However, the environmental fate of this compound is not well documented. Therefore, it seems important to study the fate and metabolism of 290-H in a model ecosystem.

### Materials and Methods

#### Herbicide and Possible Metabolites

The parent compound and its possible metabolites are below (Otto and Drescher, 1970; Cannon Laboratories, 1972; Gilman and Joseph, 1972). The chemical structure of each is shown in Fig. 1. The abbreviations used for each of the compounds are shown at the right and were used throughout the manuscript.

2-chloro-N-(1-methyl-2-propynyl)-acetanilide	(290-H)
2-hydroxy-N-(1-methyl-2-propynyl)-acetanilide	(2-OH)
N-isobutynyl aniline	(IBA)
2-oxo-N-(1-methyl-2-propynyl)-acetanilide	(2-Oxo)
2-oxo-N-(1-methyl-2-propynyl)-acetanilide	(2-Oic)

#### Radiolabeled Compound

The radiolabeled 290-H and unlabeled metabolites were supplied by BASF Chemical Corporation. The parent compound was ring labeled with <sup>14</sup>C and its specific activity was 4.8 uCi/uM. The radiochemical purity was determined to be greater than 99% by thin layer chromatography (TLC) and autoradiography.

#### Model Ecosystem

The overall procedures described by Metcalf et al. (1971) were followed with some modifications.

The model ecosystem consisted of a five gallon glass aquarium in which a sloping interface of soil, air, and water was placed (Fig. 2). About one third was composed of a terrestrial area which was made of washed white quartz sand for growing plants. A total of three and one-half liters of Standard Reference Water (Freeman, 1953) were added for the aquatic phase. The ppm concentration of salts in the water was MgSO<sub>4</sub>,36.4; K<sub>2</sub>SO<sub>4</sub>,0.135; CaCl<sub>2</sub>,14.0; NaHCO<sub>3</sub>,25.0; NH<sub>4</sub>NO<sub>3</sub>,3.0; K<sub>2</sub>HPO<sub>4</sub>,0.78; CaCO<sub>3</sub>,57.5; NaSiO<sub>3</sub>,23.6; and FeCl<sub>3</sub>,0.81. The pH was adjusted to 7.9. The standard water provided satisfactory mineral nutrition for the growth and development of the organisms in both the aerial and aquatic portions.

Twenty-five sorghum seeds were planted on the terrestrial portion of the system while 6 fish, 30 snails, 9 gammar-

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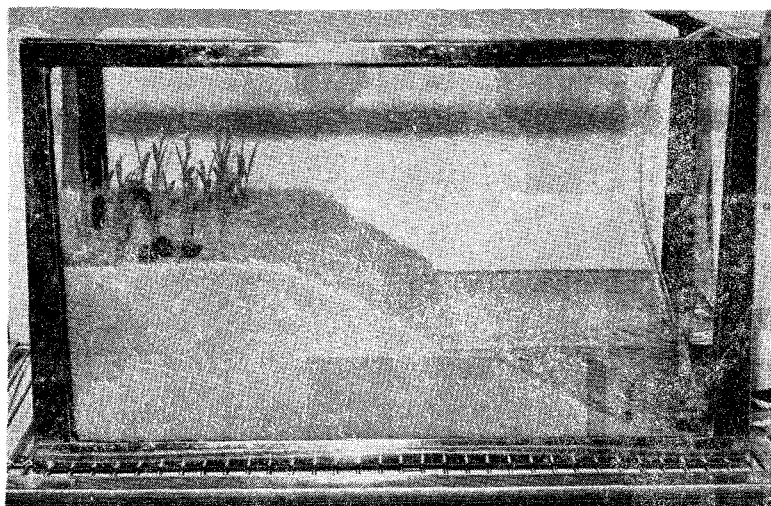
<sup>2</sup>Department of Entomology, University of Missouri, Columbia, Missouri.

<sup>3</sup>BASF, Wyandotte Corporation, Parsippany, New Jersey.

<sup>4</sup>Dept. of Entomology, University of Illinois, Urbana, Illinois.



**Figure 1.** Chemical Structure of BAS 290-H and its Possible Metabolites



**Figure 2.** Photograph of Model Ecosystem

ids, algae, and a water fern were added into the aqueous portion. The system was covered by a section of plexi-glass fitted with a fine screen to prevent animals from escaping, and to reduce the rate of water evaporation. The aquarium was housed in an environmental plant growth chamber at a temperature of 80° F and a 12 hour diurnal cycle of 5000 foot candles.

#### Organisms in the Model Ecosystem

The following organisms were used in the study for their role in the food chain magnification of 290-H.

- Sorghum (Common name, sorghum; *Sorghum halopense*)
- Fish (Common name, guppy; *Lebistes reticulatus*)
- Snail (Common name, physa; *Physa* sp.)
- Amphipod (Common name, gammarid; *Gammarus limnaeus*)
- Algae (Common name, green algae; *Cladophora glomerata*)
- Water Fern (Common name, water fern; *Azolla* sp.)
- Caterpillar (Common name, salt marsh caterpillar; *Estigmene acrea*)

#### Food Chains

The interrelationships between the community of organisms and the food web through which 290-H may be carried and transferred is shown in Fig. 3.

#### Operation and Analysis of Model Ecosystem

When the sorghum plants were about four or five inches high, they were treated with 50 uci of radiolabeled 290-H. Eight hours later several fourth instar salt marsh caterpillars were placed on the leaves to devour the plants.

At the end of the experiment (58 days), the organisms were removed from the aquarium and rinsed with distilled water several times. They were placed on paper towels to remove the surface water and fresh weight was recorded. The organisms were homogenized with one ml of acetone three times in a glass homogenizer. The combined homogenate was centrifuged at 3000 rpm for 15 minutes at 0° C. The supernatant was decanted off and the pellet resuspended in three ml of acetone and centrifuged as before. The combined supernatant was concentrated to one ml with a nitrogen current. An equivalent of Protosol, a tissue solubilizer, amounting to one to two ml per 100 mg of tissue, was placed in the vials to solubilize the tissue. These vials were then incubated at 55° C for 20 hours. An aliquot of the solubilized tissue was spotted on TLC plates to determine the material balance of the unextractable metabolites. Decolorization of the quenching materials was achieved by adding about 0.5 ml of the 20% benzoyl peroxide in toluene to the vial and heating at 55° C for one hour. Then ten ml of Aquasol scintillation fluid was added to the vial and counted for activity.

Water from the aquarium was filtered through filter paper (24 cm in diameter). An aliquot (500 ml) of the water was extracted three times with 150 ml of reagent ether. The combined ether fraction was dried over anhydrous sodium sulfate overnight and evaporated to dryness using

a rotary evaporator under reduced pressure. The residue in the flask was rinsed with seven ml of acetone and concentrated to one ml with a nitrogen current. An aliquot of the solution was taken to measure the radioactivity.

In order to separate the compounds which were conjugated with water, 20 ml of 0.5 N HCl was used to hydrolyze the aqueous part. This was done for a period of 19 hours and then extracted with ether as before. The ether extract was evaporated to dryness, and the remaining yellow precipitate was taken up in acetone, evaporated, and 0.1 ml of the solution was counted for total radioactivity.

**Thin Layer Chromatography**—TLC analysis was carried out on 20 x 20 cm aluminum plates coated with 0.25 mm fluorescent silica gel (Commercial Brinkman F-254 plate). About 15 to 20 ug of the ether extract and protosol-dissolved residue of both water and the organisms was spotted on the plates with a capillary and then the plates were developed in an appropriate solvent system. Table 1 shows several solvent systems that were tested on the cold standards. The best resolution was obtained by using 3% methanol in benzene for 290-H, IBA, 2-Oxo, and 2-OH. The potential metabolite, 2-Oic remained primarily at the origin. Gelman TLC Chambers were used for developing the plates.

**Table 1. Results of TLC Analysis of Known Compounds Used in 290-H Experiment (Using Brinkman F-254 Plates, Gelman Chambers) The R<sub>f</sub> values are given in the table.**

Compound	3% MeOH in Benzene:		Methanol:	Isopropyl
	Benzene	CHCl <sub>3</sub>	5N NH <sub>4</sub> OH	ether Hexane
		(1:1)	(1:1)	(1:1)
IBA	0.90	0.78	0.77	1.00
290-H	0.80	0.47	0.77	0.91
2-Oxo	0.63	0.16	0.77	0.83
2-OH	0.43	0.10	0.77	0.60
2-Oic	0.00	0.00	0.77	0.00

**Autoradiography**—This method was used to detect the <sup>14</sup>C spots on the TLC plates. X-ray film (Kodak N<sub>5</sub>-24-T "No" screen medical X-ray film) was exposed on the TLC plates and kept in the dark for five to six weeks (Wang and Willis, 1967). The radioactive spots appeared as dark areas on the film. Identity of the spots was confirmed by comparing their positions with co-chromatogrammed standards.

**Radioactive counting**—Except for the solubilized tissue samples, which were counted in Aquasol, all other samples were counted by using ten ml of scintillation fluid made up of 7g PPO, 0.05 g POPOP, 120 g Naphthalene, and one liter of 1,4-dioxane. An isocap/300 Liquid Scintillation System was used for counting. The efficiency of this machine was 89%, and an external standardization method for quenching correction was employed.



## Results

### Behavior of Organisms in the Model

#### Ecosystem During 58-Day Experiment

Salt marsh caterpillar larvae devoured the sorghum plants in three days. All of the larvae and other organisms survived the duration of the experiment.

#### Changes of Radioactivity in the Ecosystem Water

The radioactivity in the water was monitored over a 58-day period (Table 2). The peak of activity (Fig. 4) occurred on day 31 after application of the compound to sorghum plants reaching a maximum of 0.0962 ppm. However, the changes in activity were small between days 23 to 29. After day 31, the activity gradually decreased.

**Table 2. Radioactivity Changes in the Ecosystem Water Monitored Over a 58-Day Period.**

Days After Start of Experiment	PPM
2	0.2320
4	0.2622
6	0.0386
8	0.0476
10	0.0509
13	0.0669
15	0.0754
17	0.0685
19	0.0736
21	0.0764
23	0.0867
25	0.0819
27	0.0881
29	0.0865
31	0.0962
47	0.0677
48	0.0709
58	0.0655

#### The Concentration of Parent Compound and its Metabolites in Ether Extraction

Only a small amount (about 4% and 2%) of the 290-H or metabolites could be extracted from either unhydrolyzed or hydrolyzed water (Table 3). However, in every sample more radioactivity was in the residue portion than found in the solvent extract, although, there was significant variation between tissues as can be seen by comparing the percentage figures. The highest percentage was shown in the gammarid (67%), and the lowest was found in the fish (22%).

#### The Concentration Factor of Each Organism in the Model Ecosystem

The organisms were ranked according to their ability to

accumulate total  $^{14}\text{C}$ . A Concentration Factor, the ratio of the concentration of total  $^{14}\text{C}$  in an organism to its concentration in the water, was used to determine biological magnification. This index provided quantitative information as to how a compound could be concentrated and passed from one organism to another through the food chains (Sangha, 1971). Table 3 shows that the algae accumulated the least amount of the chemicals (C.F. = 4), while the water fern and snail (C.F. = 10) concentrated 290-H and its metabolites to the greatest degree. Fish accumulated the compounds to a C.F. of 9.

#### Analysis of Metabolites in Ecosystem Water and Organisms

In order to be certain of the contribution of 290-H and each metabolite, the solvent extract and residue from water and organisms were analyzed by thin layer chromatography (TLC) and autoradiography. The spots on the autoradiograms were identified by co-chromatography with authentic standards of the pure chemicals. The autoradiograms from the TLC plates are shown in Fig. 5 and 6.

After six weeks exposure of the X-ray films, the hydrolyzed, unhydrolyzed water, and snail residues and supernatant were found to have activity high enough to make visual spots on the film. The algae supernatant and residue from water ferns also showed a light spot at the origin.

In the unhydrolyzed water sample, four spots were identified by co-chromatography as 2-Oxo, 2-OH, unknown, and polar material (activity at the origin). The unknown compound may be either 4-hydroxy-N-isobutynyl aniline (4-OH-N-IBA) or 4-hydroxy-N-(2-chloroacetyl)-N-isobutynyl aniline reported previously by Cannon Laboratories (1972).

In the hydrolyzed water sample, one spot showed on the autoradiogram which was identified as 2-Oxo, and in the snail residue, six spots on the autoradiogram corresponded to the approximate  $R_f$  values of IBA, 290-H, 2-Oxo, 2-OH, unknown, and polar material. The snail supernatant showed the presence of polar chemicals slightly above the origin corresponding to 2-Oic and other polar compounds.

#### The Concentration of Each Metabolite In Ecosystem Water and Organisms

The individual spots on the TLC plates corresponding to the metabolites were scraped off and counted in a scintillation counter. Tables 4, 5, and 6 show the concentration of each metabolite in the water samples, aquatic plants and animals. It can be seen that even though the spots of radioactivity did not show up on the film shown in Figs. 5 and 6, there were substantial amounts of the radioactive metabolites in some of the tissues.

#### Pathway for Metabolism of 290-H in The Model Ecosystem

Much of the parent material was metabolized to more polar compounds with varying amounts of 290-H remaining in the water and organisms. The highest percentage of 290-H was 22.8% in the water ferns (Table 7). From Table 7, it appears that the major pathway of 290-H

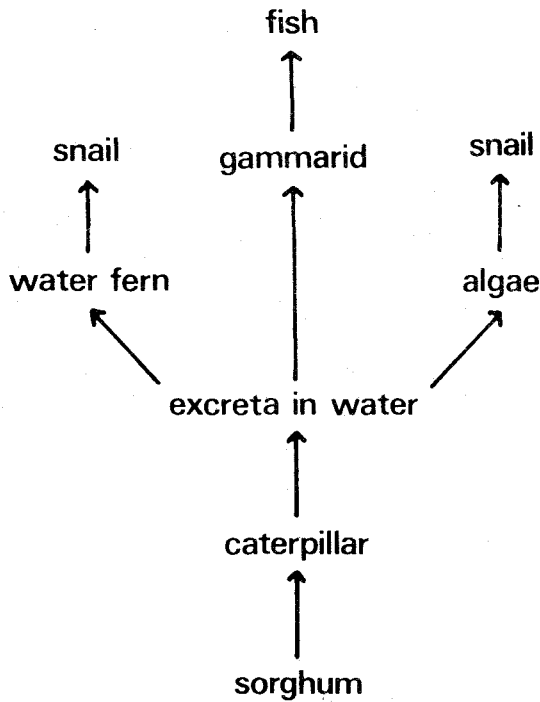


Figure 3. Possible Food Web Occurring in the Model Ecosystem

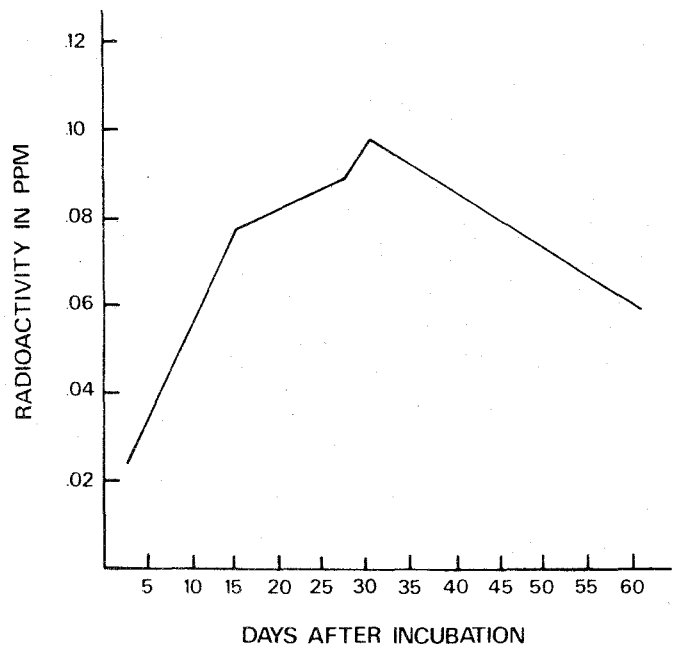


Figure 4. Changes of Radioactivity in Tank Water from Model Ecosystem Containing Organisms and Ring<sup>14</sup>C Labeled BAS 290-H

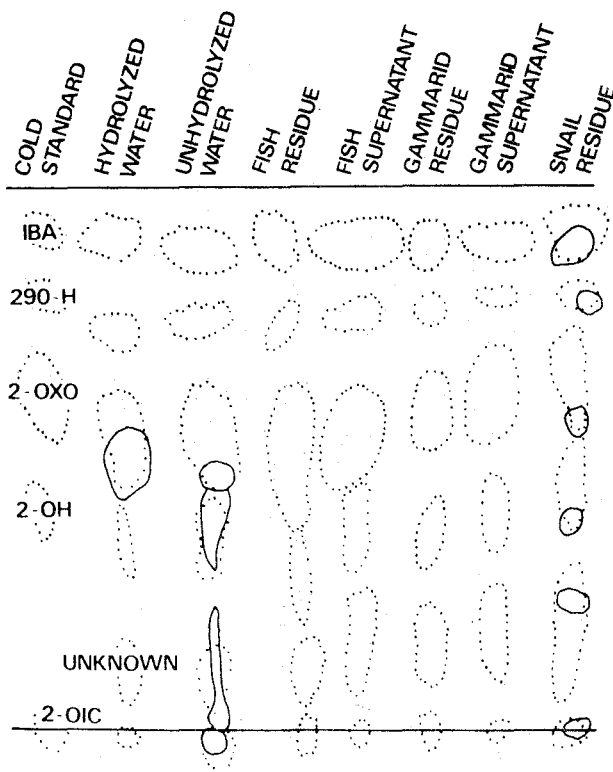


Figure 5. Radioautogram (I) of BAS 290-H in a model Ecosystem

Solid Line Represents Spots Seen in Radioautogram, While Dot Line Represents Spots Seen in U. V. Light.

The Upper Straight Line Indicates the front of Solvent, the Lower Straight Line Indicates the Origin Where the Extracts and Standards Were Spotted.

3% Methanol in Benzene was used as the Solvent System.

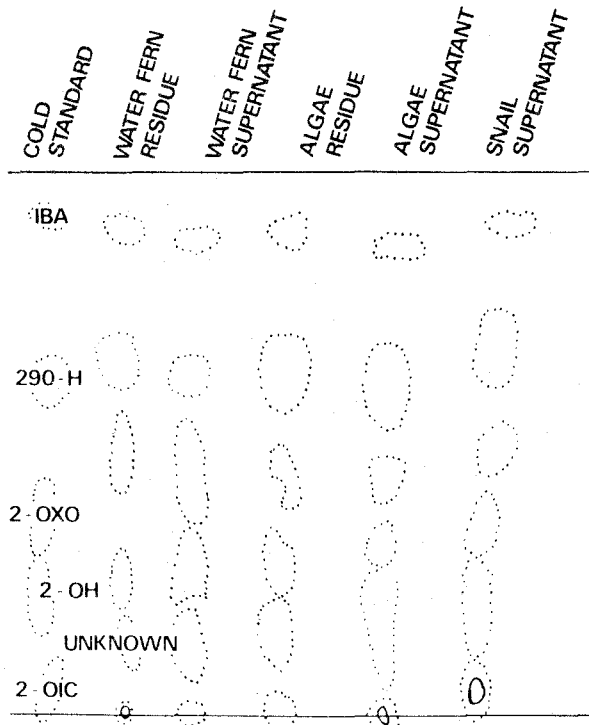


Figure 6. Radioautogram (II) of BAS 290-H in a Model Ecosystem

Solid Line Represents Spots Seen in Radioautogram, While Dot Line Represents Spots Seen in U. V. Light Corresponding to the Cold Standards.

The Upper Straight Line Indicates the front of Solvent, the Lower Straight Line Indicates the Origin Where the Extracts and Standards Were Spotted.

3% Methanol in Benzene was used as the Solvent System.

Table 3. Concentration of 290-H Plus Metabolites in Solvent and Residue Fractions of Water and Organisms from <sup>14</sup>C Labeled 290-H Experiment in a Model Ecosystem.

Sample	Concentration (PPM)			*Concentration Factor (C.F.)
	Solvent Ext.	Residue	Total	
Unhydrolyzed water	0.0031 (4%)	0.0745 (96%)	0.0776	1
Hydrolyzed water	0.0014 (2%)	0.0667 (98%)	0.0681	—
Fish	0.1595 (22%)	0.5734 (78%)	0.7329	9
Gammarid	0.2818 (67%)	0.1389 (33%)	0.4207	5
Snail	0.1838 (23%)	0.5986 (77%)	0.7824	10
Algae	0.1128 (36%)	0.1997 (64%)	0.3125	4
Water fern	0.2237 (30%)	0.5122 (70%)	0.7359	10

Table 4. Concentration in PPM of <sup>14</sup>C 290-H and Metabolites in the Model Ecosystem Water.

	R <sub>f</sub>	Unhydrolyzed Water	Hydrolyzed Water	Total
Total <sup>14</sup> C	—	0.0776	0.0681	0.1457
IBA	0.92	0.0027	0.0037	0.0064
290-H	0.81	0.0033	0.0146	0.0179
2-Oxo	0.61	0.0134	0.0306	0.44
2-OH	0.40	0.0245	0.0082	0.0327
Unknown	0.13	0.0128	0.0042	0.017
Polar material	0.00	0.0219	0.0068	0.0287

Table 5. Concentration in PPM of <sup>14</sup>C 290-H and Metabolites in Aquatic Plants.

	R <sub>f</sub>	<i>Cladophora</i> (Algae)			<i>Azolla</i> (Water Fern)		
		S.	R.	Total	S.	R.	Total
Total <sup>14</sup> C	—	0.1128	0.1997	0.3125	0.2237	0.5122	0.7359
IBA	0.92	0.0839	0.1508	0.2345	0.0291	0	0.0291
290-H	0.81	0	0.0249	0.0249	0.1022	0	0.1022
2-Oxo	0.61	0	0	0	0.0096	0	0.0096
2-OH	0.40	0.0291	0	0.0291	0	0.5122	0.5122
Unknown	0.13	0	0.0249	0.0249	0.0145	0	0.0145
Polar material	0.00	0	0	0	0.0682	0	0.0682

S: Supernatant

R: Residue

Table 6. Concentration in PPM of <sup>14</sup>C 290-H and Metabolites in Aquatic Animals from Model Ecosystem.

	R <sub>f</sub>	<i>Physa</i> (Snail)			<i>Libistes</i> (Fish)			<i>Gammarus</i> (Gammarid)		
		S.	R.	T.	S.	R.	T.	S.	R.	T.
Total <sup>14</sup> C	—	0.1838	0.5986	0.7824	0.1595	0.5734	0.7329	0.2818	0.1389	0.4207
IBA	0.92	0.1498	0.2287	0.3785	0.0241	0.1353	0.1594	0.0237	0.0176	0.0413
290-H	0.81	0	0.2119	0.2119	0.0241	0.1491	0.1732	0.0642	0.0251	0.0893
2-Oxo	0.61	0	0.0557	0.0557	0.0255	0.0854	0.1109	0.0406	0.0164	0.0570
2-OH	0.40	0.0162	0.0311	0.0473	0.0271	0.0499	0.0770	0.0338	0.0214	0.0552
Unknown	0.13	0.0068	0.0557	0.0625	0.0255	0.0768	0.1023	0.0882	0.0315	0.1197
Polar material	0.00	0.011	0.0156	0.0266	0.0332	0.0768	0.110	0.0313	0.0268	0.0581

S: Supernatant

R: Residue

T: Total

Table 7. Distribution (Percent) of Each Metabolite in Water and Organisms from the Model Ecosystem.

	Unhydrolyzed Water	Hydrolyzed Water	Fish	Gammarid	Snail	Algae	Water
290-H	4.2	21.4	21.5	20.4	17.7	8.1	22.8
IBA	2.2	5.4	19.5	10.6	59.8	74.6	6.5
2-Oxo	17.3	45.0	15.9	13.6	6.5	0.0	0.0
2-OH	31.6	12.0	12.8	13.2	5.2	9.2	50.0
Unknown	16.5	6.2	14.7	27.0	7.0	8.9	3.3
Polar material	28.2	10.0	15.6	15.2	3.7	0.0	15.2

Table 8. A Comparison of the Concentration Factors of the Individual Chemicals Found in the Organisms Studied.

	290-H	IBA	2-Oxo	2-OH	Unknown I	Polar Metabolites
Algae	35	1	0	1	1	0
Water Fern	5	6	0	16	1	2
Snail	59	12	1	1	4	1
Fish	25	10	3	2	6	4
Gammarid	6	5	1	2	7	2

in unhydrolyzed water and most organisms (fish, snail, and algae) was through 2-OH to IBA. The gammarid metabolized 290-H primarily to the unknown compound. In unhydrolyzed water, more the 2-OH was found, while in hydrolyzed water, 2-Oxo was the major metabolite formed.

Fig. 7 shows the possible pathway for metabolism of 290-H in the model ecosystem.

#### The Concentration Factor of Each Metabolite in Each Organism

Table 8 shows that the fish (25 X), snail (59 X) and algae (35 X) concentrated the parent herbicide more than any other metabolite or unknown compound. The rest of the organisms did not concentrate any of the chemicals to any significant degree.

#### Discussion and Conclusions

Salt marsh caterpillars and other aquatic organisms were all alive in the model ecosystem after completion of the experiment. This suggests that either 290-H is not highly toxic or that it can break down to relatively non-toxic compounds in a short period of time. It appears from the literature that crop species that are resistant to chloroacetanilide-type herbicides are capable of rapid detoxification by degradative mechanisms (Jaworski, 1969). This is most likely because a reaction of the halogen with endogenous substrates leads to the formation of water soluble acidic metabolites, such as 2-OH, and 2-Oxo in the plant (Otto and Drescher, 1970).

The uptake of 290-H and its metabolites caused an increase of radioactivity in the ecosystem water. The aquatic organisms absorbed and metabolized 290-H from the environmental water causing the activity in the water to decrease.

Reagent ether was used to extract 290-H and its metabolites from the water and organisms. Only a small amount (about 4% and 2%) of the compounds could be extracted from either unhydrolyzed water or hydrolyzed water. These results indicate that 290-H was extensively metabolized to conjugated or very polar materials or that ether was not an ideal solvent for extraction. In white cabbage and savoy (Otto and Drescher, 1970), the water soluble metabolites 2-OH, and 2-Oxo were found in the plant primarily bound to polar materials rather than in the free form. These were shown to be glycosidic compounds by hydrolysis of the water soluble complex with Emulsin and weak mineral acid. In the present experiments, it was theorized that the total  $^{14}\text{C}$  would increase after hydrolysis of the water sample, but the data showed opposite results. It appeared that most of the metabolites were water soluble and would not partition into ether even after extensive hydrolysis. In snails, the supernatant did not show any 290-H, but a substantial amount of 290-H remained in the residue. This indicates that unextractable residues should always be chromatographed using a tissue solubilizer to determine the type of metabolites bound to the tissues.

Some workers have suggested that the degree of extractability by organic solvents reflects the degree of meta-

bolism, i.e., the more metabolites extractable by an organic solvent, the less the degree of metabolism (Yu, et al., 1973). This, of course, is dependent on the polarity of a solvent as well as the type of metabolites. Gammarid tissue showed the highest solvent extractability, and the percentage of the 290-H kept in its body was quite high. The major metabolites in the water were primarily polar chemicals.

According to Otto and Drescher (1970), 290-H is broken down very rapidly after uptake by white cabbage and savoy and is converted to water soluble metabolites 2-OH and 2-Oxo. In lactating cows, (Cannon Laboratories, 1972) the residues found in the various tissues were mainly 290-H, 2-Oic, 4-OH-N-IBA, and IBA. In bluegill and sunfish (Gilman and Joseph, 1972), 290-H, 2-Oxo, 2-Oic, IBA, and 4-OH-N-IBA were the primary compounds. The present data suggests that there is considerable variation between aquatic organisms with regard to their capability to metabolize 290-H. No 2-Oxo appeared in the algae or water but did show up in the other organisms suggesting this variation.

Pesticides in aquatic ecosystems may not pass directly from one organism to another (Booth et al., 1973). Once the compound enters the water, the processes of absorption, adsorption, and the consumption of one food chain organism by another may all function in the accumulation of a particular pesticide. It is interesting to see that in the water fern, which is located further down the food chain, concentrated the compounds to the highest degree. This indicates that the concentration factors were not completely consistent with the positions of the organisms in the food chains and that 290-H and its metabolites do not bio-concentrate in a manner similar to the classic microchemical pollutant DDT (Metcalf et al., 1972).

The concentration factors for the metabolites and 290-H show that the fish (25 X), snail (29 X) and algae (35 X) concentrated the parent herbicide more than any other compounds. The rest of the organisms did not concentrate any of the chemicals to any significant degree.

We have subjectively used the figure 500 X as the minimum C.F. value that may suggest significant biomagnification. This decision is based primarily from model ecosystem data collected from two classic environmental pollutants (Sangha, 1971; Metcalf et al., 1971 and 1972), DDT and di-2-ethylhexyl phthalate (DEHP). These compounds could pose a threat to aquatic ecosystems. The magnification factors for 290-H in snails, algae, and fish are shown below compared with DDT and DEHP.

	<u>Snail</u>	<u>Algae</u>	<u>Fish</u>
DDT	34,500	—	84,500
DEHP	21,480	53,890	130
290-H	59	35	25

Since the algae, fish, and snails in the present experiments produced the major proportion of the total  $^{14}\text{C}$  as polar metabolites, it is not likely that 290-H would biomagnify in a manner similar to DDT and DEHP. Certainly these values are much less than those reported for the more persistent and dangerous chemicals.

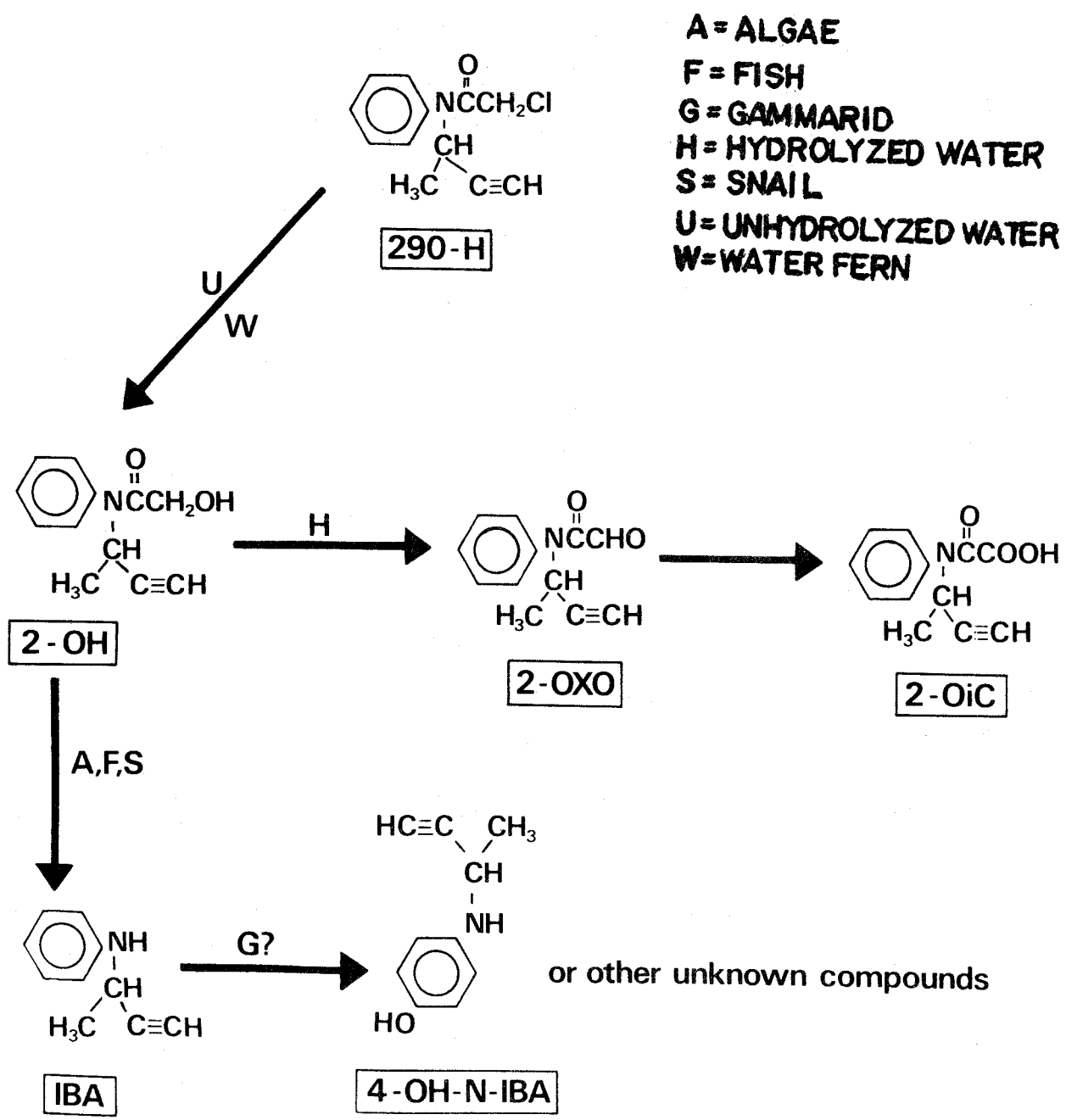


Figure 7. Pathways for Metabolism of 290-H in the Model Ecosystem based on the major metabolites formed in the water and organisms.

Therefore, these studies have shown that 290-H or any of the known metabolites do not pose any serious environmental dangers to aquatic food chains under the conditions of the test procedure. This compound seems to behave in a similar manner to Bentazon, a herbicide that was previously cycled through the model ecosystem, since most of the activity shown on the autoradiogram was present in the water (Booth et al., 1973).

In general, the overall data have shown 290-H to have favorable environmental properties. Furthermore, it appears that the model ecosystem possesses a tremendous potential as a screening tool for determining the biodegradability of new candidate herbicides.

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## Leaching and Run-off of Dinitramine under Laboratory Conditions

W. S. Belles<sup>1</sup>

**Abstract.** Laboratory leaching studies have demonstrated that dinitramine is not appreciably leached from soil. Soil types ranging from a fine sand to a silty clay loam retained 90% or more of applied dinitramine-7-<sup>14</sup>C in the top 4-cm of leaching columns after addition of up to an equivalent of ten acre inches of water. No radioactivity was recovered in water leached through columns of a sandy loam, silty loam and silty clay loam after the addition of five inches per acre of water. In a separate experiment approximately 0.02 ppm dinitramine was in the leachate after the addition of the equivalent of ten acre inches of water to columns of a fine sand soil. Repetitive leaching with daily additions of 0.5 inches per acre of water from 25 to 45 days after treatment of columns with Ring-UL-<sup>14</sup>C dinitramine showed that dinitramine and its metabolites are not readily leached from soil.

Water equivalent to 4 inches of rain was applied to a fine sand soil on a 10° slope in a run-off experiment. Dinitramine-7-<sup>14</sup>C incorporated 1.5 inches at 0.8 lb/A was not moved appreciably; the run-off water contained less than 1 ppb dinitramine. It is concluded that only under cases of extreme soil erosion following application would significant amounts of dinitramine be expected to move from the site of application.

**Introduction.** Dinitramine (N<sup>3</sup>,N<sup>3</sup>-Diethyl 2,4-dinitro-6-trifluoromethyl-m-phenylenediamine) is a preplant incorporated herbicide for the control of annual grass and broad-leaf weeds in cotton and soybeans. Movement or leaching of dinitramine from its application site by rainfall or irrigation can influence performance and possibly contaminate ground waters, streams and other nearby bodies of water.

Three separate leaching experiments and a run-off experiment were conducted in the laboratory using different soil types, leaching volumes, and a continuous or repetitive leaching technique to determine the extent of movement or leaching of dinitramine and its metabolites.

### Experimental Procedure

#### A. Leaching with Three Soil Types

Plastic tubing 6.35 cm in diameter was filled to a height of 18 cm with 20-mesh screened soil. Soils were Drummer silty clay loam, Dooly sandy loam, and Anaheim silty loam. Each column was supported on glass wool in a funnel. Soil was packed uniformly by tamping with a glass rod while filling. Columns were filled with water by gravity flow through a tube affixed to the bottom on each funnel. The tubes were removed and the columns allowed to equilibrate overnight. Soils were at field capacity when dinitramine-7-<sup>14</sup>C was applied.

Dinitramine-7-<sup>14</sup>C (50,000 dpm) equivalent to ½ lb/A was applied to each soil column. Five-ml aliquots of an ace-

tone stock solution were pipetted directly on top of each column of the two sandy loam soils, and to a separate air-dry portion of the silty clay loam soil. The latter represented an additional 2-cm layer in the soil columns. This was mixed in a beaker until the acetone was no longer detectable and the treated soil placed on top of the column.

A thin layer of 20-mesh sand and a filter paper disc was placed on top of the treated soil prior to addition of water. A total of 5 inches (400 ml) of water was leached through each column from a buret. Water was collected in separate glass bottles at 80-ml increments. Approximately 30 minutes were required for addition of each 80 ml of water.

Columns were divided into 2-cm segments after leaching, air dried and extracted with methanol. Extracts and leach water were analyzed for <sup>14</sup>C content.

#### B. Lakeland Fine Sand

Plastic tubing 6.35 cm in diameter was filled to a height of 18 cm with untreated Lakeland fine sand soil previously screened with a 16-mesh screen to remove charcoal. Each column was supported on glass wool in a funnel. Soil was packed uniformly by tamping with a glass rod while filling. Columns were brought to water holding capacity by allowing water to pass to the top of each column through the funnel stem. The columns were allowed to equilibrate overnight. Water holding capacity of each column was determined by weighing columns before adding water and after equilibration.

Dinitramine-7-<sup>14</sup>C at 1 lb/A was applied to each of four columns of the Lakeland soil. An acetone solution containing 1.424 mg of dinitramine-7-<sup>14</sup>C (Sp. Act. 0.063 uc/mg) was thoroughly mixed with 400 g of dry soil. One hundred g (2 cm of a column) of treated soil (50,000 dpm) was added to the top of each soil column after acetone evaporation. Final column height was 20 cm above the funnel rim. Water was added to bring the 2 cm of treated soil to field capacity and a filter paper disc placed on top of each column prior to leaching.

An equivalent of ten acre inches (800 ml) of water was leached through each column from a burette. The 800 ml was approximately 2.7 times the water holding capacity of each column. Water was collected in separate glass bottles at 80-ml increments. Columns were allowed to drain, divided into 2-cm segments, air dried and extracted with acetonitrile. Extracts were filtered, dried and transferred to scintillation vials for <sup>14</sup>C-detection. Water samples were evaporated to dryness and transferred to scintillation vials with acetone.

#### C. Repetive Leaching

Anaheim silty loam soil was dried, screened (16 mesh) and packed in plastic tubing (6.35 cm in diameter) supported on glass wool in a funnel. Total column length was 20 cm. The top 2 cm of soil was incorporated with 0.923 mg of dinitramine-(Ring-UL-<sup>14</sup>C) with a specific activity of 44.7 uc/mg to give a concentration of 10 ppm dinitramine. The treatment was replicated three times. Soil was brought to water-holding capacity by percolating water up through

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the funnel. The columns were maintained at water-holding capacity for 25 days at 23 C. The equivalent of one-half acre-inches of water (40 ml) was then leached daily through each column from a burette. Leachates were analyzed daily for  $^{14}\text{C}$ -content. No further attempt was made to characterize leachate  $^{14}\text{C}$  labeled compound(s) due to low activity in the water.

Forty-five days after treatment, the columns were divided into 5-cm segments, air dried and extracted repeatedly with anhydrous methanol. Extracts were filtered and analyzed for  $^{14}\text{C}$ -content.

Methanol extracts from the four replications were then combined by segment. Aliquots from each segment and dinitramine and 4731 standards were spotted on TLC plates (20 cm x 20 cm x 0.25 mm  $\text{SiO}_2$  on glass) and eluted once with benzene-ethyl acetate (4:1) and once with benzene-ethyl acetate (1:1). Plates were autoradiographed (Kodak RP Royal X-Omat X-ray film) for 3 weeks. Radioactive areas were scraped from the plates into glass scintillation vials and one-half ml of methanol added before  $^{14}\text{C}$  analyses.

#### D. Run-off

A plywood box (52¼" x 12" x 8" - 1/10,000 of an acre) was covered with polyethylene on the sides and back and with stainless steel screen on the bottom and front. The box was filled with a 4" layer of Lakeland fine sand soil. A section comprising one-fourth of the area from the top end (13" x 12" x 1.5") was removed and treated with  $^{14}\text{C}$ -labeled dinitramine at a rate equivalent of 0.8 pounds per acre (9.0 mg). This treatment was higher than the highest recommended rate for dinitramine field application on fine sand soil. The treated soil was mixed well and replaced. The entire soil mixture was then brought to field moisture capacity by allowing the box to stand in a pool of water until all the soil was wet by capillary action and then allowing it to drain overnight. The measured water uptake of the total soil plus water was 21.9%.

An amount of water equivalent to 4" of rain (10.28 liters) was sprinkled from a sprinkling can in 3.8 min. on the top end with the box raised on a 10° incline. The rate of water added was necessarily rapid, due to the rate of leaching through the soil. Leached water was caught in a plastic box and kept separate from run-off water (water coming over the bottom end of the box). Run-off water was caught by means of a galvanized tin trough at the bottom end which was directed into a 4-1 beaker. A considerable portion of the treated area was eroded and soil moved down the slope with the water. Approximately 1.51. of water plus soil was collected (3.75 lbs).

Water plus soil collected as run-off was filtered to removed soil. The soil was air-dried, weighed, and the volume of water collected calculated. Radioactivity in the soil was determined by combustion of triplicate samples. The entire volume of filtered water was evaporated to dryness, acetone was added, and aliquots were scintillation counted.

#### E. Counting Procedures

A Beckman LS-100 scintillation spectrophotometer

was used to determine radioactivity. Non-aqueous samples were counted in a PPO (2,5-diphenyloxazole) in toluene (5 g/l) solvent. Aqueous samples were counted in a 1:9 naphthalene-dioxane mixture containing 5 g of PPO/l. Counting efficiency was determined by the internal standard method.

## Results and Discussion

### A. Leaching with Three Soil Types

Movement of labeled dinitramine out of the treated areas in all three soil types was minimal with 90 percent or higher of the extracted radioactivity in the top 2-cm (Table 1). No appreciable amount of labeled dinitramine was detected below the 2-4 cm zone. Leachate water contained no detectable radioactivity.

These soils represent a range of soil types which occur in soybean and cotton growing areas; two of the soils are from the Midwest. Essentially no leaching of dinitramine can be expected from heavy rainfall or irrigation occurring soon after dinitramine incorporation. The movement of radioactivity in the Anaheim soil may be attributed to movement of treated soil particles in cracks in the soil columns.

Recovery of applied radioactivity was quite high for all three soil types. The highest recovery was with the sandy soil indicating a greater degree of binding of dinitramine in the two heavier soils.

### B. Lakeland Fine Sand

After leaching columns of Lakeland fine sand with large volumes of water (10 inches/acre) there was no appreciable movement of dinitramine from the treated zone (Table 2). Seventy-three percent remained in the top 2-cm (no movement) and nearly 95% in the top 6-cm of each column. A small amount of radioactivity was in the leachates; 1.4% of recovered activity and 1.1% of total applied  $^{14}\text{C}$ -dinitramine.

Lakeland fine sand covers an extensive area of the southeastern states and represents tillable soil in which leaching of applied chemicals would be most apt to occur. The results of this experiment demonstrate that even when large volumes of water, equivalent to heavy rainfall or irrigation, are eluted through a very light soil no appreciable downward movement of dinitramine occurs.

### C. Repetitive Leaching

The amount of  $^{14}\text{C}$ -labeled compounds leached through the columns of Anaheim silty loam soil at daily intervals is given in Table 3. Only a small percent of the total incorporated radioactivity was collected in the leach water. Daily additions of the equivalent of 0.5 acre-inches or water never leached more than 0.015% of applied  $^{14}\text{C}$ . The total amount of radioactive material in the leachates was less than 0.2% (1.8ug) of the applied  $^{14}\text{C}$ .

Analysis of methanol extracts of the soil columns show that 90% of extractable  $^{14}\text{C}$ -compounds are in the top 0-5 cm (Table 4). Less than 1% of the extractable compounds moved more than 10 cm 45 days after treatment.

Results of combustion analysis of soil after extraction is also presented in Table 4. Previous experiments (see Smith, et al. *Pesticide Biochemistry & Physiology*, Vol. 3, No. 3, Sept. 1973) show that a sizable portion of radioactivity from soil incorporated dinitramine is not readily extractable and presumably bound to soil colloids. Approximately 50% of the applied radioactivity in each 5-cm column segment was present as bound radioactive compounds and accounted for by combustion in this experiment. Little or no loss from volatilization occurred.

Results of thin-layer chromatography of the methanol extracts are in Tables 5 and 6. The columns were at 72 F with diffuse sunlight during the experiment which should allow for optimum microbial activity. Four radioactive areas representing compounds other than dinitramine were detected on the TLC plates. These ranged from 0.35 to 2.88 percent of the total extracted  $^{14}\text{C}$ . Based on comparative rf values with standards compound D is dinitramine and compound C is 4731 (6-amino-1-ethyl-2-methyl-7-nitro-5-trifluoromethylbenzimidazole) the major soil metabolite of dinitramine (Smith, et al. *Pesticide Biochemistry & Physiology* Vol. 3, No. 3, Sept. 1973).

In each 5-cm soil column segment most of the extractable  $^{14}\text{C}$  was dinitramine (Table 5). However, the relative amounts of dinitramine and the metabolites changed going down the column with less dinitramine moving down the column in relation to the 4 metabolites (origin, A, B and C). This suggests a higher water solubility and/or a weaker adherence to soil colloids of these metabolites compared to dinitramine. Even so the greatest amount of any detectable metabolite was in the top 0-5 cm and leaching of these compounds represented a very small portion of the total applied  $^{14}\text{C}$ .

#### D. Run-off

The condition of this experiment (light uncompacted soil, high water volume with rapid application) favored an excessive amount of soil erosion. The soil which was washed away (38.2 g) carried only .025% of the applied radioactivity (5.99 ppm calculated as dinitramine). Actual run-off water contained only  $3.90 \times 10^{-4}$  ppm dinitramine, or 0.007% of the applied material. Consequently, only under cases of extreme erosion after application would significant quantities of dinitramine be expected to move from application sites.

Table 1. Radioactivity Recovered from Methanol Extracts of Soil Columns

Column Depth in cm	Radioactivity Recovered					
	<u>Dooly Sandy Loam</u>		<u>Drummer Silty Clay Loam</u>		<u>Anaheim Silty Loam</u>	
	dpm x 10 <sup>-2</sup>	%	dpm x 10 <sup>-2</sup>	%	dpm x 10 <sup>-2</sup>	%
0-2	440.0	90.0	368.5	94.9	374.0	97.7
2-4	44.0	9.8	19.5	5.0	2.5	0.7
4-6	1.0	0.2	0.3	0.1	1.5	0.4
6-8	0		0		2.0	0.5
8-10	0		0		1.3	0.3
10-12	0		0		0.8	0.2
12-14	0		0		0.8	0.2
14-16	0		0		0	
16-18	0		0		0	
Water	0		0		0	
Total	489.0		388.3		382.9	
% of Applied	97.8		77.7		76.6	

Each column was treated with 50,000 DPM of dinitramine-7- $^{14}\text{C}$  and leached with 5 inches per acre of water.

Table 2. Distribution of <sup>14</sup>C Labeled Dinitramine in Lakeland Fine Sand

Column Depth (cm)	Radioactivity Recovered <sup>a</sup> (dpm x 10 <sup>-2</sup> )	% of Total Recovered Activity	% of Applied <sup>14</sup> C
0-2	294.1	73.0	58.8
2-4	60.7	15.1	12.1
4-6	26.0	6.5	5.2
6-8	7.2	1.8	1.4
8-10	2.8	0.7	.6
10-12	1.2	0.3	.2
12-14	1.1	0.3	.2
14-16	.8	0.2	.2
16-18	2.0	0.5	.4
18-20	.7	0.2	.1
G <sup>b</sup>	.5	0.1	.1
Water	5.7	1.4	1.1
Total	402.8	100.1	80.6

Columns were treated with 50,000 dpm of dinitramine-<sup>14</sup>C and leached with 10 inches per acre of water.

<sup>a</sup>Values are averages of three replications.

<sup>b</sup>Glass wool and soil within the funnel.

Table 3. Radioactivity in Water Leached Through Columns of Anaheim Silty Loam Soil with Daily Additions of 0.5 Inches per Acre of Water

Days after Treatment	Radioactivity Recovered (dpm x 10 <sup>-3</sup> )	% of Applied <sup>14</sup> C
25	0.1 <sup>a</sup>	0.001
26	0.4	0.001
27	1.5	0.002
28	3.9	0.004
29	4.8	0.005
31	5.7	0.006
32	8.1	0.009
33	6.8	0.007
34	10.7	0.012
35	11.8	0.013
36	11.3	0.012
38	9.5	0.010
39	12.1	0.013
40	12.3	0.013
41	12.5	0.014
42	13.8	0.015
43	10.9	0.012
45	13.6	0.015
Total	149.8	0.164

<sup>a</sup>Values are averages of three replications.

Columns were leached with ten ppm (9.16 x 10<sup>7</sup> dpm) of dinitramine (Ring-UL-<sup>14</sup>C) incorporated in the top 2 cm of 20 cm soil columns.

Table 4. Distribution of Radioactivity in Anaheim Silty Loam Soil

Column Depth (cm)	Methanol Extractable <sup>14</sup> C		
	Radioactivity Recovered (cpm x 10 <sup>-5</sup> )	% of Total Extracted <sup>14</sup> C	% of Applied <sup>14</sup> C
0-5	406.0	92.3	44.3
5-10	32.0	7.2	3.5
10-15	1.5	0.3	0.2
15-20	0.5	0.1	0.1
Total	440.0	100.0	48.1

Column Depth (cm)	Non Methanol Extractable <sup>14</sup> C by Combustion		% of Applied <sup>14</sup> C
	Radioactivity Recovered (dpm x 10 <sup>-5</sup> )		
0-5	467.8		51.1
5-10	13.7		1.5
10-15	3.8		0.4
15-20	2.0		0.2
Total	487.3		53.2
Total (Extractable + Non Extractable)	927.3		101.2

Columns were leached with daily increments of 0.5 inches per acre of water beginning 25 days after treatment with ten ppm (9.16 x 10<sup>7</sup> dpm) dinitramine (Ring-UL-<sup>14</sup>C) incorporated in the top 2 cm of 20-cm soil columns.

Table 5. Metabolites as a Percent of Total Extracted <sup>14</sup>C

Metabolite	rf	Soil Segment in cm					% of Total Applied <sup>14</sup> C 0-20 cm
		0-5	5-10	10-15	15-20	0-20	
Origin	0	0.92	0.12	0.02	0.01	1.07	0.51
A	.21	0.28	0.06	0.01	<.01	0.35	0.16
B	.32	0.65	0.11	0.01	<.01	0.77	0.06
C (4731)	.40	2.40	0.40	0.06	0.02	2.88	1.38
D (dinitramine)	.93	88.05	6.51	0.20	0.07	94.83	45.58
<b>Standards</b>							
.4731	.38						
Dinitramine	.94						

The top 2-cm of 20-cm soil columns were treated with ten ppm of dinitramine (Ring-UL-<sup>14</sup>C) and leached with daily increments of 0.5 inches per acre of water for 20 days beginning 25 days after treatment.

Table 6. Metabolites as a Percent of Extracted  $^{14}\text{C}$  per 5-cm Segment of Soil

	rf	Soil Segment in cm			
		0-5	5-10	10-15	15-20
Origin	0	1.0	1.6	5.3	6.8
A	.21	0.3	0.9	3.1	2.4
B	.32	0.7	1.5	4.5	4.3
C (4731)	.40	2.6	5.6	21.5	18.3
D (Dinitramine)	.93	95.4	90.4	65.6	68.2
<b>Standards</b>					
4731	.38				
Dinitramine	.94				
<b>% of Total</b>					
Extracted $^{14}\text{C}$		92.3	7.2	0.3	0.1
<b>% Recovery of</b>					
$^{14}\text{C}$ Applied to TLC Plate		83.7	102.6	100.7	91.4

The top 2-cm of 20-cm soil columns were treated with ten ppm of dinitramine (Ring-UL- $^{14}\text{C}$ ) and leached with daily increments of 0.5 inches per acre of water for 20 days beginning 25 days after treatment.

#### Soil and Sugarcane Contributions to the Degradation of Ametryne

Kishore P. Goswami and Richard E. Green<sup>1</sup>

*Abstract.* Studies of herbicide degradation are usually confined to measurements of either degradation in the soil or metabolism by plants. Too often the herbicide-plant-soil system is not studied as a whole, and consequently important interactions between plant roots and soil are not evaluated. In this investigation of the breakdown of ametryne 2-methylthio-4-ethylamino-6-isopropylamino-*s*-triazine), separate experiments were designed to evaluate ametryne degradation in soils without sugarcane plants and in a sugarcane-nutrient system without soil. These experiments were followed by a study of ametryne degradation in a combined plant-soil system in which the plant shoot and root-soil components were monitored separately for degradation products from labelled soil-applied ametryne by enclosing the system in a divided chamber.

In Hydrandep and Torrox soils without plants, ametryne residues at 60 days were, respectively, 45% and 65% of that applied; 95% ametryne remained in autoclaved soils. All evidences of degradation, including ametryne conversion to polar products,  $^{14}\text{CO}_2$  evolution, and accumulation of non-extractable  $^{14}\text{C}$  residue, indicated predominant microbial breakdown of ametryne in the non-autoclaved soils.

In nutrient solution, sugarcane roots rapidly converted ametryne to polar breakdown products. Thin layer chromatography indicated that degradation proceeded via dealkylation. The 2-hydroxy analog of ametryne was not a major product.

In the soil-sugarcane system, only 8% of the applied  $^{14}\text{C}$ -ring-labelled ametryne remained after 60 days. A large quantity of  $^{14}\text{CO}_2$  was evolved from the soil-root portion (4% of applied  $^{14}\text{C}$ ) relative to that evolved from the shoot (0.03%). The presence of sugarcane roots in the soil increased de-ethylation of ametryne and also hydrolysis at the 2-position.

No labelled volatile gases other than  $^{14}\text{CO}_2$  were measured in the gaseous effluents from the divided plant/soil chambers. However, 1% of the applied radioactivity was recovered in water condensed on the inside walls of the plant-shoot compartment; this was not  $^{14}\text{CO}_2$ , but a basic water soluble compound thought to be exuded from sugarcane leaves.

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Effects of Ultra-high Frequency (UHF) (2450 MHz) Energy  
on the Phytotoxicity of Soil-Incorporated  
Bensulide and Trifluralin

Robert M. Menges and J. R. Wayland<sup>1</sup>

**Abstract.** Applications of 4.5 kg/ha of bensulide (0,0-diisopropyl phosphorodithioate S-ester with *N*-(2-mercaptoethyl)benzenesulfonamide) and 1.1 kg/ha of trifluralin (*a,a,a*-trifluoro-2,6-dinitro-*N,N*-dipropyl-*p*-toluidine) were incorporated with the surface 2.5 cm of soil in the field in 1972. The treated soils were exposed to 180 and 730 j/cm<sup>2</sup> of UHF energy one day after herbicide treatment. Trifluralin was unaffected but 730 j/cm<sup>2</sup> of UHF reduced the biological activity of bensulide in soil as indicated in field and laboratory bioassays.

Ammonium Sulfate Enhancement of Picloram Activity  
and Absorption in Strawberry Guava  
(*Psidium Cattleianum* Sabine)

Bruce J. Wilson and Roy K. Nishimoto<sup>2</sup>

**Abstract.** Strawberry guava (*Psidium cattleianum* Sabine) is a weedy shrub or tree on ranchland in Hawaii. The objective of this study was to increase picloram activity on strawberry guava with an inorganic salt adjuvant and to measure the effect of the salt adjuvant on picloram absorption and translocation as a means of explaining the enhancement effect.

Strawberry guava seedlings were grown in pots outdoors for 4 to 5 months and subsequently in the glasshouse for 2 months before treatment with picloram alone, or plus ammonium sulfate at 0.10, 0.75, 1.0 and 10% w/v. Treatment volume was 140 L/ha. The effect of ammonium sulfate increased injury to strawberry guava by different degrees, depending on picloram rate and salt concentration. Injury tended to increase with increasing salt concentration.

Paired leaves on the upper stem of strawberry guava seedlings were treated with two 5 uL droplets per leaf (0.05 uCi <sup>14</sup>C-picloram K salt per plant) of solution containing 1000 ppmw picloram K salt alone or plus 0.5% and 10% W/V ammonium sulfate. After 2 days, 0.5% ammonium sulfate increased <sup>14</sup>C-picloram absorption about five-fold. There was about four times more <sup>14</sup>C in the upper stem and attached leaves with ammonium sulfate added than with <sup>14</sup>C-picloram alone. All of the <sup>14</sup>C in the plant was shown to be <sup>14</sup>C-picloram by paper chromatography of extracts. Picloram absorption from 0.5% and 10% ammonium sulfate treatments were equal.

Ammonium sulfate apparently increased picloram absorption through the cuticle, because stomata are absent from the upper surface of strawberry guava leaves. Using detached leaves, <sup>14</sup>C-picloram absorption was increased by the ammonium salts of sulfate, nitrate, chloride, dibasic phosphate and monobasic phosphate, but ammonium sul-

fate was the only sulfate salt that was found to increase absorption. <sup>14</sup>C-picloram absorption was increased by reducing solution pH from 6 to 4. However, ammonium dibasic and monobasic phosphate were equally effective in increasing <sup>14</sup>C-picloram absorption despite differences in solution pH of 7.7 versus 4.6, respectively.

A Progress Report on Agricultural Uses of  
Activated Charcoal

K. E. Clapp<sup>1</sup>

One primary reason activated charcoal is useful in agriculture is its ability to attract and hold a wide range of organic molecules to its surface. This is called adsorption.

The ability to adsorb is related to surface area, and activated charcoal has its surface area vastly increased over conventional charcoal by an additional manufacturing step that honeycombs the charcoal with tunnels called pores. This process increases the surface area to such an extent that one ounce of activated charcoal has more area than a football field.

Activated charcoal will adsorb most organic pesticides; however, it will not effectively adsorb the most water-soluble ones including Paraquat, Diquat, Amitrole and the methyl arsenates. Fortunately, it will also not adsorb such solubles as fertilizer compositions. Always use an activated charcoal designed specifically for agricultural purposes because conventional charcoals exhibit a wide range of properties, depending upon raw materials and manufacturing conditions.

G. F. Warren of Purdue has worked extensively with activated charcoal in agriculture over the past few years. In one of his more recent tests, he transplanted tomatoes into an area treated with one pound per acre pre-plant incorporating trifluralin. When the tomatoes were protected by dipping them in a two pound per gallon slurry of GRO-SAFE activated charcoal immediately prior to transplant, a much better growth was obtained. The yield data for this experiment shows that 10.7 tons of tomatoes were produced per acre without using activated charcoal vs 13.1 tons produced with the GRO-SAFE root dip. This is an increase of 2.4 tons per acre with GRO-SAFE. Translated into a dollar value, this gives a farmer an increased return of \$104 per acre.

L. R. Hawf experimented with direct-seeded asparagus and activated charcoal at the University of Delaware this year. He protected asparagus from the herbicide Terbacil by spraying a band of activated charcoal over the seed row. This involved spraying a slurry of the activated charcoal in a narrow band at the rate of 300 lbs. per acre in the actual band. With two pounds per acre Terbacil and no activated charcoal, excellent weed control was obtained, but no asparagus survived. By spraying a three-inch band of activated charcoal over the seed row immediately before spraying the herbicide, good weed control was maintained and protection was provided to the emerging asparagus.

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An additional direct-seeded asparagus test was run by J. E. McCully of Green Giant at Fruitland, Md. He used one pound per acre Terbacil and protected the asparagus with a one-inch band of activated charcoal with a 300 lbs. per acre rate in the band. This treatment gave excellent control over weeds in one replication with good protection to the asparagus. However, in additional replications, the same measure of protection was not provided to the asparagus, indicating a wider band should probably be used.

A. G. Ogg, Washington State University, ran experiments with direct-seeded asparagus with various herbicides and activated charcoal. He published his data at the 1974 WSSA Meeting.

R. C. Henne of Campbell's ran a direct-seeded tomato test using the herbicide Metribuzin at Clayton, Del. He supplied protection to the direct-seeded tomatoes by using GRO-SAFE in two manners. The first method was with a banded spray, the second combining the activated charcoal with a vermiculite anti-crusting agent. The control plots clearly showed a heavy weed pressure was present. One half pound per acre pre-emergence application of Metribuzin gave excellent weed control, but also gave severe damage to the tomatoes. A one-inch band with 300 lb/acre GRO-SAFE applied immediately before the pre-emergence application of the Metribuzin gave excellent protection to the tomatoes and still provided good weed control. The 300 pound per acre rate in the one-inch band is an actual rate of five pounds GRO-SAFE per planted acre. Incorporation of the same quantity of GRO-SAFE into the vermiculite anticrusting agent also gave good protection to the tomatoes. The yields from these plots show that there were an average of ten tons per acre produced without the aid of charcoal. The plots with the one-inch band of GRO-SAFE produced an average of 12.8 tons per acre. The average plot with the charcoal-vermiculite mixture produced 12.4 tons per acre. The hoed checks with no herbicide and no GRO-SAFE produced 12.6 tons per acre.

At the same location, a similar test run with one pound per acre Metribuzin gave 4.7 tons per acre without the use of charcoal, 12.9 tons per acre with the one-inch band of activated charcoal and 8.8 tons per acre with the charcoal-vermiculite mixture.

A direct-seeded tomato trial was run by A. H. Lange and his associates at Hollister, California. In this test, GRO-SAFE was applied as a one-inch band at a rate of 400 lbs. per acre in the band. The yield data from this study shows that with four pounds per acre pre-emergence application of Chloramben 21.5 tons per acre were produced without charcoal versus 34.2 tons with the use of charcoal. With two pounds per acre pre-emergence application of Isopropalin, 22.5 tons per acre were produced without charcoal versus 32.6 tons with the charcoal. Eight pounds per acre of Pebulate did not require the safening effect of activated charcoal. Plots with one pound per acre Metribuzin applied pre-emergence produced 9.2 tons without the use of charcoal versus 43 tons with the charcoal band. A. Lange was particularly impressed by the ability of the Chloramben program to control ground cherry and night shade which are closely related to the tomatoes without damaging the tomato plants.

Another direct-seeded tomato test was run in Kern County, California. The herbicide used in this case was Trefmid at the 1/4 plus four pound rate preplant incorporated. GRO-SAFE was applied as a one-inch band in the open furrow directly over the seed at 300 lbs. per acre in the band. This is an actual rate of 5 lbs. per planted acre. The yield figures for these plots show that without charcoal 35.9 tons were produced versus 41.8 tons with the charcoal band.

H. G. Myers has been running extensive tests at the University of Florida to control poa annua. His program is designed to control poa annua in Bermuda grass on golf courses. Bermuda grass goes dormant in cold seasons and overseeding with an annual rye grass is often used to provide a green cover in winter.

With this in mind, H. G. Myers applies Pronamide at one pound per acre to give both pre- and post-emergence control of the poa annua. After two weeks, he applied GRO-SAFE at the rate of 2.5 pounds per 1,000 square to inactivate or tie up the Pronamide and permit immediate overseeding with annual rye grass.

Plots were run to demonstrate the concept of using Pronamide, activated charcoal and rye grass in a program for controlling poa annua and greening up golf courses.

The University of Rhode Island has been the site of numerous turf grass experiments with activated charcoal. This year J. A. Jagschitz has continued his work with experiments on deactivation of turf herbicides with activated charcoal and charcoal coated grass seed.

An experiment was run with Merion bluegrass seeded into an area treated one week before with ten pounds per acre of Bensulide. After seven weeks, little effective coverage of grass was achieved. When the same procedure was followed with a Merion bluegrass seed coated with GRO-SAFE activated charcoal, about 20% coverage of grass was achieved. If a level of Bensulide were used to approximate a couple of month's decomposition, an even more impressive growth would have been noted.

When the same procedure was followed except a broadcast spray of 300 pounds per acre of GRO-SAFE was used prior to seeding with a normal grass seed, almost total grass coverage was achieved in the seven weeks.

Additional studies with coated grass seed are being run in conjunction with poa annua control problems in turf by J. R. Hall at the University of Maryland and H. G. Myers at the University of Florida. Coated seeds representing a wide range of crops are being tested at other locations.

G. W. Elmstrom of the University of Florida, has published several papers on his studies with the use of activated charcoal and herbicides on watermelons. This year he continued his work with both greenhouse and field studies.

W. R. De Tar of Western Illinois University has published a paper on his vermiculite-activated charcoal seed wafer system. This year he continued these studies by making a substantial quantity of these wafers with tomato seeds and planting about one half acre. He produced and planted these seed wafers with his specially designed pieces of equipment.

One of the most recently completed trials was with cotton in King's County, California. In these tests, GRO-SAFE was applied by the banded spray technique in the open furrow at a rate of 300 pounds per acre in a one-inch band or an actual use level of eight pounds per acre. The plots were six rows wide and 30 feet long and run in four replications. In general, the activated charcoal produced a faster and more uniform stand. The specific yield data shows with 3/4 pound per acre preplant incorporated Trifluralin, there were 3.05 bales per acre produced without the aid of charcoal versus 3.57 with charcoal. With 2/3 pound per acre preplant incorporated Dinitramine, there were 2.84 bales per acre produced without the charcoal versus 3.81 produced with the charcoal. With no herbicide used, there were 2.78 bales per acre produced without the aid of charcoal versus 3.67 bales per acre produced with the charcoal.

This concludes a very brief summary of some of the progress which has been accomplished with activated charcoal in the field of agriculture during 1973. Additional information and a bibliography on published data is available from ICI America.

#### An Evaluation of Potential Uses of Asulam in Western Oregon

D. R. Harper, R. J. Burr, and D. R. Colbert<sup>1</sup>

Field trials were established in 1972 and 1973 to determine weed and crop responses to postemergence applications of asulam and to study various factors which may influence its herbicidal activity.

The results of these trials have shown that asulam provides excellent (95+%) control of tansy ragwort (*Senecio jacobaea* L.), common groundsel (*Senecio vulgaris* L.), spotted catsear (*Hypochaeris radicata* L.), broadleaf dock (*Rumex obtusifolius* L.), bull thistle (*Cirsium vulgare* (Savi) Tenore), velvetgrass (*Holcus lanatus* L.), and western bracken (*Pteridium aquilinum* (L.) Kuhn var. *pubescens* Underw.). Herbicidal activity has also been observed on bentgrass (*Agrostis* sp.), ladysthumb (*Polygonum persicaria* L.), prickly lettuce (*Lactuca serriola* L.), and Canada thistle (*Cirsium arvense* (L.) Scop.). Alfalfa (*Medicago sativa* L.), peppermint (*Mentha piperita* L.), and some grass species have shown good tolerance to asulam treatments.

The addition of surfactant at 0.2% of the carrier volume did not improve tansy ragwort control. Velvetgrass control was increased by the addition of surfactant. The effectiveness of asulam is also dependent on the plant growth stage at the time of treatment. Reduced rates of asulam (1.0-2.0 lb a.i./A) are more effective on rosette tansy ragwort than on bolted plants. Canada thistle control was improved by treating after the plants were at least 6 inches tall.

Alfalfa was treated with 8 lb a.i./A of asulam at initial bloom and 4.0 lb a.i./A at several growth stages with no visible injury and peppermint has tolerated 4.0 lb a.i./A at several growth stages with no injury. Orchardgrass (*Dactylis glomerata* L.) and tall fescue (*Festuca arundinacea* Schreb.) treated with 2.0 lb a.i./A were not injured, but some

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phytotoxicity was evident at 4.0 lb a.i./A of asulam.

Potential uses for asulam are envisioned in alfalfa for tansy ragwort and thistle control, in peppermint for common groundsel, spotted catsear, prickly lettuce, and Canada thistle control, and in pasture for tansy ragwort, dock, and bracken control.

#### Influence of Yellow Nutsedge Competition on Furrow-Irrigated Cotton

P. E. Keeley and R. J. Thullen<sup>1</sup>

**Abstract.** In five field experiments conducted during 1972 and 1973, yellow nutsedge (*Cyperus esculentus* L.) was left undisturbed or removed by hoeing from planting beds 0, 2, 4, 6, and 8 weeks after cotton (*Gossypium hirsutum* L. 'Acala SJ-1') emergence, and at weekly intervals thereafter for 15 weeks from emergence. Our objective was to study the influence of nutsedge competition on growth, yield, maturity, and fiber properties of cotton, and the influence of hoeing on the survival and reproductive capacity of nutsedge. Treatments were arranged in randomized blocks replicated four or six times. Plots were cultivated four times, leaving a 20 cm band centered over the drill row. Plots were machine harvested twice.

Stands of nutsedge on undisturbed plots increased from 23 plants/m of row at cotton emergence to 100 plants/m at harvest. Compared to plots weeded at crop emergence, nutsedge competing for more than 4 weeks reduced the total yield of seed cotton. Nutsedge competing all season reduced yields 34%, compared to 20% when nutsedge competed for 6 and 8 weeks.

Nutsedge competing with cotton for more than 4 weeks reduced cotton stands and height and delayed maturity as measured by first-pick yields. Although nutsedge competition reduced yields and delayed maturity, fiber properties were not altered.

Removing nutsedge at the time of cotton emergence, followed by 15 weekly hoeings, reduced the final tuber population about six fold. Delaying the removal of nutsedge for 6 weeks, followed by nine weekly hoeings, resulted in a four-fold increase of tubers, while a 12-fold increase occurred when nutsedge was not removed.

#### Preemergence Control of Wild Oat and Annual Ryegrass in Winter Wheat in Western Oregon with Nitrofen

T. J. Neidlinger<sup>2</sup>

Annual ryegrass (*Lolium multiflorum*) and wild oat (*Avena fatua*) are two troublesome weeds infesting winter wheat fields in Western Oregon. Diuron has been the standard herbicide treatment for several years and is known to provide inconsistent control of annual ryegrass and very little control of wild oat. Barban has been used in recent years for control of wild oat, however, barban is usually

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not effective against ryegrass. Therefore, a need exists for a selective herbicide which will control both ryegrass and wild oat in winter wheat in Western Oregon.

### Methods

Ten experiments were established in Western Oregon in the fall of 1971 and 1972 to evaluate nitrofen or TOK<sup>2</sup> (2,4-dichlorophenyl-p-nitrophenyl ether) for selective grass control in winter wheat. Tests consisted of replicated small plots in a complete randomized block design. Chemical treatments were applied with a small plot bicycle sprayer using N<sub>2</sub> gas as the pressure source. Nitrofen was applied preemergence at dosages between 2.0 and 4.0 lbs. a.i./A. and evaluated compared to standard treatments of diuron at 1.6 lbs. a.i./A. preemergence and barban at 0.38 lbs. a.i./A. postemergence. Periodic weed control and crop injury ratings were taken throughout the growing season and all trials were harvested for yield.

### Results and Discussion

#### 1. 1971-72 Field Trials

Weed control ratings from 1971-72 tests are summarized in Table 1 and yield data are presented in Table 2.

<sup>2</sup>TOK is a Trade Mark of Rohm and Haas Company and of its subsidiaries and affiliates.

In general, all nitrofen treatments were safe to the crop, although some early crop phytotoxicity did result which was followed by complete crop recovery. Initial leaf tip "burn" and slight stand reduction are symptomatic of pre-emergence nitrofen treatments. The degree of injury is a function of herbicide rate and soil surface moisture at time of crop emergence. However, no permanent crop injury as expressed by yield reductions has been recorded to date from any preemergence nitrofen treatment, even with weed competition lacking.

Nitrofen provided good control of both ryegrass and wild oat at rates between 2.0 and 4.0 lbs. a.i./A. The 2.0 lb. rate of nitrofen provided comparable weed control to the 1.5 lb. rate of diuron. In these three trials, ryegrass was the predominant species. Wheat yield increases averaged 13.4, 15.4 and 16.1 bu/A. greater than the control for nitrofen rates of 2.0, 3.0 and 4.0 lb. a.i./A., respectively.

#### 2. 1972-73 Field Trials

Seven trials were established in the fall of 1972 to compare the effectiveness of preemergence treatments of nitrofen and diuron for control of ryegrass and wild oat. Postemergence treatments of barban and nitrofen were also evaluated at two locations.

Although fair to good weed control was achieved with postemergence nitrofen treatments, objectionable foliar

**Table 1. Average Percent Wheat Injury and Weed Control at Final Evaluation for Three Preemergence Wheat Trials.**

Treatment	Dosage Lb ai/A	% Wheat Injury and Weed Control								
		Trial A			Trial B			Trial C		
		Wheat	Ryegrass	W. Oat	Wheat	Ryegrass	W. Oat	Wheat	Ryegrass	W. Oat
nitrofen (EC)	2.0	0	89	-	6	86	83	0	70	83
"	3.0	3	83	-	6	90	85	4	81	85
"	4.0	6	90	-	11	90	86	0	84	90
nitrofen/diuron	2.0+1.0	5	90	-	15	89	79	0	86	85
" "	3.0+1.5	8	93	-	10	89	84	6	88	86
diuron	1.5	5	79	-	0	25	13	4	83	15

**Table 2. Average Yields (bu/A) for Three 1971-72 Preemergence Wheat Trials.**

Treatment	Dosage Lb ai/A	Trial No.			Avg. of 3 trials	Increase Over Untreated Check
		A	B	C		
nitrofen (EC)	2.0	60.1	79.2	61.4	66.9	13.4
"	3.0	57.5	84.6	64.6	68.9	15.4
"	4.0	57.7	80.6	70.4	69.6	16.1
nitrofen/diuron	2.0+1.0	62.4	80.6	69.6	70.9	17.4
" "	3.0+1.5	64.8	83.1	68.2	72.0	18.5
diuron	1.5	62.1	77.7	59.9	66.6	13.1
check	--	44.6	73.9	42.1	53.5	--

“burn” from the emulsifiable concentrate formulation resulted in less than desirable affect on the wheat. Yields, however, were not significantly lower than the checks, and in one test the postemergence nitrofen rate of 2.0 lb. a.i./A. yielded significantly higher than the check, but significantly lower than the 2.0, 3.0 and 4.0 lb. preemergence nitrofen treatments.

Weed control ratings for preemergence nitrofen and diuron treatments and postemergence barban treatments are presented in Tables 3 and 4. The 3.0 lb. a.i./A. rate of nitrofen resulted in superior control of ryegrass and wild oat compared to diuron at 1.6 lb. a.i./A. Diuron was ineffective against wild oat. Nitrofen at 2.0 lb. a.i./A. preemergence and barban at 0.38 lb. a.i./A. postemergence provided equal control of wild oat in the two trials where they were compared. Nitrofen was superior to barban for ryegrass control.

Wheat yield data for the seven 1972-73 trials are presented in Table 5. Large yield increases were obtained in all tests except trials G and K where little or no weed population developed. In these particular trials, yields from nitro-

fen treatments were equal or greater than the controls indicating that early phytotoxicity shortly after crop emergence had no effect on wheat yield. Special note should be made of the yield results from test J where a dense wild oat population infested the field along with a lesser population of ryegrass. The control yielded only 16.5 bu/A. while the 2.0, 3.0 and 4.0 lb. a.i./A. nitrofen treatments yielded 57.3, 59.7 and 62.7 bu/A., respectively. Diuron at 1.6 lb. a.i./A. resulted in a wheat yield of 30.4 bu/A. which was nearly double the control yield but only half as much as the nitrofen treatment yields. The greater wheat yield from the nitrofen treatments is attributed to the fair to good control of wild oat which diuron was ineffective against.

Finally, as the last column in Table 5 indicates, a treatment such as nitrofen which controls both annual ryegrass and wild oat can be of great benefit to the wheat grower of Western Oregon, by increasing his yields as much as 20 bu/A.

Table 3. Average Percent Annual Ryegrass Control at Final Evaluation for Four Winter Wheat Trials in 1972-73.

Treatment	Dosage Lb ai/A	% Ryegrass Control				Average
		Trial No.				
		D	E	F	G	
nitrofen (EC)	2.0	85	89	71	83	82
"	2.5	89	-	-	85	87
"	3.0	88	98	81	90	89
"	4.0	91	97	80	-	89
diuron	1.6	61	75	58	76	68
barban	0.375	5	20	-	-	13

Table 4. Average Percent Wild Oat Control at Final Evaluation for Five Winter Wheat Trials in 1972-73.

Treatment	Dosage Lb ai/A	% Wild Oat Control					Avg.
		Trial No.					
		D	F	E	H	J	
nitrofen (EC)	2.0	74	86	89	41	59	70
"	3.0	80	90	98	69	84	84
"	4.0	64	93	98	76	89	84
diuron	1.6	3	0	0	0	0	1
barban	0.375	76	-	78	-	-	77

Table 5. Average Wheat Yields of Nitrofen, Diuron, and Barban Treatments vs. the Untreated Check

Treatment	Dosage Lb ai/A	Wheat Yield (bu/A)								Yield Increase Over Check
		Trial No.								
		D	K	F	E	H	G	J	Avg.	
nitrofen (EC)	2.0	65.5	86.2	115.6	118.4	54.6	85.1	57.3	83.2	17.1
"	3.0	69.4	92.6	114.5	118.8	59.5	86.7	59.7	85.9	19.8
"	4.0	68.1	81.8	111.8	116.8	62.3	-	62.7	83.9	20.8
diuron	1.6	53.5	91.5	116.2	111.5	49.5	87.3	30.4	77.1	11.0
barban	0.375	46.2	-	-	115.4	-	-	-	80.8	7.4*
Check	-	39.3	83.6	85.2	107.5	46.5	84.1	16.5	66.1	-

\*Check average computed from trials where the compared treatment was tested.

### Post Emerge Wild Oat Control in Cereals with Avenge\*

C. R. Amen<sup>1</sup>

Avenge\*, 1,2-Dimethyl-3,5-Diphenylpyrazolium methyl sulfate, was extensively tested during 1972 and 1973 in wheat and barley for control of wild oats. Selective control of wild oats was obtained with postemergence treatments. Depending upon the degree of wild oat infestation, rates of 0.5 to 1.0 lb ai/A gave good control.

Application of sprays when wild oats were in the 3 to 5-leaf stage of growth provided effective control. Yield increases of as much as 20% to 30% were obtained with the effective treatments.

The addition of a wetting agent to the spray solution was determined to be necessary for optimum performance. Wetting agents found to be effective additives were Triton X100, Tergitol NPX, and X77. Optimum rates for all these materials were in the range of 0.5% to 0.75% v/v.

Combination treatments with 2,4-D amine and MCPA reduced the effectiveness for wild oat control. This was reflected in lowered yields with the 2,4-D combinations, but MCPA combinations showed increased yields over untreated checks.

Some varieties of spring wheat in parts of the U. S. were injured at rates above 0.5 lb ai/A, but none of the varieties tested in the Northwest showed any evidence of injury. At rates needed for effective control in barley of winter wheat no phytotoxicity was observed.

### The Effect of Several Dinitro Aniline Herbicides on Root Development of Cotton and Soybean Seedlings

H. Fred Arle<sup>2</sup>

*Abstract.* Possible differences in the relative phytotoxicities of nine substituted dinitroaniline herbicides on root

\*Trademark

<sup>1</sup>Agriculturist, American Cyanamid Company.

<sup>2</sup>ARS, USDA Cotton Research Center, Phoenix, Arizona.

development of cotton and soybeans were compared under greenhouse conditions. Glass-front boxes were filled with untreated soil to within 2 inches of the top. Each of the herbicides was applied at .75 lb/A and thoroughly incorporated into 2 inches of soil and then added to the glass-front boxes. Soybean and cotton were seeded (5 seeds of each) at a depth of .75 inch. The primary root therefore had to elongate 1.25 inches before reaching untreated soil. Water was slowly added into a small furrow at the backside of the glass boxes until moisture reached the full depth of 12 inches. The following herbicides were included in the study:

- trifluralin (a,a,a-trifluoro-2,6 dinitro-N,N-dipropyl-p-toluidine)
- nitralin [4-(methylsulfonyl)2,6-dinitro-N,N-dipropyl aniline]
- An. 56477 [N,N,bis(2-chloroethyl)-2,6-dinitro-p-toluidine]
- AC-92553 [N-(ethylpropyl)-2,6-dinitro-3,4-xylylidine]
- fluchloralin [N-(2-chloroethyl)-2,6-dinitro-N-propyl-4-trifluoromethyl aniline]
- profluralin [N-(cyclopropylmethyl) a,a,a-trifluoro-2,6-dinitro-N-propyl-p-toluidine]
- butralin [(1,1-dimethyl)-N-(1 methyl propyl)-2,6-dinitrobenzamine]
- dinitramine (N<sup>4</sup>,N<sup>4</sup> diethyl-a,a,a-trifluoro-3,5-dinitro-toluene-2,4-diamine)
- USB-3153

The application rate of .75 lb/A was higher than the recommended rate for dinitramine and lower than the suggested use-rate for butralin. Each of the materials had some effect on the test crops with considerable difference in severity. There was also some difference in the tolerance of cotton and soybeans as indicated by secondary root development. Secondary roots usually were more numerous on soybeans but frequently these were somewhat thickened and not of normal length.

Nitralin and dinitramine were most toxic, retarding not only the secondary roots in the zone of incorporation but

also inhibiting the development of the primary root and of top growth. Secondary root development of cotton seedlings was least affected by butralin and AC-92553. On soybeans root development was least affected by butralin, Am. Cy. 92553, fluchloralin and An. 56477.

When primary roots were able to penetrate the zone of herbicide incorporation, secondary root development was normal in the untreated soil and top growth of cotton and soybeans appeared normal after the second week. The toxic effect of the dinitroanilines was much more severe under the conditions of this greenhouse experiment than is customarily observed under field conditions.

### Effect of Sustained Herbicide Applications and Crop Production on Weed Communities

Lambert C. Erickson<sup>1</sup>

This project was Idaho's contribution to the Western Regional Project titled, "Response of Plants and Plant Communities to Sustained Use of Herbicides." My interpretation of the regional project title infers that plants are crops, and plant communities are that aggregate of vegetation prevailing within the crop area.

In this instance spring sown crops were sustained on the same plot areas for a 5-year interval; these crops or cultures were: barley, flax, field peas, Ideal wheat, a dwarf sunflower, 2-year buckwheat, and no-crop.

The objectives of course were to determine the effects of sustained cropping on the composition of the weed flora, on crop yield, and other factors such as disease, as results of sustained monocropping.

Superimposed on these 7 x 200 ft. crop drill strips were five herbicides at five rates of each; these were terbutryn (Igran), dicamba (Banvel D), linuron (Lolox), silvex (Kuron), and a picloram (Tordon) plus 2,4-D combination. All of these were applied pre-emergence on the day after seeding. Final individual plot sizes were 7 x 40 feet.

In this complex study I want to refer only a few items and their statistical significance over the 5-year interval.

1. No herbicide (at any rate) delayed or reduced germination under field conditions.
2. Toxicity symptoms (1 month) were significant in the following at 5% or better:

dicamba at	1.7	1.1	.56	.28	0	
	X					barley
	X	X	X	X		flax
	X	X	X	X		peas
silvex at	2.2	1.7	1.1	.56	0	
	X	X	X			flax
picloram	.14	.07	.035	.017	0	
	X					barley
	X					flax
	X	X	X	X		peas

### 3. Plant height reduced:

terbutryn	2.2	1.7	1.1	0.5	0	
	X	X	X	X		flax
dicamba	1.7	1.1	0.56	0.38	0	
	X	X				barley
	X	X	X	X		flax
	X	X	X	X		peas
linuron	1.7	1.1	0.56	0.38	0	
	X	X	X			barley
	X	X	X	X		flax
	X	X				wheat
silvex	X	X	X	X		
	X					flax
						peas
picloram	.14	.07	.035	0.017		
	X	X	X			flax
	X	X	X	X		peas

### 4. Yield increased:

dicamba	1.7	1.1	.56	.28		
				X		flax
linuron	X	X	X	X		
						flax

### 5. Yields decreased:

picloram	0.14	.07	.035	.017		
	X	X	X	X		peas

The density of the weed flora was highly transitional in response to the sustained crop and herbicides employed. The following slides show the influence of three herbicides and their statistically significant responses on weed stands and weights.

<b>Terbutryn</b>	2.2	1.7	1.1	0.56		
decreased weed stands in	X	X	X	X		barley
" " "	X					flax
" " "	X					peas
" " "	X	X	X	X		wheat
decreased weed wts. in	X	X				barley
" " "	X					peas
" " "	X	X	X	X		wheat
<b>Dicamba</b>	1.7	1.1	0.56	0.28		
decreased weed stands in	X	X				barley
" " "	X					wheat
decreased weed wts. in	X	X	X	X		wheat
<b>Picloram</b>	0.14	0.07	0.035	0.07		
decreased weed stands in	X	X	X			barley
" " "	X	X	X			wheat
decreased weed wts. in	X	X	X			wheat

The plot area was sown to over 30 species of weed seeds. These were composited into a uniform mixture totaling 114 pounds of total weed seeds per acre. The weed seeds were derived from mill screenings collected from throughout the state. Neither barnyard grass nor dodder prevail under the continuous wheat-pea or wheat-fallow sequence followed

<sup>1</sup> University of Idaho, Moscow, Idaho.

in northern Idaho where this study was conducted. Dodder disappeared completely after three years. Seven species prevailed in sustained and sufficient quantities for statistical evaluation. In the following slides three species are included to illustrate their performance.

### COBEX -A New Herbicide in Beans

G. K. Harris and J. D. Stone<sup>1</sup>

Tests conducted prior to 1973 indicated that COBEX had good potential for controlling problem weeds in beans, and also had adequate crop tolerance. Consequently, our 1973 program was designed with the objective of obtaining additional data on the performance of COBEX in dry and green beans under a wider range of field conditions.

This report covers the western states in which the tests were conducted—California, Colorado, Idaho, Montana, Washington and Wyoming.

Each test was conducted in cooperation with the distributor and farm cooperator for each area. The plot sizes varied from 1 to 4 acres. All treatments were made in the spring and were preplant incorporated using the grower's usual tillage practice and spray equipment. Tools for incorporating the herbicide included tandem discs, rolling cultivators, spring tooth harrows, and spring shank cultivators. COBEX was incorporated at depths from 1½ to 3 inches. Tests covered the major soil types encountered in the bean growing areas of the West. The standard herbicide used for comparative purposes at each test location was the one normally used by the grower. These included Eptam at 3 lbs/A, Lasso at 3 lbs/A and Treflan at ½ lb/A.

<sup>1</sup>U. S. Borax & Chemical Company, Anaheim, California.

COBEX treatments ranged from 1/3 to 2/3 lb/A according to soil type. The higher rates of COBEX were used with the objective of obtaining crop tolerance data. The majority of the tests were at the ½ lb/A rate.

The table lists the weed species and summarizes the herbicidal ratings of COBEX, Eptam, Lasso and Treflan. The problem weeds in the beans included barnyardgrass, giant, green, purple and yellow foxtail, sandbur, black nightshade, hairy nightshade, kochia, lambsquarters, pigweed, purslane and smartweed (pennsylvania).

From 58 evaluations, the control of the broadleaf weeds averaged 93% from the 1/3 lb/A treatments of COBEX, while from 28 evaluations of the grasses, control averaged 95%. At the ½ lb/A rate, 74 broadleaf evaluations showed average control of 94% and 32 grass evaluations averaged 96%. Similar control of broadleaves and grasses was obtained from the 2/3 lb/A rate. Of particular interest was the high percentage control of black nightshade at all three rates. Since nightshade is one of chief problem weeds in beans the results indicate that COBEX has a real advantage as an herbicide in beans. A few combinations of COBEX with Eptam also looked most promising for control of black nightshade. No crop phytotoxicity was noted in any of the 1/3 and ½ lb/A treatments. Slight injury (4%) was reported at the 2/3 lb/A rate. Bean yields from all the COBEX treatments averaged 2100 lbs/A, while those from the comparison herbicides averaged 2060 lbs/A.

The results of these 1973 tests show that COBEX has definite potential for use in dry and green beans while combinations of COBEX with other bean herbicides also look promising, and will be investigated further.

Herbicide Performance Ratings in Dry and Green Beans  
(California, Colorado, Idaho, Montana, Washington, Wyoming)

Weed Species	COBEX 1/3 lb/A	COBEX 1/2 lb/A	COBEX 2/3 lb/A	Eptam 3 lb/A	Lasso 3 lb/A	Treflan 1/2 lb/A
Barnyardgrass	(13) <sup>a</sup> 94	(17) 94	(8) 91	(3) 90	(4) 91	(3) 93
Black nightshade	(15) 92	(17) 96	(3) 95	(3) 90	(3) 86	(2) 15
Foxtail: giant	(5) 95	(4) 98	(1) 99	(2) 90		
green	(7) 97	(8) 98	(1) 99	(2) 95		(2) 100
purple		(1) 99				
yellow	(1) 95		(1) 99			
Hairy nightshade	(5) 77	(6) 77	(6) 80	(1) 95		(2) 35
Kochia	(8) 97	(8) 98	(1) 99	(2) 95		(1) 95
Lambsquarters	(14) 97	(18) 96	(5) 92	(3) 93	(3) 98	(2) 98
Pigweed	(14) 95	(21) 96	(11) 93	(3) 88	(3) 98	(2) 92
Purslane	(2) 90	(3) 95	(3) 93			(1) 100
Sandbur	(2) 99	(2) 99				(1) 80
Smartweed		(1) 75	(1) 80			
Crop Phytotoxicity: (Percent Stand Reduction)						
Dry Beans	(17) 0	(22) 0	(11) 4	(3) 0	(3) 0	(4) 0
Green Beans	(1) 0	(2) 0	(2) 0			

<sup>a</sup>Numbers in parenthesis equal number of evaluations.

## Canning Tomato Herbicide--Varietal Interaction Trial

J. P. Orr and C. L. Elmore<sup>1</sup>

### Method and Materials

In past years there have been indications that some herbicides have given more injury to certain tomato varieties over others. A study was done this past year to determine if any tomato variety had more tolerance to a herbicide or herbicides than any other variety, particularly early season plantings. At Hamatani Farms, Courtland, California, on a clay loam soil, napropamide, 1.5 lbs. 3.0 lbs/A; isopropalin 1.0, 1.5, 2.0, 4.0; and trifluralin + diphenamid at 0.25 + 4.0 was applied preplant at a volume of 40 gal/A, with a backpack sprayer and disc incorporated 4 to 6 inches, 3 times in opposite directions. Each treatment was 40 x 67.5 feet and replicated four times. The field was bedded up, and planted with the grower's Stanhay Planter on April 6, 1973. Varieties planted included VF-7879, NC-317, VF-65, VF-10, VF-315, VF-198 and XP-270. Weed control and crop tolerance data was taken throughout the season. On August 27th the early season varieties were harvested; and the late season on September 7, 1973. At that time 10 feet of row was pulled, vines shaken, and red, pink and green fruit weighed.

### Varietal Response

Generally there was no tomato varietal interaction with the herbicide treatments. However, by partitioning the isopropalin treatments, and fitting them to a quadratic line; VF-198 and VF-109 yields had a significant regression. There was no significant regression with VF-7879, NC-317, VF-65, VF-10, NC-315 and XP-270. The highest isopropalin yields of each variety was obtained at the 1.5 and 2.0 lbs/A rates. These rates were significantly higher yielding than the 1.0 and 4.0 lbs/ac treatments.

<sup>1</sup>University of California, Davis, California.

As a whole, there was a very significant yield response to the isopropalin rates. Maximum isopropalin yields of 29.8 and 29.9 tons/A were obtained with the 1.5 and 2.0 lbs/A rates. From the yield response curve, rates below 1.5 lbs/A and above 2.0 lbs/A yields were reduced significantly. The 1.0 lb/A rate yielded 25.5 tons/A and the 4.0 lbs/A rate yielded 24.9 tons/A. In comparison, napropamide 3.0 lbs/A yielded 31.1 tons/A; isopropalin 1.5 lbs/A yielded 28.5 tons/A; and trifluralin + diphenamid yielding 28.5 tons/A.

This past spring was considered warm early in the growing season. Under cold or very cool spring temperatures the reaction of varieties to herbicide treatments could be more significant than was obtained this past season.

### Weed Control

Lambsquarter (*Chenopodium album* L.) and redroot pigweed (*Amaranthus retroflexus*) control was equal with all herbicide treatments giving 100% control. Shepherdspurse (*Capsella buriss-pastoris*) control was poor except for trifluralin + diphenamid which gave 80% control. This was unusual for trifluralin + diphenamid. Watergrass (*Echinochloa crus-galli*) control was excellent giving 97% to 100% control with isopropalin at rates of 1.5, 2.0 and 4.0 lbs/A; and napropamide at 3.0 lbs/A giving 98% control. Good control of watergrass (*Echinochloa crus-galli*) was obtained with trifluralin + diphenamid giving 95%, isopropalin 94% at 1.0 lbs/A; and napropamide 88% at 1.5 lbs/A rate. Napropamide at the 1.5 lbs/A rate gave the poorest watergrass (*Echinochloa crus-galli*) control compared to the other treatments. This is why tomato yields were reduced significantly with this treatment compared to the higher yielding treatments of napropamide at 3.0 lbs/A. Napropamide at 3.0 lbs/A yielding 31.1 tons/A; isopropalin at 1.5 lbs/A and 2.0 lbs/A yielded 29.8 tons/A. Napropamide yields at 3.0 lbs/A were significantly higher than trifluralin + diphenamid yielding 28.5 tons/A and napropamide 1.5 lbs/A yielding 28.5 tons/A, isopropalin 1.0 lbs/A yielding 25.5 tons/A, isopropalin 4.0 lbs/A yielding 24.9 tons/A and the control which yielded 24.4 tons/A.

Table 1. Canning Tomato Herbicide--Varietal Interaction--1973--Tons/A (Reds)

Treatments	Formulation	Lbs a.i. Rate/ac	VF- 7879	NC- 317	VF- 65	VF- 10	VF- 109	VF- 198	NC- 315	SP- 270	Treat- ment Avg.	Sign. Diff. @ 5%
1. napropamid	2E	3.0	30.4	32.9	24.2	32.9	32.3	35.1	34.0	27.3	31.1	A
2. isopropalin	6E	1.5	29.1	27.1	27.6	32.0	29.9	38.8	32.0	24.8	29.8	AB
3. isopropalin	6E	2.0	30.6	30.1	28.9	29.7	28.1	36.5	28.7	26.9	29.9	ABC
4. trifluralin + diphenamid	50w	0.25+4.0	29.1	30.3	23.4	31.1	28.3	32.1	29.3	24.5	28.5	BC
5. napropamide	2E	1.5	28.9	28.2	21.9	30.8	29.7	31.0	30.8	27.1	28.5	BC
6. isopropalin	6E	1.0	29.0	25.4	25.4	27.8	25.4	30.7	23.7	17.3	25.5	CD
7. isopropalin	6E	4.0	28.9	27.5	22.8	25.3	17.7	26.7	25.9	24.5	24.9	D
8. control			29.6	30.2		27.0	13.7	32.4	22.4	18.1	24.4	--
		Variety Average	29.4	28.9	24.5	29.5	25.6	32.5	28.3	23.8	--	

**Table 2. Trifluralin + diphenamid, napropamide yield comparisons—Tons/A (Reds)**

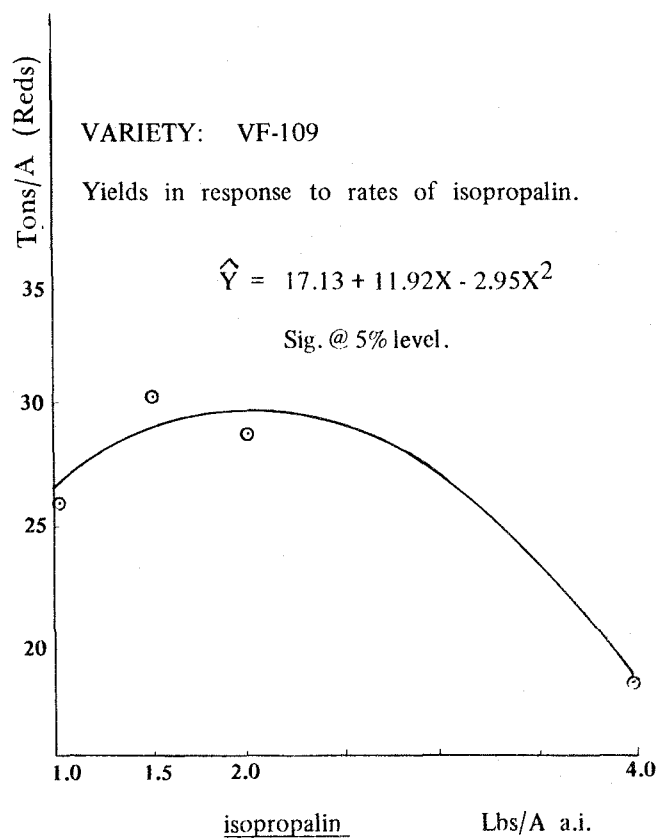
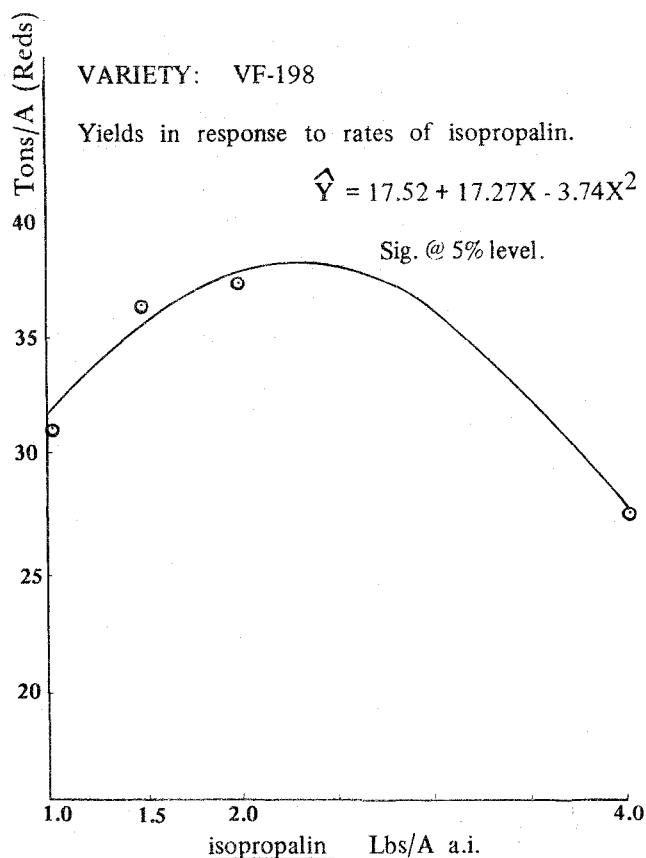
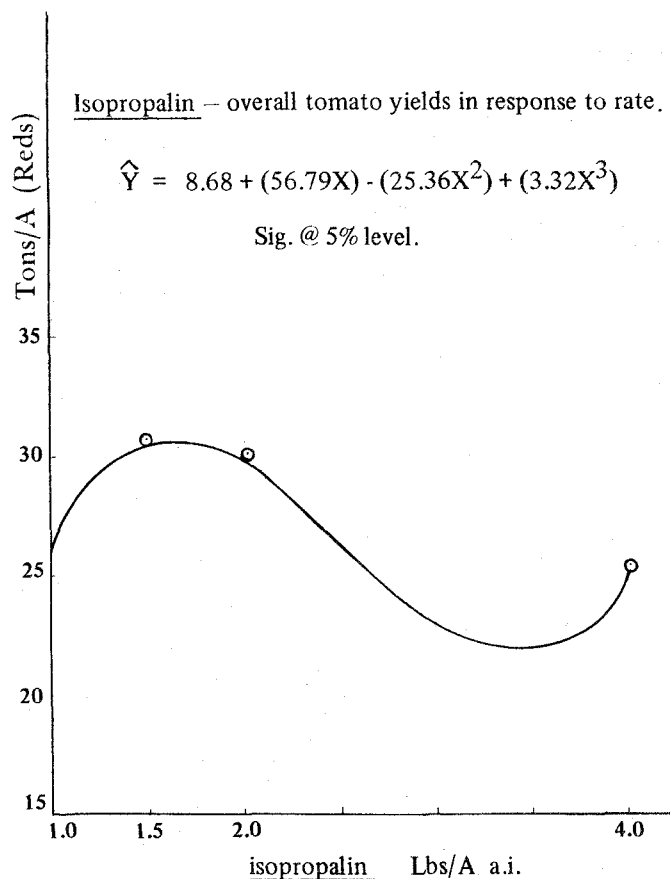
Variety Means	Tons/A (reds)	trifluralin + diphenamid	napropamide	napropamide	control
		0.25+4.0	1.5	3.0	0
A. VF-7879	29.4	29.1	28.9	30.4	29.6
B. NC-317	28.9	30.3	28.2	32.9	30.2
C. VF-65	24.5	23.4	21.9	24.2	21.9
D. VF-10	29.5	31.1	30.8	32.9	27.0
E. VF-109	25.6	28.3	29.7	32.3	13.7
F. VF-198	32.5	32.1	31.0	35.1	32.4
G. NC-315	28.3	29.3	30.8	34.0	22.4
H. XP-270	<u>23.8</u>	<u>24.5</u>	<u>27.1</u>	<u>27.3</u>	<u>18.1</u>
Overall Mean	27.8	28.5(BC)	28.5(BC)	31.1(A)	24.4

**Table 3. Isopropalin yield comparisons—Tons/A (Reds)**

Variety Means	Tons/A (Reds)	Rates of Isopropalin Lbs/Ac. (Reds)				
		1.0	1.5	2.0	4.0	C-
A. VF-7879	29.4	29.0	28.9	30.6	28.9	29.6
B. NC-317	28.9	25.4	28.2	30.1	27.5	30.2
C. VF-65	24.5	25.4	21.9	28.9	22.8	21.9
D. VF-10	29.5	27.8	30.8	29.7	25.3	27.0
E. VF-109	25.6	25.4	29.7	28.1	17.7	13.7
F. VF-198	32.5	30.7	31.0	36.5	26.7	32.4
G. NC-315	28.3	23.7	30.8	28.7	25.9	22.4
H. XP-270	<u>23.8</u>	<u>17.3</u>	<u>27.1</u>	<u>26.9</u>	<u>24.5</u>	<u>18.1</u>
Overall Mean	27.8	25.5 (CD)	28.5 (AB)	29.9 (ABC)	24.9 (D)	24.4

**Table 4. Tomato Herbicide—Varietal Interaction Trial—1973—Weed Control**

Treatments	Formulation	Lbs a.i. Rate/A	Watergrass	Sheperdspurse ( <i>Capsella bursis-pastoris</i> )	Lambsquarter ( <i>Chenopodium album L.</i> )	Redroot Pigweed ( <i>Amaranthus retroflexus</i> )
1. trifluralin + diphenamid	50W	0.25+4.0	9.5	8.0	10.0	10.0
2. napropamid	2E	1.5	8.8	1.7	10.0	10.0
3. napropamid	2E	3.0	9.8	4.0	10.0	10.0
4. control	—	—	0.0	0.0	00.0	00.0
5. isopropalin	6E	1.0	9.4	1.1	10.0	10.0
6. isopropalin	6E	1.5	9.7	0.0	10.0	10.0
7. isopropalin	6E	2.0	9.9	1.0	10.0	10.0
8. isopropalin	6E	4.0	10.0	0.0	10.0	10.0
	Weed Control	10	=	100% Control		
	Tomato Stand	10	=	100%		
	Tomato Vigor	10	=	100%		



### Oryzalin for Weed Control in Trees and Vines

F. O. Colbert, D. H. Ford, and L. G. Peterson<sup>1</sup>

Research by university and Eli Lilly and Company scientists during the past several years has resulted in the development of oryzalin, a promising new dinitrosulfanilamide herbicide for surface application in orchards and vineyards. Oryzalin has the chemical name 3,5-dinitro-N<sup>4</sup>,N<sup>4</sup>-dipropylsulfanilamide and has been given the trademark, SURFLAN™. Oryzalin has been found to be herbicidally active on most annual grasses and certain broadleaf weeds, while showing excellent safety to established trees and vines.

#### Toxicology

Results of toxicological studies place oryzalin in the relatively non-toxic category with an acute oral LD<sub>50</sub> > 10,000 mg/kg to rats and gerbils and an LD<sub>0</sub> > 1,000 mg/kg in cats and dogs. The LD<sub>50</sub> in chickens is approximately 1,000 mg/kg.

When applied to shaved rabbit skin, the dermal LD<sub>50</sub> of oryzalin is > 2,000 mg/kg, with only slight irritation resulting. There is no indication of toxicity from applying oryzalin to rabbit eyes, and the irritation produced is mechanical in nature.

Ninety day feeding studies with concentrations up to 750 ppm caused no observable toxic effects in dogs, and

<sup>1</sup>Plant Science Representatives, Eli Lilly and Company, Fresno, California.



provided a safe level for rats of 250 ppm. Young chicks feeding on mash containing 500 ppm oryzalin for three weeks did not differ from control birds receiving no oryzalin.

The LC<sub>50</sub> of oryzalin for fingerling fish, after 96 hours exposure, is as follows: goldfish >1.4 ppm; bluegill 2.8 ppm; rainbow trout 3.3 ppm; and fathead minnow > 7.5 ppm. Inhalation tests have further substantiated the safety of this compound.

These data allow the conclusion that under recommended use conditions, oryzalin poses no environmental hazard to wildlife, birds, or fish.

### Physical Properties

Oryzalin exhibits certain desirable physical properties which permit its successful use as a surface applied herbicide (Table 1).

**Table 1. Some Physical Properties of Oryzalin and Trifluralin.**

Property	Oryzalin	Trifluralin
Vapor Pressure mm Hg, 30°C	<1 x 10 <sup>-7</sup>	1.14 x 10 <sup>-4</sup>
Solubility Water, 25°C	2.5 ppm	<0.5 ppm

In comparison with trifluralin, oryzalin has a lower vapor pressure, higher water solubility and tends to be more stable under UV light. Thus, oryzalin can be surface applied and herbicidally activated by rain or sprinkler irrigation with minimal compound loss to the atmosphere. Excessive rainfall or irrigation does not leach oryzalin out of the weed seed germination zone, and shallow cultivation will not decrease its effectiveness.

### Biological Activity

Research has demonstrated that established nonbearing and bearing trees and vines are tolerant to oryzalin 75W at rates up to 8 lb/A (a.i.).

Oryzalin 75W, applied as broadcast or strip treatments at rates of 2 to 4 lb/A (a.i.) and activated by rainfall or sprinkler irrigation, has provided control of certain annual grasses and broadleaf weeds. A summary of data from 11 replicated California trials, evaluated in 1973, demonstrates excellent control of the weed species listed in Tables 2 and 3.

**Table 2. Annual Grasses Controlled (95%) by Oryzalin 75W at 2-4 LB/A After Six Months.**

Common Name	Scientific Name
Annual bluegrass	<i>Poa annua</i>
Barnyardgrass	<i>Echinochloa crus-galli</i>
Large crabgrass	<i>Digitaria sanguinalis</i>
Southwestern cupgrass	<i>Erichloa gracilis</i>
Wild oat	<i>Avena fatua</i>

**Table 3. Annual Broadleaf Weeds Controlled (97%) B Oryzalin 75W at 2-4 Lb/A After Six Months.**

Common Name	Scientific Name
Common chickweed	<i>Stellaria media</i>
Common lambsquarters	<i>Chenopodium album</i>
Common purslane	<i>Portulaca oleracea</i>
Henbit	<i>Lamium amplexicaule</i>
Redroot pigweed	<i>Amaranthus retroflexus</i>
Shepherdspurse	<i>Capsella bursa-pastoris</i>

The recommended rate range of 2 to 4 lb/A is based on the length of weed control desired regardless of soil type. The 2 lb/A rate will provide short-term (4 to 6 months) weed control in orchards and vineyards. Where longer term (6 to 8 months) weed control is required, the 4 lb/A rate should be considered.

In addition, these field trials have shown that oryzalin at 2 to 4 lb/A will partially control or suppress populations of several other annual broadleaf weeds common in western orchards and vineyards (Table 4).

**Table 4. Annual Broadleaf Weeds Partially Controlled (< 70%) by Oryzalin 75W at 2-4 Lb/A.**

Common Name	Scientific Name
Annual sowthistle	<i>Sonchus oleraceus</i>
Black mustard	<i>Brassica nigra</i>
Black nightshade	<i>Solanum nigra</i>
Common groundsel	<i>Senecio vulgaris</i>
Prickly lettuce	<i>Lactuca serriola</i>
Smartweed	<i>Polygonum sp.</i>
Spotted spurge	<i>Euphorbia maculata</i>

Where problem weeds exist that are not controlled satisfactorily with oryzalin, a combination treatment may be desirable. Oryzalin has been found to be compatible with simazine and diuron as tank-mix combinations. An example of the complementary weed control spectra that can be obtained from one such combination is described in Table 5.

**Table 5. Percent Control of Selected Weeds With Tank-Mix Combination of Oryzalin + Simazine<sup>a</sup>**

Treatment	Rate Lb/A	3 Month Obs.		6 Month Obs.	
		Common Ground- sel	Annual Sow- thistle	South- western Cupgrass	Barn- yard- grass
Oryzalin	2	33	25	92	98
Oryzalin+ Simazine	2+1.5	100	100	98	100
Simazine	1.5	100	100	25	20

<sup>a</sup>Averages from two trials.

## Weed Programs for Newly Planted Irrigated Trees and Vines

Harold M. Kempen<sup>1</sup>

The winter annual spectrum of simazine or diuron plus the extended summer annual spectrum of oryzalin can be used in combination to provide excellent season-long weed control. Adequate crop safety has been demonstrated with tank-mix combinations of oryzalin plus simazine or diuron when used at label recommended rates.

A request is being submitted to the Environmental Protection Agency for an experimental permit to allow large-scale evaluation of oryzalin on nonbearing and bearing fruit and nut crops. The principal points included in this experimental permit are summarized as follows:

1. Oryzalin is recommended for use on established nonbearing or bearing almonds, apples, apricots, avocados, cherries (sweet), figs, grapes, grapefruit, nectarines, olives, oranges, peaches, pears, pistachios, plums, prunes, and walnuts.
2. Oryzalin should be surface applied and incorporated with rain or overhead sprinkler irrigation.
3. Oryzalin is recommended at a rate range of 2 to 4 lb/A for all soil textures. The 2 lb/A rate should be used when short-term (4 months) weed control is desired; whereas, 4 lb/A should be considered where long-term (6 to 8 months) weed control is required.
4. Tank-mix combinations of oryzalin at 2 to 4 lb/A a.i. plus label recommended rates of simazine or diuron are suggested where a broader weed control spectrum is desired.

The following precautions should be considered to insure maximum performance of oryzalin for weed control in orchards and vineyards.

1. Oryzalin is not recommended for use on soils containing more than three percent organic matter.
2. Areas to be treated should be free of established weeds and excessive trash (weed residues, prunings, etc.). Such residue should be thoroughly mixed into the soil before applying oryzalin.
3. The soil should be in good tilth, firm, and free of clods at the time of application.
4. If one-half inch of rainfall (or its equivalent in sprinkler irrigation) does not occur within one week after application, oryzalin should be incorporated into the top one inch of soil.

### Summary

1. Oryzalin surface applied at rates of 2 to 4 lb/A has provided control of many annual grass and broad-leaf weeds in orchards and vineyards.
2. Oryzalin has demonstrated excellent safety on tree and vine crops.
3. Oryzalin poses no environmental hazard.
4. Oryzalin is easy to apply as a broadcast or strip treatment and can be activated by rainfall or sprinkler irrigation.
5. Oryzalin has been effectively used in tank-mix combination with simazine or diuron to provide a broader weed control spectrum.

Weed control programs for newly planted tree and vine crops must be handled much differently than where these crops are established. Herbicide selection is usually reduced because of reduced tolerance. Farm management companies fear the alleged as well as the real herbicide damage to newly planted perennial crops. Absentee owners want orchards and vineyards to look nice when they make their infrequent visits to their tax shelters. Therefore, managers need attractive rather than economic weed management programs.

Little competition is afforded against weeds. In contrast, weed competition affects young irrigated trees and vines severely. Plant loss or stunting affects subsequent annual operations for two or more years.

Hazards to trees from most photosynthetic inhibitors like simazine or diuron are more acute in the Southern San Joaquin Valley of California, due to a combination of unique environmental and edaphic conditions. Temperatures are higher, often exceeding 35 C. This plus very low relative humidity conditions (10%) makes uptake of these herbicides during periods of high transpiration several times greater than "normal." Concomitantly, soils are very low in organic matter—often 0.1% to 0.3%—making such herbicides active at much lower rates. Soils are mostly derived from granite and are usually low in clay.

Therefore such herbicides are not safe to use in all Kern County's deciduous trees (but walnut) or newly planted grapes.

In Kern County 76,126 acres of the 139,200 acres of perennial trees and vines in 1972 were non-bearing. Over 22,000 more acres were planted in 1973. Though wine grapes, almonds and citrus make up the major part of the plants, other relatively exotic perennials such as pistachios, kiwi, pomegranates, limes and persimmons are grown here. Other deciduous crops grown include nectarines, peaches, figs, walnuts, plums, apples and apricots. Olives and citrus are evergreen.

Weeds which compete include many annual grasses and broadleaved weeds as well as perennials (Table 1). However, many annual weeds are effectively controlled with preplant incorporated trifluralin. Many growers supplement trifluralin with tillage and with post-plant surface applications of nitratin at 2 to 4 lb/A. By keeping rates of these dinitroaniline herbicides relatively high, broad spectrum annual weed control is achieved. Escape weeds can often be controlled with separate or combined sprays of post-emergence contact herbicides such as paraquat, DNBP formulations, or if protected with tree wraps—with weed oil.

Perennial weeds offer the chief deterrent to effective herbicide programs. Bermudagrass plus yellow nutsedge are the most serious pests. Both grow rapidly and extract moisture quickly. Perennial grasses can be killed by dry fallow—the summer before planting. Where this is not possible,

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**Table 1. Weeds in Kern County Perennial Crops.**

<b>A. Winter Annual Weeds</b>	
Shepherdspurse	Annual bluegrass
London rocket	Cheeseweed
Mare's tail	Chickweed
Filaree	Common groundsel
Red Brome	Sowthistle
Foxtail barley	Prickly lettuce
Rangeland species	Fiddleneck
<b>B. Summer Annual Weeds</b>	
Pigweeds	Barnyardgrass
Lamsquarters	Lovegrass
American black nightshade	Purslane
Hairy nightshade	
<b>C. Perennial Weeds</b>	
Yellow nutsedge	Silverleaf nightshade
Bermudagrass	

soils should be treated with dinitroaniline herbicides pre-plant. Subsequent repeated cultivations and handweeding are essential or perennial weeds may kill young trees or vines, usually due to drought.

During the first dormant season, moderately good control of perennial grasses or bindweed has been achieved by the following procedure. Soil from the tree or vine rows is removed. Trifluralin at maximum labeled rates is mixed well into the row middles. The row furrows are also sprayed and treated soil returned. The end result is a layer of trifluralin covered with soil treated with trifluralin. Two years of such treatment should give excellent control.

**Table 2. Layered Herbicides for Nutsedge Control in Grapes<sup>1</sup>**

	lb/A	Rating (0 to 10) <sup>2</sup>		
		Nutsedge 5/23/73	Nutsedge 7/9/73	Grape injury 7/9/73
Dichlobenil	3	9.5	9.4	0.7
Dichlobenil	6	10.0	10.0	1.7
Dichlobenil + trifluralin	3 + 1	9.5	9.0	1.3
Dichlobenil + trifluralin	6 + 2	7.5	9.8	1.5
Norflurazon	1½	8.8	8.0	0
Norflurazon	3	9.5	9.3	0.7
Napropamide	3	9.3	9.2	0.3
Napropamide	6	10.0	9.8	0
Alachlor	6	8.3	6.3	0
Alachlor	12	9.3	7.3	0
EPTC	6	9.5	7.5	0
EPTC	12	10.0	8.0	0.3

<sup>1</sup>Treated 3/1/73. Rainfall 3/4/73. Cajon sandy loam.

Variety: Petite Sarah

Applied with a Reddick ditcher to cover herbicide with ½-1" of soil.

Sprinkler irrigated after 4/9/73.

<sup>2</sup>Rated 0 to 10: 0 = no effect; 10 = kill. Average 4 replications.

Recent tests show that glyphosate will kill bermudagrass but no drift onto tree or vine foliage or green wood must be allowed. No crop injury occurred where woody bark was sprayed.

For yellow nutsedge control a topical application of napropamide at 4 lb/A over August plantings of potted wine grapes followed by immediate sprinkler irrigation has been successful in one field application. Also subsurface applications of napropamide, EPTC, alachlor, norflurazon or dichlobenil were safely and effectively used under sprinklers. This was accomplished in second year vines by using a modified Reddick ® ditcher.

A three-year tolerance study on trees and vines begun after planting in 1969 showed four herbicides to be safe: nitralin-2, 8 lb/A; napropamide-2, 8 lb/A; oryzalin-2, 8 lb/A and oxadiazon-2, 8 lb/A. Annual treatments were made to soil with 0.7% O.M., 15% clay, 29% silt and 56% sand, under solid set sprinklers. Herbicides were applied to pistachio, walnut, nectarine, peach, pear, apple, almond, grape, olive, orange and lemon.

A two year tolerance trial on second year Nonpareil almonds showed the above herbicides to be safe under sprinkler irrigation as well as linuron at 1 or 2 lb/A; nitrofen at 4 or 8 lb/A; norflurazon at 1 or 2 lb/A; and the combination of oxadiazon plus napropamide at 4 lb/A each. The test was on a sandy clay loam with 1.1% organic matter, 21.8% clay, 15.8% silt and 62.4% sand.

On this site, weeds present were rangeland species dominated by filaree, red brome, tarweed and turkey mullein. Oxadiazon and linuron were the only satisfactory treatments because resistant species were present in other treatments. Other recent studies indicate oxadiazon is the most effective herbicide for winter annuals. Combinations of it

Table 3. Tolerance of Trees and Vines under Sprinklers to Herbicides.<sup>1</sup>

Plant	Variety	Tree injury ratings on methazole <sup>2</sup>					
		2 lb/A			8 lb/A		
		69	70	72	69	70	72
Apple	Golden Delicious	0	0	0	0	—	—
Apple	Red Delicious	0	0	0	0	0	0
Apricot	Carleton	0	—	—	7	—	—
Apricot	Nugget	0	—	—	0	—	—
Grapes	Chenin Blanc	2	0	0	3	7	2
Grapes	French Colombard	2	0	0	3	0	0
Grapes	Tinta Madeira	2	0	0	3	0	0
Lemon	Navel	0	0	0	3	10	—
Orange	Navel	0	0	0	0	0	0 0
Orange	Atwood Navel	0	0	0	0	0	0
Peach	Carson	0	0	0	0	4	0
Peach	Loadel	3	—	—	3	—	—
Peach	Palora	0	0	0	0	6	0
Pear	Bartlett	0	0	0	0	6	0
Pistachio	Kerman	0	0	0	0	0	0
Plum	Barton	0	—	—	2	—	—
Prune	French	0	—	—	0	—	—
Walnut		0	0	0	0	1	—

<sup>1</sup>Treatment dates: 7/24/69; 9/1/70; 2/2/72.  
Plot size: 10 x 10 ft.; no replications. Sandy loam soil.

<sup>2</sup>No injury occurred from nitralin at 2 or 8 lb/A; oryzalin at 2 or 8 lb/A or napropamide at 2 or 8 lb/A or Oxadiazon which was included in the test 9/1/70 and 2/2/72. Methazole rate of 8 lb/A was reduced to 4 lb/A in 1970 and 1972. The citrus was treated with simazine at 2 lb/A in 1970. Where dashes occur, trees were pulled after the first year. Ratings 0 to 10: 0 = no effect; 10 = kill.

Table 4. Tolerance Trials on 2nd Year Nonpareil Almonds under Sprinklers.<sup>1</sup>

Treatments	lb/A	Weed control ratings (0 to 10)			
		12/14/72	4/13/72	1/19/73	7/6/73
Glyphosate	1/2	2.7	6.3	8	3.3
Napropamide	4	6.3	6.6	8	5.7
Napropamide	8	7.7	6.6	8	7.7
Oxadiazon	4	8.8	8.6	9.8	7.7
Oxadiazon	8	9.8	9.1	9.8	7.7
Oxadiazon + napropamide	4 + 4	9.6	8.6	9.8	9.0
Oxadiazon + napropamide	8 + 8	9.8	8.1	10	9.7
Oryzalin	2	6.0	7.0	7	5.3
Oryzalin	4	7.0	6.6	8	5.3
Nitralin	2	6.7	8.0	7	4.7
Nitralin	4	6.3	7.6	8	5.3
Nitrofen	4	4.0	5.0	7	1.0
Nitrofen	8	5.0	7.3	8	3.3
Linuron	1	8.0	9.5	9.8	8.2
Linuron	2	8.5	9.8	9.8	6.0
Norflurazon	1	3.0	4.0	6	4.7
Norflurazon	2	6.0	7.5	9	6.5
Untreated	—	2.0	1.6	0	2.7

<sup>1</sup>Treated 1/7/72 and 12/14/72 during dormant season. Plots were 10 x 20 ft. 3 replications. Oxadiazon rates were 2 and 4 lb/A on 1/7/72. Paraquat at 1/2 lb/A was added to 1/7/72 treatments. Glyphosate at 1/2 lb/A was added to 12/14/72 treatments.

No tree injury occurred.

plus napropamide or oryzalin show most promise for year-long weed control under various rainfall regimens along with concurrent safety to young trees and vines. In some instances, foliar herbicides such as glyphosate, DNBP or paraquat would be needed the first season to control emerged weeds.

If registrations can be obtained on these minor crops, effective chemical programs should be achievable.

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#### Survival of Ponderosa Pine Seedlings Following Control of Competing Grasses<sup>1</sup>

R. E. Stewart and T. Beebe<sup>2</sup>

**Abstract** Survival of ponderosa pines planted in orchardgrass, timothy, hard fescue (*Festuca ovina* var. *duriscula*), and pinegrass (*Calamagrostis rubescens*) can be increased 150 percent on sites with light-textured pumice soils and 700 percent on sites with heavier-textured residual soils in central Washington by spraying atrazine or dalapon before planting. Scalping (mechanical removal of vegetation within 1 foot of each tree), pronamide, and terbacil were less effective for increasing pine survival.

#### Introduction

Orchardgrass, timothy, and hard fescue were seeded on forest sites to stabilize soils denuded by extensive wildfires in 1970 on the Wenatchee National Forest in central Washington. Seeding success varied with grasses averaging only 3 percent ground cover and forbs 10 percent 1 year after the burn (Tiedemann and Klock 1973). However, cover from seeded grasses and the dominant native pinegrass rapidly increased during the second year. Available data

<sup>1</sup>This publication reports research involving pesticides. It does not contain recommendations for their use nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

<sup>2</sup>Pacific Northwest Forest and Range Exp. Sta., Forest Service, U. S. Dept. of Agric., Roseburg, Oregon, 97470, and Wenatchee National Forest, Forest Service, U. S. Dept. of Agric., Entiat, Washington, 98822.

suggested that mortality of ponderosa pine seedlings planted in established orchardgrass and timothy would be high (Baron 1962). Therefore, silviculturists on the Entiat Ranger District felt that reduction of grass cover on critical sites would be necessary to insure establishment of newly planted ponderosa pine seedlings.

Few studies were available to help foresters select treatments or evaluate effect of grass control on plantation success. Heidmann (1968, 1970) found simazine, dalapon, and atrazine to be useful for site preparation in northern Arizona: In central Idaho, grass control with simazine increased pine survival, especially on west aspects (Hall 1971). Based on experience in forests on the wetter, coastal side of the Cascade Range, Newton and Webb (1970) recommend mixtures of atrazine and dalapon for establishing ponderosa pines in central Oregon and Washington. However, herbicidal effects on grasses and conifers and optimum timing of application for conditions on the Wenatchee National Forest were unknown.

During April of 1972, a study was installed at several locations in the Entiat Ranger District to determine effects of various treatments on survival of newly planted ponderosa pines. Pronamide, terbacil, atrazine, dalapon, and scalping were compared as methods for increasing survival of seedlings planted in dense grass communities.

#### Methods

Five study areas were selected to sample major soil differences within the burn. Two areas were located on sites with heavy-textured residual soils; three areas were located on sites with lighter-textured pumice soils. Average annual precipitation for both types of site conditions was 18 to 24 inches; elevations ranged from 2,400 to 3,400 feet.

At each study area, six plots were installed with the help of District personnel. Each plot consisted of a line of five contiguous 1/100-acre (21- x 21-foot) subplots oriented at right angles to the contour. One of six treatments was then randomly assigned to each plot in a randomized block design with the five study areas as blocks. Treatments were: (1) none—control, (2) scalp, (3) 2 lb ai pronamide per acre, (4) 2 lb ai terbacil per acre, (5) 4 lb ai atrazine per acre, and (6) 5 lb ai dalapon per acre.

Herbicidal sprays were applied between April 19 and 21, after snow had melted. Sprays were applied with knapsack sprayers in 2 gallons of water to each 1/100-acre subplot. Sixteen 2-0 ponderosa pine seedlings were then planted in each subplot, a total of 80 seedlings per plot, within 4 days after spraying. Except for the removal of vegetation and the mulch of dead grass around each tree on scalped plots, trees were planted in undisturbed grass and forb cover.

Plots were examined in June, the beginning of the dry summer period, and in October of 1972 and 1973 to determine effects of treatments on grasses, forbs, and conifers. Visual estimates of ground cover and vegetation control were made to the nearest 5 percent on each 1/100-acre subplot. Survival of ponderosa pine seedlings after two growing seasons was analyzed by analysis of variance and treatment differences compared by individual degree of freedom tests.

## Results and Discussion

Pine survival and herbicidal effect on grasses were highly influenced by soil type (Table 1). Both grass control and survival of ponderosa pine seedlings were greater on pumice soils than on residual soils, but the influence of grass control on survival was greater on residual soils.

Pronamide was ineffective on grasses, and none of the herbicides controlled common perennial forbs such as western bracken, fireweed, panicle willowweed, common yarrow, arrowleaf balsam root (*Balsamorhiza sagittata*), spreading dogbane (*Apocynum androsaemifolium*), and heartleaf arnica (*Arnica cordifolia*). Forb cover was generally greater on residual soils and tended to increase during the second season following grass control. However, perennial grasses did not readily invade chemically treated plots during the second growing season despite an excellent grass seed crop in adjacent untreated areas (Fig. 1).

Susceptibility of grasses to herbicides varied by species and soil type. Timothy and hard fescue were usually more susceptible than orchardgrass or pinegrass. More species were controlled by spring applications on pumice soils than on residual soils. Relative susceptibility<sup>1</sup> of individual species on pumice soils was:

	Orchard- grass	Timothy	Hard Fescue	Pinegrass
2 lb ai pronamide	R	R	R	R
2 lb ai terbacil	S	S	S	S
4 lb ai atrazine	I	S	I	I
5 lb ai dalapon	S-I	S	S-I	S-I

<sup>1</sup>Susceptibility rating is R = Resistant (little or no effect), I = Intermediate (more than 50 percent of plants controlled, but many recovering the following year), S-I = Susceptible to Intermediate (50 to 75 percent controlled with little recovery), and S = Susceptible (more than 75 percent controlled with little recovery).

Although primary emphasis of grass seeding after wildfires is soil stabilization, susceptibility to herbicides and competitive ability should be considered if possible when selecting grass mixtures for use on areas to be planted to conifers. For example, Baron (1962) has classified eight grass species used for erosion control according to their influence on ponderosa pine survival. Similar data should be developed for other species.

Terbacil, atrazine, and dalapon controlled grasses satisfactorily on pumice soils, but only dalapon produced consistent results under all study conditions. This may be due to greater foliage activity and less dependence of dalapon on rainfall after treatment compared with the other two herbicides. Preplant sprays of dalapon and atrazine significantly increased ponderosa pine seedling survival compared with planting in untreated grasses—an average of 7 times on residual soils and 1.5 times on pumice soils.

Preplant sprays of terbacil increased seedling survival on residual soils; however, survival on pumice soils was no different from that on untreated plots despite excellent reduction in grass cover. This reduced survival may be due to direct herbicidal toxicity and excessive exposure to insolation (Fig. 2). Newton and Webb (1970) note that herbicidal toxicity may be greater on light-textured soils. This may explain why terbacil was more effective on pumice soils and suggests that lower herbicidal rates may produce good grass control on these sites with a greater margin of safety for conifers.

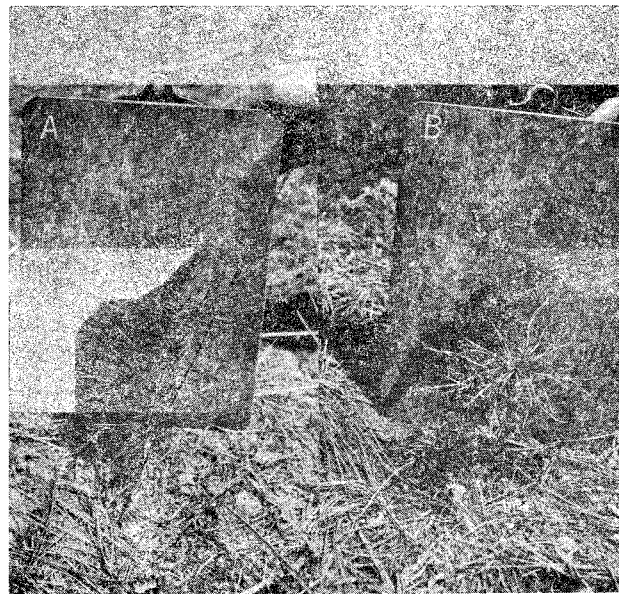
Herbicidal sprays were more effective than scalping. In fact, survival on scalped plots was not significantly different from that on untreated plots. Heidmann (1969) found that soil moisture was higher on sprayed plots than on scalped plots due to the presence of a dead grass mulch on the former. Further, it was necessary to retreat scalped plots to maintain a slight advantage in moisture compared with

Table 1. Initial grass control, present grass cover, and ponderosa pine seedling survival on residual and pumice soils.

Treatment	Soil type	First year grass control	Second year cover		Second year ponderosa pine survival
			Grass	Forb	
- - - - - Percent - - - - -					
none	Residual	—	68	17	3
	Pumice	—	75	13	39
Scalp	Residual	—	74	12	13
	Pumice	—	71	7	40
Pronamide	Residual	0	70	19	16
	Pumice	0	69	9	23
Terbacil	Residual	28	46	20	21
	Pumice	90	13	16	31
Atrazine	Residual	2	52	13	20
	Pumice	64	27	4	62
Dalapon	Residual	78	24	34	21
	Pumice	73	26	17	58



**Figure 1.** On pumice soils, grass cover averaged 26 percent on plots sprayed with dalapon (A) and 13 percent on plots sprayed with terbacil (B) two seasons after treatment.



**Figure 2.** Ponderosa pine seedlings planted in pumice soils following dalapon treatment (A) had full crowns and good growth, while seedlings on terbacil plots (B) were stunted and chlorotic.

untreated plots. In the present study, other factors such as higher soil temperatures and removal of topsoil from pumice soils on scalped plots may also contribute to the observed differences. However, soil moisture is a major limiting factor in central Washington, and conditions for ponderosa pine seedling establishment should be more favorable on sprayed than on scalped plots.

Trends in seedling survival on untreated, scalped, and sprayed (average of atrazine and dalapon) plots were similar after the first growing season (Fig. 3). Apparently the advantages of preplant spraying are primarily conferred during the first growing season. It is during this critical period of initial seedling establishment that plantation failure is most likely. By using atrazine or dalapon to reduce competition from grasses, it is possible to increase the number of trees surviving the initial establishment period. This increase is then carried through the second growing season.

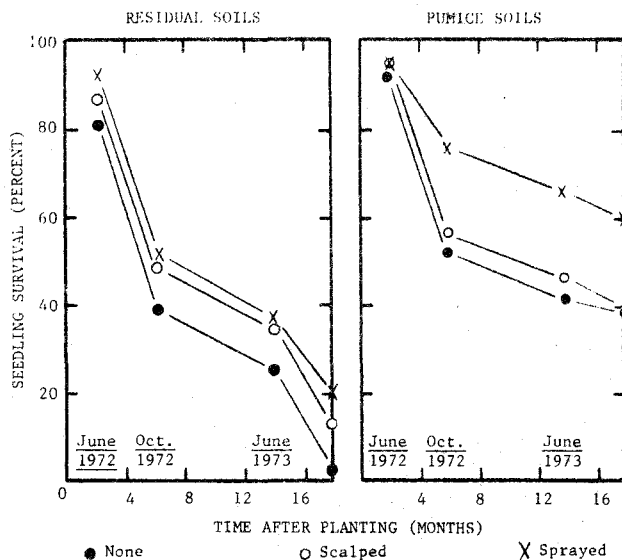


Figure 3. Survival of ponderosa pine seedlings planted in untreated grass, after scalping, or after spraying with atrazine and dalapon during the first two growing seasons.

Feeding activities of pocket gophers (*Thomomys* sp.) and meadow voles (*Microtus* sp.) were an additional factor contributing to seedling mortality. These losses usually occur during winter when mortality due to other factors is low (Crouch 1971, Lawrence et al. 1961). Average survival on all study plots decreased 12 percent during the first winter after treatment. Pocket gophers and meadow voles depend on herbaceous vegetation for food and cover. Therefore, broadcast spraying of herbaceous vegetation may reduce populations and feeding injury on ponderosa pines (Keith et al. 1959, Hull 1971). Even on small test plots where nearby cover is available, spraying with terbacil, atrazine, or dalapon reduced root and stem girdling of seedlings by 39 percent compared with untreated plots.

Results of this study show that preplant sprays of 4 lb ai per acre atrazine or 5 lb ai per acre dalapon applied during spring can increase survival of ponderosa pines planted in dense communities of orchardgrass, timothy, hard fescue, and pinegrass. Preplant sprays are more effective than hand scalping, the most common site preparation method. Significant increases in pine survival can be obtained without

complete removal of vegetation, an important factor on unstable soils. Further, atrazine and dalapon sprays will not affect perennial forb or shrub cover that provides additional soil protection. Aerial sprays of dalapon will be evaluated during 1974 to determine if results from these test plots are applicable to the Entiat Ranger District operational planting program.

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#### Herbicides for Container-grown Ornamentals

W. L. Currey<sup>1</sup>

Container-grown, woody ornamentals comprise an estimated 90% of a \$42 million industry in Florida. The cost of hand weeding container ornamentals often exceeds \$3,000 per year. Herbicides have given variable results due to improper choice of herbicide, rates and application technique.

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Two experiments were conducted at May Nursery Co., Florida during 1973 to evaluate seven herbicides on two species of *Illex*. Previous work indicated that the *Illex* genus is more susceptible to herbicide injury than other popular plants. The potting media in each experiment was 1/3 imported peat, 1/3 ground pine bark, 1/6 fly ash and 1/6 perlite.

Experiment one was initiated March 28, 1973 with a total of 250 one-gallon containers of *Illex compacta* receiving each herbicide spray. Six weeks after application, 80% or better control of *Gnaphalium* sp. (Cudweed) was observed with alachlor at 8 lb/A, and 4 or 8 lb/A of oxadiazon, trifluralin, oryzalin, A-820 and napropamide. There was severe stunting of *Illex* growth from trifluralin, oryzalin and oxadiazon. All plants recovered by the 13 week rating. At this rating the fresh weight of weed growth from each treatment was determined. Herbicides showing 80% or better suppression of weeds (*Digitaria sanguinalis* and *Gnaphalium* sp.) were the 8 lb/A rates of alachlor, napropamide, and A-820. Both 4 and 8 lb/A rates of trifluralin, oryzalin and oxadiazon provided equal control.

Ten randomly selected plants from each treatment were studied for root growth characteristics by a water displacement technique. Severe root reduction was observed with all treatments that provided excellent weed control except alachlor and napropamide at the 8 lb/A rates.

The second experiment, initiated August 10, 1973, evaluated granular formulations of alachlor, napropamide, oxadiazon and oryzalin. No reduction in growth of *Illex helleri* was evident from any of these treatments. Ratings and fresh weight of weeds taken at 8 and 21 weeks after application indicated excellent control of *D. sanguinalis*, *Gnaphalium* sp. and *Chamaesyce hyssopifolia* (spotted purple) from 5 and 10 lb/A of oxadiazon, or oryzalin and from 10 and 15 lb/A rates of alachlor or napropamide.

#### Establishment of Ornamental Highway Ground Covers in California with AMEX™ 820

K. W. Dunster<sup>1</sup>, R. A. Fosse<sup>1</sup> and R. R. Johnson<sup>2</sup>

AMEX™ is a four-pound-per-gallon formulation of N-sec.-butyl-4-tert.-butyl-2,6-dinitroaniline. A recent change in the American Chemical Society nomenclature system renames this compound 4-(1,1-dimethylethyl)-N-(1-methylpropyl)-2,6-dinitrobenzenamine. The common name "butralin" has been accepted by WSSA for this compound.

Currently registered for preplant weed control in cotton and soybeans on a limited basis, butralin has demonstrated promising selectivity in several other crops including ornamental plantings. Effective weed control has been obtained in numerous trials with preemergence application followed by rainfall or sprinkler irrigation for incorporation and activation in the soil.

Excellent tolerance of butralin has been recorded for most important California ornamental ground cover species in comparative trials conducted at six locations during 1972 and 1973. The addition of diphenamid and in some in-

stances DCPA can be expected to selectively improve the control of weeds resistant to butralin and other dinitroaniline herbicides. Research results in other areas and California trials by Lange and Elmore<sup>3</sup> have demonstrated high tolerance levels of many woody plant species to exaggerated rates of butralin. Research and demonstration trials are continuing in 1974, anticipating label registration for 1975 use.

#### Ornamental Tolerance

Trials to evaluate several butralin treatments for tolerance by ice plant (*Carpobrotus edulis*), Algerian ivy (*Hedera Canariensis*) and trailing African daisy (*Osteospermum fruticosum*) were established two months post plant on a southern California freeway site in 1972. Good ornamental tolerance was evident with several treatments at rates above those required for satisfactory weed control (Table 1). Similar results in established ice plant and Algerian ivy were observed in trials conducted cooperatively with the Orange County and Los Angeles County Flood Control Districts.

Additional trials were initiated on several ground cover species when they were transplanted into Foster fine sandy loam soil at the Amchem Research Farm near Visalia, California in 1972. Initial applications were made on April 5. Plots were handweeded to remove surviving weeds and re-treated with the same rates on August 15. Results presented in Table 2 indicate adequate tolerance by ice plant, Algerian ivy and English ivy (*Hedera helix*) of 6 lb/A butralin applied and sprinkler activated one day after transplanting. Combination with diphenamid somewhat decreased plant vigor while DCPA combination allowed rapid plant establishment. Repeat applications were safe on ice plant, but double combination applications of butralin at 3 lb/A or trifluralin at 2 lb/A with diphenamid at 10 lb/A appeared to injure both ivies.

Stonecrop (*Sedum brevifolium*), snow-in-summer (*Cerastium tomentosum*), carpet bugle (*Ajuga reptans*), common periwinkle (*Vinca minor*), trailing daisy and coyote bush (*Baccharis pilularis*) in the Visalia trials demonstrated good tolerance of single and repeat application of 4 lb/A butralin. Combinations with diphenamid decreased stand and vigor of all these species. Sand verbena (*Verbena pulchella*) appears quite susceptible to butralin and should not be treated with it. Many of the treatments in Table 2 show irregular differences in stand or vigor between the first and second evaluations. These early reductions appeared to be due to high summer air and soil temperatures and to variable species response to the management regimes used.

Detailed trials to further define the influence of soil incorporation, planting date and water management on butralin tolerance by ice plant and English ivy were established at the Amchem Research Farm, Manteca, on Hanford fine sandy loam soil in 1973. Results presented in Table 3 indicate good ivy tolerance with all management systems including preplant incorporation. Ice plant tolerance appeared adequate with application and sprinkler activation immediately after transplanting. Vigor reduction occurred with preplant incorporation of butralin alone or combined with diphenamid.

<sup>1</sup> Amchem Products, Inc., Fremont, CA 94536.

<sup>2</sup> Amchem Products, Inc., Ambler, PA 19002.

<sup>3</sup> Personal communication. (Univ. California, Davis).

Table 1. Ornamental tolerance and weed control with butralin treatments. San Diego Freeway, Los Angeles, 1972.

Treatment <sup>1</sup>	Rate lb/A	Percent injury <sup>2</sup>			Percent weed control <sup>2</sup>		
		Ice-plant	Algerian ivy	African daisy	Broad-leaf	Grass	Ave.
Butralin	2	0	0	0	70	80	75
Butralin	4	0	0	0	90	90	90
Butralin	6	0	0	30	92	99	96
Butralin + diphenamid	2 + 10	0	10	0	80	70	75
Butralin + diphenamid	4 + 10	0	0	10	90	90	90
Butralin + DCPA	4 + 10	0	0	10	100	90	95
Trifluralin + diphenamid	2 + 10	10	0	20	95	85	90
Control	—	0	0	10	0	0	0

<sup>1</sup>Treated February 15, 2 months postplant; sprinkler irrigated February 16.

<sup>2</sup>Average of 3 replications; evaluated April 12.

Table 2. Tolerance of newly transplanted ground covers to single and repeated applications of butralin alone and combined with diphenamid or DCPA (percent reduction<sup>1</sup>). Visalia, California, 1972.

Treatment	Rate lb/A	Ajuga		Baccharis		Capro-brotus		Ceras-tium		Hedera Canar-ien-sis		Hedera helix		Osteo-spermum		Sedum		Verbena		Vinca	
		Std	Vig	Std	Vig	Std	Vig	Std	Vig	Std	Vig	Std	Vig	Std	Vig	Std	Vig	Std	Vig	Std	Vig
Butralin <sup>2</sup>	2	0	10	10	0	0	0	10	17	17	13	0	3	10	13	0	43	17	37	0	3
Butralin 2X <sup>3</sup>	2	8	17	8	7	8	7	17	7	28	0	25	3	17	23	17	12	25	20	0	3
Butralin	4	0	7	10	7	0	0	17	10	10	3	10	0	0	3	0	13	10	43	0	0
Butralin 2X	4	0	17	8	3	0	7	25	15	33	0	25	7	8	10	0	18	25	63	8	0
Butralin	6	10	3	10	7	0	10	50	30	17	13	20	10	23	7	0	53	10	67	0	20
Butralin 2X	6	8	7	0	8	0	7	25	13	17	3	25	7	25	7	0	13	33	63	42	23
Butralin + diphenamid	2 + 10	0	33	0	37	10	27	17	73	10	43	0	40	20	20	50	83	0	40	23	40
Butralin + diphenamid 2X	2 + 10	8	13	0	10	0	40	50	62	33	17	0	17	0	0	75	73	8	40	33	33
Butralin + diphenamid	3 + 10	0	23	0	20	0	17	17	77	50	60	10	40	17	13	23	70	20	37	27	40
Butralin + diphenamid 2X	3 + 10	17	3	0	7	0	13	33	37	67	80	33	57	8	3	42	57	17	52	42	28
Butralin + DCPA	3 + 10	0	43	0	7	10	10	27	43	10	10	0	3	27	23	0	73	50	83	0	40
Butralin + DCPA 2X	3 + 10	8	30	0	7	0	20	33	42	17	0	0	0	25	23	25	57	67	87	33	60
Trifluralin + diphenamid	2 + 10	20	63	20	33	0	30	0	17	27	50	33	40	37	30	33	90	0	13	33	57
Trifluralin + diphenamid 2X	2 + 10	42	7	8	7	0	30	17	33	42	0	33	22	41	33	58	53	0	10	41	50
Weedy check		0	20	0	50	0	20	0	50	0	0	0	0	0	30	15	70	0	20	0	0
Weedy check 2X		0	10	17	25	8	17	17	18	17	0	17	0	30	40	42	33	0	0	17	0

<sup>1</sup>Average of 3 replications.

<sup>2</sup>Treated April 5; evaluated July 24.

<sup>3</sup>Treated April 5; retreated August 15; evaluated October 24.

**Table 3. Influence of incorporation, planting date and water management on ground cover tolerance of butralin alone and combined with diphenamid. Manteca, California 1973.**

Treatment <sup>1</sup>	Rate lb/A	Vigor <sup>2</sup>					ck.
		Percent of handweeded control					
		1 <sup>3</sup>	2 <sup>3</sup>	3 <sup>3</sup>	4 <sup>3</sup>	5 <sup>3</sup>	
Ice plant							
Butralin	3	81	99	124	95	137	107
Butralin	4	57	101	117	105	128	102
Butralin + diphenamid	3 + 8	29	80	100	93	119	84
Average		56	93	114	98	128	98
Weedy check		75	106	96	109	100	97
English ivy							
Butralin	3	111	100	126	100	102	107
Butralin	4	112	89	120	97	90	102
Butralin + diphenamid	3 + 8	120	89	126	84	89	102
Average		114	93	124	94	94	104
Weedy check		98	80	82	107	77	89

<sup>1</sup>Treated May 10-17, 1973.

<sup>2</sup>Evaluated June 6, 1973.

<sup>3</sup>Methods of application

1. Treat—power incorp—plant—sprinkle same day.
2. Plant—treat—sprinkle same day.
3. Plant—sprinkle—treat next day—sprinkle.
4. Plant—sprinkle—treat 4 days later—sprinkle.
5. Plant—sprinkle—treat 7 days later—sprinkle.

**Table 4. Weed control obtained with butralin alone and combined with diphenamid. Visalia, California, 1972.**

Treatment <sup>1</sup>	Rate lb/A	Hoe time hrs/A <sup>2</sup>	Percent control <sup>3</sup>			
			LQ	Pigweed	Byg	Mustard
Butralin	2	15.5	100	90	83	98
Butralin	4	6.3	100	99	99	99
Butralin	6	2.9	100	100	100	100
Butralin + diphenamid	2 + 10	2.2	100	100	100	100
Butralin + diphenamid	3 + 10	1.7	100	100	100	100
Butralin + DCPA	3 + 10	4.6	100	95	100	100
Trifluralin + diphenamid	2 + 10	3.1	100	100	100	100
Weedy check		203.0	0	0	0	0

<sup>1</sup>Applied April 5; 3/4" sprinkler irrigation followed application immediately; 3.66" irrigation in first three weeks.

<sup>2</sup>Recorded June 7; average of three replications.

<sup>3</sup>Evaluated August 2.

## Weed Control

All treatments used in the 1972 Visalia research farm series significantly decreased weed removal hoe time requirements, as reported in Table 4. Combination treatments were more effective than butralin alone, with diphenamid performing better than the comparable rate of DCPA. Satisfactory control of barnyardgrass (*Echinachloa crusgalli*), lambsquarters (*Chenopodium album*), pigweed (*Amaranthus* spp.) and mustard (*Brassica nigra*) was apparent with all treatments 5 months after application.

Preplant incorporation provided excellent pigweed and barnyardgrass control but appeared to decrease hairy nightshade (*Solanum sarachoides*) control in the application timing trials at the Manteca research farm. All preemergence sprinkler activated treatments produced excellent nightshade and barnyardgrass control; treatment 7 days after planting appeared to decrease the degree of pigweed control (Table 5).

## Preemergence Weed Control in Ground Cover Ornamentals

Clyde L. Elmore<sup>1</sup> and W. A. Humphrey<sup>2</sup>

Many ornamental plants are planted for ground covers because of their prostrate growth habit, ability to retain soil against erosion and their beauty of either foliage or flowers. These plants are usually perennials and planted as rooted cuttings. However, Large-leaf iceplant (*Carpobrotus edule*) is normally planted as unrooted cuttings with 1 or 2 nodes below the soil surface.

Weeds are a major factor in establishment of ground cover plantings. During the first few months of growth, competition from weeds can be so severe that the ground cover plants can not survive. With hand weeding, some ornamental plants are usually destroyed and the weeding costs are exorbitant. Preemergence herbicides can be effectively utilized in many ground cover species to reduce competition and promote establishment. A rapid growing, uniform stand can be achieved at a relatively low cost.

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<sup>2</sup>Farm Advisor, Cooperative Extension, University of California, Anaheim.

Table 5. Influence of incorporation, planting date, and water management on weed control with butralin alone and combined with diphenamid. Manteca, California, 1973.

Treatment <sup>1</sup>	Rate lb/A	Percent weed control <sup>2</sup>				
		1 <sup>3</sup>	2 <sup>3</sup>	3 <sup>3</sup>	4 <sup>3</sup>	5 <sup>3</sup>
Pigweed						
Butralin	3	100	96	94	99	91
Butralin	4	100	100	94	100	93
Butralin + diphenamid	3 + 8	100	100	100	100	96
Nightshade						
Butralin	3	89	100	—	100	—
Butralin	4	90	100	—	100	—
Butralin + diphenamid	3 + 8	96	100	—	100	—
Barnyardgrass						
Butralin	3	99	100	100	100	100
Butralin	4	100	100	100	100	100
Butralin + diphanamid	3 + 8	100	100	100	100	100

<sup>1</sup>Treated May 10-17.

<sup>2</sup>Evaluated June 6.

<sup>3</sup>Methods of application

1. Treat—power incorp.—plant—sprinkle same day.
2. Plant—treat—sprinkle same day.
3. Plant—sprinkle—treat next day—sprinkle.
4. Plant—sprinkle—treat 4 days later—sprinkle.
5. Plant—sprinkle—treat 7 days later—sprinkle.

Research has been conducted to evaluate preemergence herbicides for 1) weed control, 2) plant tolerance to the herbicides, 3) effect on rooting of lateral shoots and 4) cost of establishment of ground covers for one year.

Plot size was 10 ft. x 20 ft. with 5 plants of 6 species of ground covers in each plot. Plants consisted of rooted liners in 4 inch plant bands except *Carpobrotus edule* which were planted as unrooted cuttings with two nodes below the soil surface. The statistical design was a randomized complete block with 4 replications. The soil was a sandy loam with an analysis of: 58.5% sand; 22.5% silt; 19.0% clay with 0.99% organic matter. The trial was sprinkler irrigated when needed. Plots were individually hand weeded at 1.5 months and 10 months after the initial treatments.

Weeding costs per acre and 1000 square feet were determined by measuring the time required to weed all treatments (Table 1).

Weed control and phytotoxicity were also evaluated visually using a 0-10 scale, 0 = no control or no effect, 10 = complete control or dead. (Tables 2 and 3.)

Seven months after treatment the *Carpobrotus edule* was pruned uniformly to a 2 foot wide strip in each plot and the prunings weighed (Table 4).

The effect of preemergence herbicides on rooting of *Carpobrotus edule* prostrate shoots were measured. Three shoots were lifted in each replicate to determine if they were rooted. If appreciable resistance upon lifting occurred

the shoot was considered rooted. Each replication was given an affirmative or negative recording (Table 5).

Nitralin did not give early control because of a high population of tolerant weeds especially common groundsel. Rooting of the *Carpobrotus edule* shoots were inhibited by nitralin when evaluated at both 2 and 3 months after treatment.

The combination of diphenamid plus trifluralin is a standard treatment in many areas of California. Excellent early weed control was achieved with no affect on rooting of *C. edule*. A slight suppression of growth of *Vinca major* and *Sedum brevifolium* was noted.

Nitrofen gave less than acceptable weed control throughout the test. No phytotoxic effect was observed on plant material.

Oxadiazon provided excellent long residual weed control at both 2 and 4 lb/A. Injury was severe on *S. brevifolium* particularly after the second application. No affect was observed on rotting of *C. edule*.

Alachlor gave 85% or better weed control through 2 months with loss of control at all rates by six months. No phytotoxicity was observed on any plant species. Alachlor at 8 lb/A significantly reduced the fresh weight of *C. edule*.

Oryzalin gave acceptable weed control at 2 and 4 lb/A for the duration of the experiment. At 1 lb/A oryzalin did not give acceptable control. Although no observable phytotoxicity was found on the ground plants rooting was re-

Table 1. Cost of weeding ground cover ornamentals for 1 year following planting.

Herbicide	Lb a.i./A	Herbicide <sup>1</sup> \$/A	Weeding <sup>2</sup> %/A	Total \$/A	Total \$/1000 ft <sup>2</sup>
nitralin	2	36	1239	1275	30
Diphenamid + trifluralin	10 + 2	82	469	551	15
nitrofen	4	38	1599	1637	38
Oxadiazon	1	28	1264	1292	30
oxadiazon	2	40*	356	396	10
oxadiazon	4	65	202	267	8
alachlor	2	27	852	879	21
alachlor	4	38	815	853	20
alachlor	8	61	560	621	16
oryzalin	1	16	1079	1095	26
oryzalin	2	36*	479	515	13
oryzalin	4	57	176	233	7
butralin	4	35*	920	955	23
butralin	8	55	557	612	15
nitrofen	2 + 1	41	915	956	23
+ nitralin					
nitrofen	4 + 2	66	467	533	14
+ nitralin					
weeded control			5070	5070	116

\* Estimated price.

<sup>1</sup> Applied 7-13-72; 3-9-73 (\$7.50 application cost/application).

<sup>2</sup> Contractor bid price of \$9.50/hr. to weed and remove debris.

duced with increased rate at the 2 month evaluation.

Butralin gave acceptable weed control through the 2 month evaluation. Butralin at 4 and 8 lb/A reduced rooting of *C. edule* until 3 months.

Acceptable weed control was also apparent with a combination of nitrofen and nitratin. No apparent injury was

apparent on any of the ground cover species with either a 2 + 1 or 4 + 2 lb/A combination. Rooting of *C. edule* was suppressed for 2 months although the plants were rooted by the 3 month evaluation.

Rooting and fresh weight of the *C. edule* was severely reduced by weed competition in the nonweeded and even the weeded control.

**Table 2. Preemergence weed control with six herbicides and two herbicide combinations in ground cover ornamentals.**

Herbicide	Lb (a.i.)/A	Weed control <sup>1</sup>			
		1 MO.	2 MO.	6 MO.	9 MO.
nitratin	2	4.8	8.0	6.5	5.5
diphenamid + trifluralin	10 + 2	9.5	9.2	4.0	5.8
nitrofen	4	6.8	7.5	5.8	4.2
oxadiazon	1	6.5	9.0	6.2	6.5
oxadiazon	2	9.2	8.8	8.2	8.8
oxadiazon	4	9.8	9.8	9.6	9.5
alachlor	2	8.6	8.9	3.2	6.2
alachlor	4	9.1	8.9	4.8	6.2
alachlor	8	9.4	9.4	4.8	6.8
oryzalin	1	5.7	8.5	6.0	4.0
oryzalin	2	7.0	9.5	8.6	8.2
oryzalin	4	9.1	9.8	8.9	6.5
butralin	4	7.0	8.5	4.8	4.8
butralin	8	9.0	9.2	6.8	6.0
nitrofen + nitratin	2 + 1	7.5	8.1	6.0	4.0
nitrofen + nitratin	4 + 2	9.0	9.1	7.5	6.8

<sup>1</sup>weed control 0 = no control; 10 = complete control.

The plots were hand weeded at 1½ months following treatment.

**Table 3. Phytotoxicity of six premerge herbicides and herbicide combinations to six ground covers.**

Herbicide	Rate lb/A	<i>Sedum brevifolium</i>			<i>Delasperma alba</i>			<i>Algerian ivy</i>		
		1 mo.	3 mo.	8 mo.	1 mo.	3 mo.	8 mo.	1 mo.	3 mo.	8 mo.
nitratin	2	0.2	0.8	0.8	0.5	0.8	0.0	1.0	0.8	0.0
diphenamid + trifluralin	10 + 2	1.2	1.5	3.0	1.0	1.0	0.0	1.5	0.8	0.0
nitrofen	4	0.0	0.5	0.2	0.8	1.2	1.0	2.0	2.0	1.0
oxadiazon	1	0.2	1.5	3.8	2.0	0.8	0.8	1.8	0.5	0.8
oxadiazon	2	1.0	0.0	5.5	2.8	0.5	1.2	1.5	1.0	0.2
oxadiazon	4	0.8	1.5	7.8	3.5	0.8	2.2	2.0	0.5	1.2
alachlor	2	0.5	1.5	0.0	0.8	1.2	0.2	0.8	0.5	0.0
alachlor	4	1.2	0.8	0.0	1.2	1.0	0.2	2.2	1.0	0.0
alachlor	8	1.5	2.5	0.8	1.0	0.2	1.8	2.0	0.2	0.0
oryzalin	1	0.0	1.0	0.0	1.0	1.8	0.8	0.8	1.2	0.0
oryzalin	4	0.0	0.0	0.2	0.2	0.2	0.5	1.5	0.2	0.0
butralin	4	0.0	0.8	0.2	0.8	1.5	0.2	1.5	0.8	0.0
butralin	8	0.5	1.5	0.8	0.8	1.8	0.0	1.0	1.0	0.0
nitrofen + nitratin	2 + 1	0.5	0.5	0.2	1.0	0.2	0.8	2.8	1.2	0.8
nitrofen + nitratin	4 + 2	0.5	0.5	1.0	0.2	0.2	1.8	1.8	0.2	0.2
weeded	—	0.0	0.8	0.2	1.0	2.0	0.0	0.2	1.0	0.0

0 = no effect, 3 = unacceptable damage, 10 = dead plants

(Cont.)

Table 3. Phytotoxicity of six preemergence herbicides and herbicide combinations to six ground covers.

Herbicide	Rate lb/A	<i>Osteospermum frut.</i>			<i>Carpobrotus edule</i>			<i>Vinca major</i>		
		1 mo.	3 mo.	8 mo.	1 mo.	3 mo.	8 mo.	1 mo.	3 mo.	8 mo.
nitralin	2	1.2	0.5	0.0	2.0	1.5	0.0	1.2	0.8	0.2
diphenamid + trifluralin	10 + 2	0.5	0.5	0.0	2.0	0.2	0.0	3.0	0.0	1.0
nitrofen	4	1.2	0.8	0.0	0.5	1.2	0.0	1.2	1.2	2.0
oxadiazon	1	1.0	0.2	0.8	0.8	0.0	0.5	1.8	0.5	0.5
oxadiazon	2	0.8	0.2	0.8	2.0	0.2	0.5	1.8	0.0	0.8
oxadiazon	4	0.8	1.0	0.0	2.8	1.2	1.0	1.8	0.2	0.8
alachlor	2	0.8	0.0	0.0	2.5	0.8	0.0	1.2	0.5	0.0
alachlor	4	1.5	0.2	0.0	1.0	0.0	0.0	1.2	0.0	0.0
alachlor	8	2.0	0.2	0.5	1.5	1.2	0.0	1.8	0.0	0.5
oryzalin	1	0.5	1.0	0.8	1.0	1.2	0.0	1.5	1.8	0.2
oryzalin	2	1.0	0.2	0.2	0.8	1.0	0.0	1.0	0.8	0.8
oryzalin	4	0.5	0.5	0.0	1.2	0.8	0.0	0.8	0.0	1.2
butralin	4	0.2	1.0	0.5	1.8	1.2	0.0	2.5	0.2	0.2
butralin	8	0.2	0.2	0.0	1.5	0.5	0.0	1.2	0.5	1.2
nitrofen + nitralin	2 + 1	0.2	0.0	1.0	1.8	0.2	0.0	1.2	0.5	2.0
nitrofen + nitralin	4 + 2	0.8	0.0	0.2	0.2	0.2	0.0	0.8	0.0	2.5
weeded	—	0.8	2.2	0.2	2.0	3.8	0.0	1.0	1.8	0.0

0 = no effect, 3 = unacceptable damage, 10 = dead plants

Table 4. Effect of six preemergence herbicide and herbicide combinations on the fresh weight of cuttings from *Carpobrotus edule* 7 months after treatment.

Herbicide	lb a.i./A	Fresh weight (lbs)*	
nitralin	2	71.4	abcd
diphenamid + trifluralin	10 + 2	43.9	cd
nitrofen	4	61.2	abcd
oxadiazon	1	91.8	ab
oxadiazon	2	68.5	abcd
oxadiazon	4	67.1	abcd
alachlor	2	57.8	abcd
alachlor	4	68.7	abcd
alachlor	8	49.9	cd
oryzalin	1	60.5	abcd
oryzalin	2	71.6	abcd
oryzalin	4	74.6	abc
butralin	4	47.6	cd
butralin	8	53.7	bcd
nitrofen + nitralin	2 + 1	68.9	abcd
nitrofen + nitralin	4 + 2	94.0	a
weedec control	—	31.9	de
nonweeded control	—	2.4	e

\* Fresh weight values followed by the same letter are not significantly different ( $P = 0.05$ ).Table 5. Effect of six preemergence herbicides on prostrate shoot rooting of *Carpobrotus edule* at 2 and 3 months after treatment.

Herbicide	Rate lb a.i./A	2 Months		3 Months	
		Rooted*	Non-rooted	Rooted	Non-rooted
nitralin	2	1	3	3	1
diphenamid + trifluralin	10 + 2	4	0	4	0
nitrofen	4	4	0	4	0
oxadiazon	1	4	0	4	0
oxadiazon	2	4	0	4	0
oxadiazon	4	4	0	4	0
alachlor	2	4	0	4	0
alachlor	4	3	1	4	0
alachlor	8	4	0	4	0
oryzalin	1	3	1	4	0
oryzalin	2	1	3	4	0
oryzalin	4	0	4	4	0
butralin	4	1	3	4	0
butralin	8	1	3	4	0
nitrofen + nitralin	2 + 1	0	4	4	0
nitrofen + nitralin	4 + 2	1	3	4	0
weeded control	—	1	3	4	0
nonweeded control	—	0	4	1	3

\* 3 shoots were lifted in each of the four replications.

If appreciable resistance occurred the plants were considered rooted for that replication. Each figure represents the number of replications rooted.

**PROWL\***  
**Herbicide for Field Corn and Cotton**

R. S. Nielsen

**Abstract.** PROWL\* Herbicide for field corn and cotton, a dinitro aniline identified as N-(1-Ethylpropyl)-2,6-Dinitro-3,4-Xylidine was evaluated as a PPI application at six locations in 1972 and 1973 on cotton in the San Joaquin Valley of California. Soil types ranged from loamy sand to fine sandy loam containing organic matter of 1% or less.

Pigweed (*Amaranthus* spp.), nettleleaf goosefoot (*Chenopodium murale*), lambsquarters (*Chenopodium album*), crabgrass (*Digitaria* spp.), barnyardgrass (*Echinochloa crus-galli*), common foxtail (*Hordeum leporinum*), were susceptible species occurring in these trials. Non-susceptible weeds encountered were groundcherry (*Physalis longifolia*), nuts-edge (*Cyperus* spp.) and morningglory (*Ipomoea* spp.). Susceptible species were effectively controlled at the rate of .75 lb. A/A at 6 locations, and at the rate of .5 lb. A/A at 5 locations.

PROWL at the rate of 1 lb. A/A exhibited no effect upon cotton plant stand or yield of seed cotton compared to untreated checks.

An experimental permit is anticipated in 1974 for use of PROWL on cotton.

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\*American Cyanamid Co., Fresno, Ca.

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**Evaluation of Herbicides for Hawaiian Sugarcane**

R. V. Osgood and H. W. Hilton<sup>1</sup>

Weed control operations on the Hawaiian sugarcane plantations are centered around the use of five herbicides: ametryne, atrazine, diuron, dalapon and 2,4-D. All of the acreage is treated with herbicides, and recommendations are made by the Experiment Station of the Hawaiian Sugar Planters' Association (HSPA). Large numbers of screening tests are necessary to determine the suitability of a new herbicide for the variable climatic and soil conditions. We evaluate new herbicides for five soil types, four rainfall regimes, types of irrigation (irrigated and unirrigated) for four islands, and for crop varietal tolerance. An IBM 1130 computer was programmed to summarize the raw data from individual tests, make a summary report and to accumulate data from large numbers of tests. The reliability of the accumulated data improves as the number of comparisons with standard herbicides increases.

Phytotoxicity is not an overriding consideration when making weed control recommendations in Hawaiian sugarcane. The crop is grown for two to three years before harvest, which is an adequate period of time for overcoming minor damage resulting from herbicides applied during the first 6 months of the crop.

For consideration, new soil active herbicides must perform better than ametryne in irrigated sugarcane and better

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<sup>1</sup> Hawaiian Sugar Planters' Association, Honolulu, Hawaii.

than diuron in unirrigated cane. The compound should be active postemergence, i.e., control emerged seedlings of broadleaves and grasses in addition to giving extended pre-emergence control. Three new soil active compounds are of interest: GS 14254, metribuzin and EL 103. New post-emergence herbicides must perform better than dalapon on grasses and better than 2,4-D on broadleaves or provide a special attribute, such as low toxicity to sugarcane or less hazard of application. Three compounds are of interest: glyphosate, asulam, and picloram.

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**Influence of Nitratin and Trifluralin on  
Sugarbeet Growth**

E. E. Schweizer<sup>1</sup>

**Abstract.** Nitratin [4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline] and a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin) can produce gall-like growths and constrictions in the primary roots of sugarbeets (*Beta vulgaris* L.), if these chemicals are sprayed directly on the hypocotyledonary tissues of small seedlings. Growing seedlings in soils that contain sufficient residues of either herbicide can cause the primary roots to twist. The studies summarized herein were conducted to determine (a) the concentration of nitratin and trifluralin required in soil to cause twisting or sprangling in the primary roots of sugarbeets, and (b) what effect different concentrations of these herbicides have on the growth of sugarbeet seedlings.

We applied the herbicides as a broadcast treatment in April to simulate a residue problem. In 1969, nitratin and trifluralin were applied at 0.06, 0.11, 0.22, 0.45, 0.67, and 0.90 kg/ha. In 1973, trifluralin was applied at 0.06, 0.11, 0.22, 0.34, 0.45, and 0.56 kg/ha. The herbicides were incorporated with a rototiller to a depth of 17 cm in 1969 and 12 cm in 1973 (trifluralin only). The soil was a clay loam in 1969 and a sandy clay loam in 1973.

A concentration as low as 0.06 kg/ha of nitratin or trifluralin induced root twisting. The 0.06-kg/ha rate of trifluralin produced six times more twisted roots when incorporated 17 cm deep than 12 cm. As the concentration of either herbicide increased in 1969, the number of twisted roots declined, but the number of sprangled roots increased.

Trifluralin reduced the weight of tops and roots more than nitratin at rates of 0.45, 0.67, and 0.90 kg/ha. Significant reductions in tops and roots resulted from trifluralin applications of 0.45 kg/ha or more in 1969 and 0.11 kg/ha or more in 1973. These results indicate that sugarbeet injury from trifluralin residues in soil could be minimized, or perhaps prevented, by plowing 20 cm or deeper and thoroughly mixing the soil before planting sugarbeets.

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<sup>1</sup> Western Region, Agr. Res. Serv., U.S. Dept. of Agr., Fort Collins, CO 80521



## Influence of Trifluralin on Sugarbeet Root Development

Robert F. Norris and Dennis W. Stevenson<sup>1</sup>

**Abstract.** Small amounts of trifluralin remaining in the soil following application to the previous crop can cause malformation of sugarbeet roots. Sugarbeet roots normally show a slight spiral growth, about 100° twist per 15 cm of root length. Trifluralin in the soil greatly increased the magnitude of this twisting; 0.03 lb/A increased the twisting to 280° and 0.5 lb/A resulted in 885° of twisting. Intermediate rates of herbicide caused intermediate degrees of twisting. Top growth and yield were only significantly (at p - 0.05 level) reduced when 0.5 lb/A was applied, but a trend for reduced growth was evident at 0.25 lb/A.

Transferring seedlings at cotyledon stage from nutrient solution without to one with trifluralin resulted in immediate cessation of root growth; quantities as low as 10<sup>-9</sup> M could be detected. Some recovery of growth occurred with time, especially at concentrations below 10<sup>-7</sup> M. Considerable disruption of cell contents occurred at concentrations of 10<sup>-4</sup> and 10<sup>-5</sup> M. Serial sections made from roots grown in 10<sup>-7</sup> M trifluralin showed pronounced changes in the diarch stele; 180° of twisting developed in a 2 cm section of root. Similar twisting of the stele was observed in field-grown sugarbeets. Changes in stele orientation were observed within five days of transfer to nutrient solution containing trifluralin.

Trifluralin appears to alter the differentiation pattern of the sugarbeet stele. This causes the pronounced twisting that has been observed in beet roots grown in trifluralin-containing soil. The sugarbeet root, both in terms of elongation and degrees of twisting, could probably be used as a sensitive bioassay for trifluralin.

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### Date of Application and Performance of Metribuzin in Potatoes<sup>1</sup>

R. L. Zimdahl, J. M. Foster, and J. G. Walker<sup>2</sup>

Metribuzin has proven to be an excellent herbicide for weed control in potatoes. The experiments reported herein were designed to determine the rate and time of application which would maximize weed control and minimize herbicide use while preventing crop injury.

#### Rate and Timing Study—1972

##### Methods and Procedure

A randomized block design with four replications was

<sup>1</sup>This is a report on the evaluation of herbicides for the control of weeds in potatoes. It does not contain recommendations for use nor does it imply that potential uses have been registered.

<sup>2</sup> Associate Professor, Research Technician, Weed Research Laboratory, Dept. of Botany and Plant Pathology, and Superintendent, San Luis Valley Research Center.

established on the San Luis Valley Research Center in Colorado. All treatments were applied with a bicycle type plot sprayer in 28 gallons of water per acre. Preemergence treatments were applied May 16 and postemergence on June 8. Temperatures were 73 (Air) and 53 (Soil) and 60 (Air) and 65 (Soil) on each date. The soil surface was dry on both dates. When the postemergence treatments were applied, the potatoes were 1 ½ to 4 inches tall and pigweed had 8-10 leaves. Russet Burbank potatoes were planted May 11 and harvested September 22. The soil was a loamy sand with 0.3% organic matter and a pH of 8.3.

#### Results and Discussion

No injury to potatoes was seen in this experiment. We expected severe injury from the 4 lb/A and some injury at 2 lb/A. We also did not expect to see the difference between pre- and postemergence weed control.

In Northern Colorado, metribuzin has consistently provided excellent preemergence weed control but has not been as satisfactory in the San Luis Valley. The only important weed in the plots was redroot pigweed (*Amaranthus retroflexus* L.) (Table 1). The harvested potatoes were graded as U.S. No. 1 4-10 oz., >10 oz., U.S. No. 2, B size, and culls. Inspection of the data showed that the major portion of yield was U.S. No. 1 4-10 oz. and B. size. The differences seen in these data were very similar to those shown by the total yield data and only total and U.S. No. 1 4-10 oz. are shown in Table 1.

These plots were not cultivated at all. Thus, the disturbance of a preemergence application by cultivation was not a factor in the poor weed control. The San Luis Valley is a unique environment and we look first to climatic or irrigation (furrow) practices to account for the failure of preemergence weed control. These data and other studies clearly indicate that metribuzin should be used postemergence in the San Luis Valley.

The yield difference between pre- and postemergence is related to weed control, not injury. One quarter pound is insufficient at either time but one half up to 2 pounds appeared to give equal weed control. The highest rate (4 lbs. ai) caused slight yield depression postemergence but none preemergence.

In the fall of 1972 the plot area was divided into two halves each of which contained at least one plot of each time rate combination. One half of the plot area was chiseled and the other plowed. Barley, which is susceptible to metribuzin, was seeded in the spring of 1973 to determine the presence of phytotoxic residues. The barley was severely injured by 4 lb/A and 2 lb/A caused a noticeable reduction in stand. None of the other rates caused any injury to the barley and we concluded that metribuzin carryover will not be a problem if the recommended rate of 0.75 lb/A is used.

#### Timing Study—1973

##### Methods and Procedure

Metribuzin at the recommended rate of 0.75 lb/A and at

1.5 lb/A was applied preemergence and at several additional stages of growth (Table 2). Norchips were planted in Northern Colorado (location A) and Russet Burbanks were planted at the San Luis Valley Research Center (location

rows of all plots were machine harvested at location B on September 24.

### Results and Discussion

The primary weed problem at location A was barnyard grass (*Echinochloa crus-galli* L.). This is a warm season grass which did not emerge until after June 15. The control ratings (Table 3) show less than 70% control for metribuzin applied prior to June 22. After this date the control improved to better than 90%. This again emphasizes the often superior weed control obtained from postemergence applications of metribuzin. The yields and control ratings in Table 3 do not indicate any increase or decrease in yield from metribuzin.

At location B redroot pigweed (*Amaranthus retroflexus* L.) was the principle weed problem and a complete harvest did reveal a detrimental effect from late application (Table 4). Metribuzin gave very acceptable control of redroot pigweed but control from late season applications was poorer. The pigweed was fully mature in July and although it was injured it was not killed.

**Table 1. Metribuzin Rate and Timing Study—Weed Control Ratings and Yields—1972.**

Time of Application and Rate of Metribuzin	Pigweed Control <sup>1</sup> Rating	Yield <sup>2</sup> cwt/a	
		U.S. No. 1	Total
<b>Preemergence</b>			
0.25	3.3	100	211
0.5	4.2	130	251
0.75	3.6	130	255
1.0	4.3	127	249
2.0	4.5	111	232
4.0	6.8	127	257
<b>Postemergence</b>			
0.25	6.0	125	239
0.5	7.5	147	281
0.75	7.9	139	259
1.0	8.4	136	247
2.0	9.4	126	250
4.0	9.7	106	224
Check	—	110	225

<sup>1</sup>0 = No Control; 10 = Complete Control. Rating shown is an average of three dates of observations of four replications.

<sup>2</sup>Yield determined by harvesting 40 feet of two center rows of each four row plot. Average of four replications.

**Table 2. Metribuzin Application Dates—1973.**

Location A—Peckham		Location B—S.L.V.	
Date	Stage of Potato Growth	Date	Stage of Potato Growth
May 19	Planting	May 18	Planting
25	None	30	None
June 4	None	June 11	10% Emergence
8	50% Emergence	20	50% Emergence
15	100% Emergence	27	6" High
22	2" High	July 11	18" High, just flowering
30	10" High	23	30" High, full bloom
July 7	14" High		

B). Each plot had 4 row plots with 4 replications. A bicycle type plot sprayer was used to apply the herbicide in about 20 gals. of water/A at each location and no unusual soil or atmospheric conditions were encountered.

Weed control observations were made at each location. Five feet of each of the 2 center rows of the May 25, June 15, July 6, and untreated check plots were hand harvested at location A on September 13. Forty feet of the 2 center

**Table 3. Barnyard Grass Control and Potato Yield, Location A—Peckham**

Rate of metribuzin lbs/A	Date of application	Stage of potato growth	Barnyard grass control <sup>1</sup>	Potato yield cwt/A <sup>2</sup>
0.75	5/25	none	7.3	282
1.5			6.0	247
0.75	6/4	none	5.8	—
1.5			8.0	—
0.75	6/8	50% emergence	6.5	—
1.5			7.5	—
0.75	6/15	100% emergence	5.8	204
1.5			4.3	255
0.75	6/22	2" high	7.5	—
1.5			7.8	—
0.75	6/30	10" high	9.5	—
1.5			9.8	—
0.75	7/6	14" high	9.3	229
1.5			10.0	244
0	none	—	0	227

<sup>1</sup>0 = no control, 10 = complete control.

<sup>2</sup>Yields computed from a hand harvest of 5 ft. of each of the center 2 rows.

No metribuzin treatment increased tuber yield above the weedy check yield (Table 4). Thus, although pigweed control ratings were high the weed density was not great enough to affect the yield even when it was almost completely eliminated by metribuzin.

However, when metribuzin was applied at 18" or later yields were reduced below the check. The effect on the yield of U.S. No. 1 was not as great. We conclude that late applications of metribuzin may be detrimental to potato

Table 4. Redroot Pigweed Control and Potato Yield, Location B—S.L.V.

Rate of metribuzin lbs/A	Date of Application	Stage of potato growth	Redroot pigweed control <sup>1</sup>	Potato yield cwt/A <sup>2</sup>	
				Total	U.S. No.1
0.75	May 30	none	9.3	307	139
1.5			9.5	293	124
0.75	June 11	10% emergence	9.4	299	143
1.5			9.3	300	132
0.75	June 20	50% emergence	9.3	289	143
1.5			9.7	315	156
0.75	June 29	6" High	8.8	295	144
1.5			9.3	266	118
0.75	July 11	18" High, just flowering	8.7	245*	93*
1.5			7.8	230*	88*
0.75	July 23 (a)	30" High, full bloom	7.8	254	112
1.5			7.8	252*	115
0.75	July 23 (b)	30" High, full bloom	8.3	235*	105
1.5			7.8	192*	74*
0	none	—	0	308	148

<sup>1</sup>0 = no control, 10 = complete control. Rating is an average of reps. each observed on dates.

<sup>2</sup>Yields computed from a machine harvest of 40 ft. of the center 2 rows of each plot.

\*Those marked with an asterisk yielded significantly less at the 5 percent level.

<sup>a</sup>Over the row nozzle plugged (See Figure 1).

<sup>b</sup>Level spray boom used.

yield and should not be employed. We are confident that earlier stages of growth are also susceptible to injury but we cannot yet define how much larger than 6" potatoes can grow before injury will occur.

These potatoes were furrow irrigated which requires a furrow about 10 inches deep. Because we have experience some problems with complete coverage of the soil with a level sprayer boom we designed a special potato boom. This boom (Figure 1) achieves complete row coverage. The

2. July 23 (b)—A standard level spray boom was used.

The boom was raised over the potato foliage in an attempt to simulate the coverage from aerial application.

The data show less effect from the late application when the over the row nozzle was plugged (July 23 (a)) than when the potato foliage was sprayed (July 11 and July 23 (b)). Therefore, it is likely that metribuzin's foliar activity is the prime cause of injury as opposed to soil action.

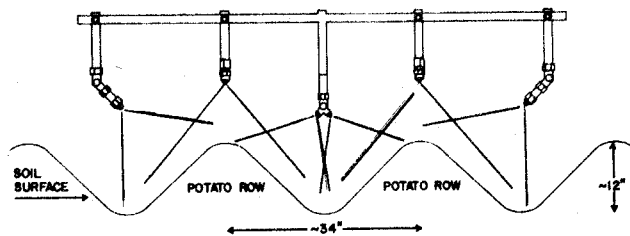


Figure 1. Experimental Potato Sprayer

boom was used for all treatments with the following exceptions:

1. July 23 (a)—The over the row nozzles were plugged so no herbicide was sprayed directly on the potato foliage.

## New Methods of Applying Preemergence Herbicides

P. Eugene Heikes<sup>1</sup>

A sizeable portion of the corn in Colorado is grown in the Eastern part and irrigated with center pivot sprinklers or gated pipe irrigation systems. The soil in this area is classified as sandy loam ranging from 70 to 85 percent sand, with 0.5 to 0.6 percent organic matter. Sandburs (*Cenchrus pauciflorus*) is the most troublesome weed in this area. The herbicides that have been most effective for control for sandburs must be soil incorporated and are commonly incorporated by double disking or similar type tillage equipment. This experiment was designed to study injecting herbicides into center pivot sprinklers and gated

<sup>1</sup>Colorado Extension Service, Fort Collins, Colorado.

pipe irrigation systems and soil incorporate herbicides with water rather than with mechanical means.

**CENTER PIVOT SPRINKLER:** This was a 180 acre circle. A surveyor's transit was used to lay out the plots. Each plot was 15 acres with a 3 acre check between plots; the main purpose of the check or buffer was to clean out the sprinkler system between treatments. There were eight different treatments with one 33 acre block where butylate was applied at 4 lbs. a.i. per acre. A Gifford-Hill type center pivot sprinkler was selected for this experiment. This make of sprinkler is electrically driven with an electric motor on each of the towers which controls the speed as the system moves across the field. The speed can be adjusted with a switch at the control center; this was adjusted to apply approximately 1/2" of water which wet the sandy loam soil between 8 and 10 inches.

The system was calibrated by running it over one-15 acre block, injecting water into the system and measuring the amount of water used. There was 35 gallons of water injected during the test run of 3 hrs. and 45 minutes. Herbicides were mixed in a 55 gallon barrel, bringing each treatment up to the 35 gallons of solution. The sprinkler was not shut off between plots but continued running with water over the three acre buffer.

The corn was planted May 9 and 10; herbicides were applied May 15-17.

**FIELD OBSERVATIONS:** Observations were made June 19; the corn was 8 to 12 inches high. It was evaluated for

control of sandburs, smooth pigweed, green foxtail and volunteer rye (seeded the previous fall) and corn injury.

**GATED PIPE INJECTION:** The purpose of this experiment was to evaluate the effectiveness of EPTC + R-25788 applied in irrigation water for control of grasses and broad-leaf weeds that emerge in the water furrow.

Every other row of corn was irrigated June 22 with the water/herbicide solution. The rows were 30" apart and approximately 2600 ft. long. An application of 4 lbs. EPTC a.i. per acre was applied. Irrigation water was run approximately half-way across the field before starting the herbicide injection; this took approximately 2 hours. The herbicide was injected into the water for another 2 hours, or 4 hours total for the water to reach the end of the rows.

First observations were made July 12. In the untreated rows, there was a dense stand of pigweed; in the rows where EPTC/R-25788 was injected with the first irrigation, there was almost no pigweed. A second observation was made September 4. The effect of the EPTC was also evident at the lower end of the field where waste water ponded.

Based on this experiment, it appears that soluble herbicides such as EPTC can be effectively applied by injecting into irrigation water. However, rate of the application will vary; for this reason, herbicides applied by this method should have at least a 2X safety margin.

#### HERBICIDES APPLIED BY CENTER PIVOT SPRINKLER

##### Holyoke, Colorado

Percent Stand Reduction—Observations 6/19

Herbicide and Rate a.i. per acre	Sandbur	Smooth Pigweed	Foxtail	Rye	Corn Injury	
					Stunt	Stand
EPTC/R-25788 (Eradicane) 4 lbs.	94	95	99	50	0	0
EPTC/R-25788 (Eradicane) 6 lbs.	99	100	99	50	0	0
vernolate 4 lbs.	97	100	95	50	0	0
vernolate/ cynazine 2 + 1 lb.	50	90	70	80	20	0
alachlor 3 lbs.	85	70	85	50	0	0
alachlor atrazine 2 + 1 1/2 lbs.	92	100	87	95	0	0
atrazine 4L 2 lbs.	95	100	90	95	5	0
atrazine 4L 2.4 lbs.	95	100	98	95	10	0
butylate 4 lbs.	65	90	80	40	0	0

**Problems Encountered by Adding Foaming Agents to Pesticide Sprays**

**Frank Black<sup>1</sup>**

During the past four years, the use of foaming agents with pesticide sprays applied through foam nozzles for reducing drift has become quite popular. Their use for brush control sprays is an accepted practice to reduce the drift of these sprays into nearby fields. Two years ago a few reports at the weed and pesticide conventions were given demonstrating crop injury from a few specific foamed spray combinations. In 1972 ICI America decided to investigate the phytotoxicity of a number of pesticide-foaming agent combinations. We selected corn and tomatoes for our test. The University of Delaware agreed to plant the crops and allow us to apply our sprays at their Georgetown Research Station. Forty-one separate spray mixtures were applied. Twenty-seven were applied to corn and thirty-four were applied to tomatoes. Two commercial foaming agents were selected; they will be referred to as Agent A and Agent B. Four experimental foaming agents were added to investigate the effect from chemical type. The chemical types in this study were two nonionic foaming agents and four essentially anionic agents.

Chemical Type

Agent A	Nonionic Ether
Agent B	Anionic Mixture
AL-1135	Nonionic Ester
AL-1172	Anionic
AL-1173	Anionic
AL-1174	Anionic

We selected standard insecticides and fungicides which are recommended for use on corn and tomatoes. They were Sevin 50W, Malathion 5E, Manzate and combinations. The 41 spray mixtures applied are shown in Table I.

Corn height: 11" to 14" at the time of spraying.  
 Tomato height: 13" to 15" at the time of spraying.  
 Sprayer: ICI America's Plot Sprayer with foam nozzle.  
 Dilution or gals. spray per acre: 20 GPA  
 The treatments were applied August 23 and August 24. The timing was as follows:

August 23

36 to 41: 8-10:00 (Rear half of tomato plots sprayed twice (2X).)  
 Sprayer Cleanout  
 1 to 7: 10-12:00  
 Sprayer Cleanout  
 12:00-2:00 Lunch and rest:

During this time, field next to corn plots was irrigated and eight of the treated plots in the corn were washed off. It is

<sup>1</sup>Development Associate, Specialty Chemicals Division, ICI America, Wilmington, Delaware.

questionable whether injury would occur with this short contact.

8 to 14: 2-3:00  
 Sprayer Cleanout  
 15 to 21: 3:30-5:00  
 Sprayer Cleanout

August 24

22 to 28: 9:00-10:30  
 Sprayer Cleanout  
 29 to 35: 10:30-12:00

Observations on August 24

Most of the sprays were causing definite injury to tomatoes, and there wasn't any apparent injury to the corn from the sprays applied on the 23rd.

September 12

35 mm color slides were taken of all the corn plots and 1/2 of the tomato plots. There was definite crop injury evident in the treatments on corn, but the damage to tomatoes had completely disappeared.

**DISCUSSION**

The study indicates that the combination of foaming agents with the insecticides Sevin or Malathion may be phytotoxic to corn or tomatoes under the conditions listed below:

Age of Crop: Corn 11 to 14 inches high. Tomatoes less than 15 inches high. Gallons of Spray per Acre: 20 GPA with 1% Foaming Agent. The levels for the pesticides per

**Table 1. FOAMING AGENT PESTICIDE TREATMENTS.**  
 Location: University of Delaware Georgetown Sub-station.

No.	Pesticide	Amount/Acre	Foaming Agent	%	Crop
1	Sevin 50W	3 lbs	None	0	Corn & Tomatoes
2	Sevin 50W	3 lbs	Agent A	1%	Corn & Tomatoes
3	Sevin 50W	3 lbs	Agent B	1%	Corn & Tomatoes
4	Sevin 50W	3 lbs	AL 1135	1%	Corn & Tomatoes
5	Sevin 50W	3 lbs	AL 1172	1%	Corn & Tomatoes
6	Sevin 50W	3 lbs	AL 1173	1%	Corn & Tomatoes
7	Sevin 50W	3 lbs	AL 1174	1%	Corn & Tomatoes
8	Malathion 5E	1 pint	None	0	Corn & Tomatoes
9	Malathion 5E	1 pint	Agent A	1%	Corn & Tomatoes
10	Malathion 5E	1 pint	Agent B	1%	Corn & Tomatoes
11	Malathion 5E	1 pint	AL 1135	1%	Corn & Tomatoes
12	Malathion 5E	1 pint	AL 1172	1%	Corn & Tomatoes
13	Malathion 5E	1 pint	AL 1173	1%	Corn & Tomatoes
14	Malathion 5E	1 pint	AL 1174	1%	Corn & Tomatoes
15	Sevin + Malathion	3 + 1 pint	None	0	Corn
16	Sevin + Malathion	3 + 1 pint	Agent A	1%	Corn
17	Sevin + Malathion	3 + 1 pint	Agent B	1%	Corn
18	Sevin + Malathion	3 + 1 pint	AL 1135	1%	Corn
19	Sevin + Malathion	3 + 1 pint	AL 1172	1%	Corn
20	Sevin + Malathion	3 + 1 pint	AL 1173	1%	Corn
21	Sevin + Malathion	3 + 1 pint	AL 1174	1%	Corn
22	Manzate	4 lbs	None	0	Tomatoes
23	Manzate	4 lbs	Agent A	1%	Tomatoes
24	Manzate	4 lbs	Agent B	1%	Tomatoes
25	Manzate	4 lbs	AL 1135	1%	Tomatoes
26	Manzate	4 lbs	AL 1172	1%	Tomatoes
27	Manzate	4 lbs	AL 1173	1%	Tomatoes
28	Manzate	4 lbs	AL 1174	1%	Tomatoes
29	Sevin + Manzate	3 + 4 + 1 pint	None	0	Tomatoes
30	Sevin + Malathion	3 + 4 + 1 pint	Agent A	1%	Tomatoes
31	Sevin + Malathion	3 + 4 + 1 pint	Agent B	1%	Tomatoes
32	Sevin + Malathion	3 + 4 + 1 pint	AL 1135	1%	Tomatoes
33	Sevin + Malathion	3 + 4 + 1 pint	AL 1172	1%	Tomatoes
34	Sevin + Malathion	3 + 4 + 1 pint	AL 1173	1%	Tomatoes
35	Sevin + Malathion	3 + 4 + 1 pint	AL 1174	1%	Tomatoes
36	None	0	Agent A	1%	Corn & Tomatoes
37	None	0	Agent B	1%	Corn & Tomatoes
38	None	0	AL 1135	1%	Corn & Tomatoes
39	None	0	AL 1172	1%	Corn & Tomatoes
40	None	0	AL 1173	1%	Corn & Tomatoes
41	None	0	AL 1174	1%	Corn & Tomatoes

**PLOT DESIGN  
GEORGETOWN SUBSTATION**

**CORN**

	15	9	2	1	5	20	12	
	3	18	36	11	40	13	4	
	9	14	⑦	④①	39	21	10	
		⑥	③⑧	16	37	17	8	
		③⑧	③⑦	③⑥	39	7	13	
		17	④	10	1	12	9	
2X 1X	37							
	16	8	15	3	6	19	40	
	41	21	14	11	20	2	5	18

Plots 20 ft. long — 1 row of corn 3.8 oz. of spray per plot. 50 psi.

○ Plots treated Wed. morning and irrigated Wed. noon for about 1½ hours.

◻ Irrigated Area.

acre: Malathion 5 lb. per gallon emulsifiable 1 pint per acre. Sevin 50W 3 pounds per acre. Foam Nozzle height above crop 12 to 16 inches.

The injury to tomatoes disappears three weeks after spraying probably because only about 10 to 20% of the leaf surface had intercepted the spray. The injury to the corn was probably increased because the majority of the spray collected and drained into the whorl or growing point of the plant.

The pesticides are completely non phytotoxic when the sprays do not contain foaming agents at the 1% level. Foaming agents at 1% level sprayed at 20 gallons per acre without either Malathion or Sevin generally resulted in practically no injury to corn. We observed the second day of spraying that the plots in tomatoes and the one plot in corn that had been given a double spray (2X) in the rear half of each treatment that moderate to heavy damage to the crop was evident in both tomatoes and the one corn plot. This 2X treatment would be about 40 gallons per acre for these straight surfactant sprays.

It was noted on September 12 that the treatments which showed the greatest injury to the corn seemed to have stopped all growth but it still had green and yellow leaves which appeared to be alive. This suggests that Malathion or Sevin may have growth regulating properties for grasses when combined with the right surface active agent.

Compatibility studies were conducted in our formulation laboratory to investigate the effect of foaming agents upon the dispersion of the pesticides in water. In a few cases, we found that specific foaming agents would effect the emulsion performance of some emulsifiable concentrates. We also found that in a few mixtures that the following might effect the dispersion of foaming agent plus pesticide spray mixtures.

1. Percentage foaming agent
2. Gallons per acre or dilution
3. Order of addition to the spray tank of each formulation.

The majority of our thirty-five spray mixtures gave satisfactory spray tank dispersions for the time necessary to apply each treatment.

**PLOT DESIGN  
GEORGETOWN SUBSTATION  
TOMATOES**

11	③⑥	29	21	24	④①	27	25
34	33	4	8	6	28	26	3
9	12	7	22	23	5	③⑨	31
13	35	10	14	④①	1	30	2

③⑧	11	32	③⑦	12	24	29	1
25	32	8	9	21	33	35	22
4	34	26	23	2	27	31	10
28	7	13	5	14	30	6	3

○ No duplicates: Upper half of each plot sprayed twice or at a 2X concentration. These plots were straight foaming agents with no pesticide plots—20 ft. long one row of tomatoes 3.8 oz. spray per plot. 50 psi. - 1 - Delavan Foam Nozzle.

**Table 2. PHYTOTOXICITY RATINGS ON CORN. Ratings Taken from Pictures Taken 9/12/72.**

Treatment	Remarks	Rating	Remarks	Rating	Rating Average
1. Ubs/A Sevin 50W		1		1	1
2. *Agent A	Stunted	7	Twisted	3.5	5.5
3. *Agent B	Wilted & Twisted	5		2	3.5
4. *AL-1135	Irrigated Stunted	5		2	3.5
5. *AL-1172	Stunted	7	Stunted	3.6	5.75
6. *AL-1173	Stunted	7.5	Irrigated	4	5.75
7. *AL-1174	Irrigated	1		2	1.5
8. 1 pr Malathion 5E		1		2	1.5
9. *Agent A	Wilted	7	Lodged	6.5	6.75
10. *Agent B	Wilted & Lodged	7	Stunted	6	6.5
11. *AL-1135	Wilted & Stunted	3	Twisted	4	3.5
12. *AL-1172	Wilted & Lodged	7.5	Stunted	5.5	6.5
13. *AL-1173	Wilted & Lodged	3.6	Wilted	2.5	4
14. *AL-1174	Lodged	9	Lodged	9	9
15. Mtl. & Sevin		1		2	1.5
16. *Agent A	Young Plants Stunted	8	Burned Leaves	6	7
17. *Agent B		7		6	6.5
18. *AL-1135	Stunted	2.5	Twisted	2.5	3.5
19. *AL-1172	Stunted	7.5	Stunted	7	7.25
20. *AL-1173	Wilted & Lodged	7.5	Wilted	7	7.25
21. *AL-1174	Lodged	8.5	Lodged	8.5	8.5
36. 1/2 Agent A	Irrigated	1		1	1
37. 1/2 Agent B	Irrigated	1	Twisted	2	1.5
38. 1/2 AL-1135	Irrigated	2	Irrigated	2	2
39. 1/2 AL-1172		2	Stunted	3.5	3
40. 1/2 AL-1173		1	Stunted	3.5	2.5
41. 1/2 AL-1174	Irrigated	1	Young Plants Border Row	6	1.5

Ratings: 7.5 or 1.5 or 1.6 Damage varied on plot.  
 Ratings: 1-No Effect, 2-Slight Damage; 3 to 5-Moderate Damage; 6 to 8-Heavy Damage; 9-Severe Damage.

### SUMMARY AND RECOMMENDATIONS

Caution is recommended when foaming agents are added to any pesticide spray; please test any new combination completely before recommendations are made to the grower. Test for spray tank compatibility and investigate the dilutions that the applicator might use and field test the combination for crop safety. Finally, determine the utility of the foaming agent to pesticide spray. Is it beneficial?

The commercial use of foaming agents with contact herbicides has demonstrated the utility of these adjuvants for reducing drift insecticide and "Agent A" are looking very promising for controlling the Spruce Budworm.

There is a place for foaming agents in pesticide sprays but let us be certain that we find the areas and mixtures where this type of adjuvant is beneficial.

### ACKNOWLEDGEMENT

We wish to express our appreciation to the University of Delaware for the planting of these crops and for allowing ICI America to use their Georgetown Substation for this study.

### Yellow Foxtail—The Most Serious Weed in California Alfalfa Hay?

Robert F. Norris and Carl A. Schoner Jr.<sup>1</sup>

The incidence of yellow foxtail (*Setaria glauca* (L.) Beauv.) in California alfalfa hay during the summer months

<sup>1</sup>Botany Department, University of California, Davis, and Cooperative Extension Service, Woodland, Ca.

is increasing. Observations indicate that the weed is able to outcompete alfalfa and cause premature stand loss. Botanical separations of yield from several locations at which different herbicides were used to control the weed showed that alfalfa yield was reduced by as much as 30% per cutting in the late summer and early fall. Incidence of the weed can be reduced by practices that optimize alfalfa vigor, such as controlling winter weeds and irrigating for maximum alfalfa growth.

Samples of yellow foxtail seed were obtained from several locations in the eastern U.S.A. These were grown at Davis and Woodland, and their growth and competitive ability compared with plants from seed of California origin. Plants grown from seed collected outside of California were not able to withstand the frequent cutting, and the competition afforded by the alfalfa. Native California plants not only survived, but competed with the alfalfa to the point where crop yields were considerably depressed.

All yellow foxtail plants grown from seed sources outside California showed an upright growth habit; those grown from California seed showed a very pronounced decumbent growth habit. The main culm and all tillers of California plants grew horizontal and remained within a few cm of the soil surface, except for the last one or two internodes. A right angle bend from horizontal to vertical at the last, or last-but-one node, permitted the culm to grow vertically and to place the inflorescence at, or above, the height of the alfalfa. This growth habit means that all meristems remain below cutter-bar height. We now feel that an ecotype of yellow foxtail has been selected which is adapted to survive California alfalfa cultural practices.

### Growth and Water Use Efficiency of Seven Annual Plant Species

Laurence O. Baker<sup>1</sup>

Seven annual plant species were seeded into a Bozeman silt loam soil. Rows were 30 cm apart x 6.1 m long. Plots were 3.04 m wide. Vegetation free plots of the same size separated each of the seeded plots. Steel access tubes were installed to 1.98 m under all except kochia, russian thistle and three bare plots where they were installed 2.74 m deep. The soil was sampled weekly for soil moisture with a Troxler Neutron Probe beginning July 1st. Vegetation was also sampled weekly by clipping one m of row to ground level.

Approximately 37 cm of water were present in the soil July 1st. Precipitation totaling 10.8 cm was received during July, August, and September. During the first week in August increased growth on border rows was first observed. This became more prominent on the kochia and redroot pigweed plots and at maturity plants in the first and second row bordering the bare plots were 25-35 cm taller than plants in the center of the plot.

<sup>1</sup>Plant & Soil Science Dept., Montana State University.

Above ground dry matter production ranged from about 4300 kg/ha from cow cockle and green foxtail to more than 16,000 kg/ha from russian thistle. Russian thistle produced almost 4,000 more kg/ha on the same amount of water as kochia. Cow cockle, spring wheat and wild oat matured first. Redroot pigweed, russian thistle and kochia continued growing until killed by frost.

Water use ranged from 17.1 cm (green foxtail) to 34.2 cm (kochia). Figures will be presented to show the amount of water used by each specie and the depth from which the water was taken.

Russian thistle used water more efficiently than any other specie with the ratio of 209 grams of water required for each gram of above ground dry matter produced. Kochia, redroot pigweed and wild oat were approximately equal in water use efficiency with a ratio of about 275. Only green foxtail and cow cockle were less efficient than wheat.

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#### A Device to Measure Soil Temperature Variations Over a Large Range of Time Intervals

S. Tamez, R. M. Menges and J. R. Wayland<sup>1</sup>

*Abstract.* A device that measures the temperature to an accuracy of  $\pm 0.5^{\circ}$  C is discussed. By the use of an automatic recording device the temperature of up to 50 different points is made using thermocouples in 3-mm (diam) soil probes. Response time is 2 sec. The construction of probe holders to give both horizontal and vertical temperature profiles of soil is described. The unified field instrument is made by the addition of a two-wheeled cart and auxiliary power generator. Several applications are shown.

<sup>1</sup>Agricultural Research Technician and Research Leader, Subtropical Texas Area, Southern Region, Agricultural Research Service, U.S. Department of Agriculture, Weslaco, Texas 78596 and Assistant Professor, Department of Physics, Texas A&M University, College Station, Texas 77843, respectively.

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#### Response of Rush Skeletonweed to Selected Herbicides using Various Application Methods

Roland Schirman<sup>1</sup>

*Abstract.* Field infestations of Rush Skeletonweed (*Chondrilla juncea*) near Spokane, Washington, were treated with selected herbicides during the period 1965-1971. Application was made as a broadcast spray, shank injection, or solid layering.

Fall applied picloram at rates greater than one-half pound per acre gave acceptable control regardless of method of application. Temporary suppression was attained

<sup>1</sup>USDA ARS Dept. of Agronomy & Soils, Washington State University, Pullman, Wash. 99163.

with surface and solid layer applied dicamba, dichlobenil or fenac. Phenoxy herbicides applied as a spray in the spring prior to bolting also gave temporary suppression while layering of these materials and trifluralin was totally ineffective.

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#### Interactions of Weed and/or Weevil Control on Weed Growth and Weevil Populations in Established Alfalfa

Robert F. Norris and Warren R. Cothran<sup>1</sup>

Winter weeds in established alfalfa reduce crop vigor, and can cause reductions in yield and quality for several cuttings. Attacks by the larvae of the Egyptian alfalfa weevil (*Hypera brunneipennis* Boh.) severely damage the first, and in combination with the adults the second, cutting of alfalfa. Herbicides can be employed to control the weeds, and insecticides are used to control the weevil larvae.

Controlling winter weeds has consistently increased the size of the weevil larval population during the last three years. Weed control with diuron in 1971 resulted in a 10% increase in weevil larvae in comparison with the untreated check. GS-14254 (2-sec-butylamino-4-ethylamino-6-methoxy-s-triazine) provided essentially complete weed control in 1972, and caused a 26% increase in numbers of weevil larvae. GS-14254 applied to different fields in 1973 resulted in 80% and 60% increases in weevil numbers. These increases in weevil larvae have also been noted for treatments with insecticides when comparing with and without weed control.

The insecticides heptachlor, azinphosmethyl, or carbofuran have been used experimentally to control weevil larvae. These treatments have resulted in increased yields of weeds at the first cutting. Earlier treatments provided the largest increases in yield of weeds. The degree of effect ranged from none to 20% increases, which depended on the species of weeds present, their density, and the stand density of the alfalfa.

It is evident that weed control can alter weevil attack in alfalfa, and that insecticides used for weevil control can increase weed growth. Integration of weed and weevil control practices is essential for optimum productivity and quality.

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<sup>1</sup>Botany and Entomology Departments respectively, University of California, Davis.



## Plant Protection—What Is It?

Lambert C. Erickson<sup>1</sup>

Education has always been a top rung priority in this Western Weed Society or Conference. My personal file begins with the Minutes of the WWCC (7th Annual) meeting in Boise, in June 1945. Education, and especially extension education, was discussed at length at that meeting. I found some most charming research remarks given at that meeting. Dr. Robbins was sure that "something new had been added." Clarence Seely said, "What the eventual place of 2,4-D will be, no one knows for sure." Bill Harvey said, "Morning glory is one of the easiest of the perennial weeds to kill, and about 300 g.p.a. of solution seemed ample." "We've come a long way, baby."

The first reference to higher education in weedology appears to be a summary statement in 1948, again by that towering giant in this field, W. W. Robbins, in which he said, "We have sadly neglected the educational phases of weed control; this pertains to resident instruction in colleges of agriculture and to extension departments." In 1949 Professor Morris of Montana State, speaking as a panel member on Education and Publicity, offered the following. "A weed specialist should have fundamental training in systematic botany, plant physiology, plant anatomy, inorganic and organic chemistry, some principles of engineering, and mechanics and soils. Then he should be trained in applied crop production and crop and weed ecology." In 1950 (12th Annual Weed Conference) Dr. Robbins reported on a survey "Instruction in Weeds and Weed Control in the 12 Western States." Four of the 12 states offered undergraduate weed courses ranging from 2 to 7 credits, and ranging from 5 to 80 in student enrollment. He concluded, "There is serious need for more weed courses at both the undergraduate and graduate level."

The first formal presentation on weeds in academia was apparently made by Dr. Foy, "Educational Requirements for Careers in Weed Control," before this Society in 1963. He at that time reported a survey of 72 institutions showing:

1	institution	had	4	courses	in	weed	control
6	"	"	3	"	"	"	"
18	"	"	2	"	"	"	"
25	"	"	1	"	"	"	"
14	"	"	0	"	"	"	"

8 institutions did not respond, probably no courses offered.

During the 13 year interval, 1950 (Robbins report) to 1963, there appears to have been a real improvement in the percentage of institutions offering Weed Science courses; from 66.67% in 1950 to 69.44 in 1963.

Dr. Foy did an excellent job of reviewing variations in the curriculum to fit the anticipated knowledge requirements at the B.S., M.S. and Ph.D. levels. He stated, "Normal adequate training (in applied weed control) involves such fundamental and applied sciences as:

Agricultural Engineering  
Agronomy  
Biometry  
Botany  
Horticulture  
Inorganic Chemistry  
Mathematics  
Organic Chemistry  
Physics  
Plant Anatomy  
Plant Biochemistry  
Plant Physiology  
Plant Taxonomy  
Weed Control

He continued, "Well balanced training in the fundamental and applied sciences is stressed for those planning careers in weed control."

In reviewing the four curricula presented by Dr. Foy it is conspicuous that "Weed Control" suggested one course. Progress in these 30 years (December 1944 to 1974) now dictates that the curriculum title be changed from Weed Control to Weed Science and that the discipline contain from 2 to 5 or more specific courses and that they be given in the following order:

- B.S.—include Weed Biology (taxonomy, geography, ecology)  
Weed Control (cultural chemical aspects)  
M.S.—include the above courses, plus weed anatomy, ecology, physiology, properties and functions of herbicides.  
Ph.D.—include above plus advanced systematics-aquatics; advanced seed anatomy, morphology, physiology; advanced herbicide chemistry; statistical analyses of methodologies.

The above proposal suggests that a curriculum in Weed Science approximate the following:

6	semester	credits	in	Weed	Science	for	the	B.S.	degree
12	"	"	"	"	"	"	"	M.S.	"
21	"	"	"	"	"	"	"	Ph.D.	"

The WSWS should take the lead in presenting a quality curriculum and standards of training qualifications for representative levels in the discipline of Weed Science.

Thus far what I have said is prelude and prologue to the initial question in the title of this paper, Plant Protection—What Is It?

Many meetings of national scope have been held on this topic. Some of note are:

1. RICOP Meeting, January 1972, Washington, D.C.
2. RICOP Meeting, June 1972, St. Louis, Mo.
3. Workshop on Pest Management, December 1972, Honolulu, Hawaii.
4. "Present Status of Undergraduate Programs in Plant Protection in the United States. Houston B. Couch, Head, Plant Pathology, Virginia Poly. Institute, September 1973.

This last report gives this information:

Of 55 Land Grant Institutions queried on Plant Protection, 42 responded to the questionnaire as follows:

<sup>1</sup>University of Idaho, Moscow, Idaho.

22 now had or would have Pl. Prot. in 1973-74 year, 10 reported plans for having such a program by 1975-76, 10 reported no plans in Plant Prot. in foreseeable future.

A summary of 19 institutions showed a wide variation in curriculum or option content. Of the many inputs in the mentioned curricula, I chose to evaluate three disciplines which are involved in Plant Protection or Pest Management: entomology, plant pathology and weed science. Among 21 program entries the credit hours in these disciplines were:

Entomology, 9.4 average, with a range from 3 to 18

Plant Pathology, 9.4 average with a range from 4 to 24

Weed Science, 3.6 average, with a range from 0 to 7

Other titles given this combined study field were: Economic Biology, Plant Health Technology, and Plant Health Specialist. Another interesting entry in the survey is Pest

Management. In credit hours it ranged from 0 to 37. We should ask, what is it?

Since, under Plant Protection, we find Weed Science omitted three times, and then, when mentioned, with a maximum of 7 credits, versus 18 for Entomology, and 21 for Plant Pathology. The respective average credits are 3.5 for weeds versus 9.4 for the other two fields.

It's time we asked ourselves, what is weed science? We learn that in this field of plant protection its worth 3.5 credits. Is the weed problem only 16% of Plant Protection? That's what academia is telling us. I believe it should be a time for decision at this meeting. It's time we returned from this meeting with a statement in hand to our respective administrations and to WSSA for national action.

#### Curricula and Options in Plant Protection, Pest Management etc., in Nineteen States.

Curr. or Opt.	Title	In Institution	Year estab.	Ent.	Pest Mgt.	Pl. Path.	Weed Sci.	
C	P. Pro	Arizona	69-70	10		9	3	
C	P. Pro	Arkansas	70-71	12		12	6	
C	P. M.	Calif., Berkeley	72-73	11	37	24		
C	P. Pro.	Calif., Davis	67-68	16	6	8	4	
C	E. Bio.	Clemson U.	73-74	3		12		
?	P.M. & P. Pro.	Florida U.	?	9	6	6	3	
C	P. Pro.	Idaho	73-74	7	7	7	7	
o	P. Pro.	Illinois	62-63	7		6	3	
O	P. Pro.	Kansas State	73-74	12	10	5	3	
C	P.M. & P. Pro.	Main U.	?	4	8	4	2	
O	P.H.T.	Minnesota	73-74	11		21	5	
O	P. Pro.	Mississippi U.	66-67	13	8	11	3	
O	P. Pro.	Montana State U.	73-74	7		7	4	
C	P. Pro.	Ohio State U.	73-74	8	4	8	3	
O	PHS	Oklahoma State	?	8		12	4	
O	P.M. for P. Pro	Oregon State-Agr.	72-73	10	10	5	5	
o	" " -Ent.	" " -Ent.		18	8	5	4	
C	P. Pro.	Purdue Univ.	72-73	3	2	9	7	
O	P. Pro.	Texas A & M-Bio. Sci.	73-74	3	3	6		
	" " -Pl. Prot.	" " -Pl. Prot.		12	3	6	6	
C	P. Pro.	Virginia Poly.	73-74	14	9	11	4	
Average					9.43	5.77	9.4	3.58
Range					3-18	0-37	4-24	2-7

PM = Pest Management; E. Bio. = Economic Biology; PHT = Plant Health Technology; PHS = Plant Health Specialist.

The University of Idaho

College of Agriculture

Announces

A CURRICULUM IN PLANT PROTECTION

This curriculum will be offered beginning this Fall Semester 1973. The objective is to prepare students for professional careers in the broad field of Plant Protection. The program integrates the fields of Entomology, Plant Pathology and Weed Science to produce individuals with broader concepts and understanding of our agricultural, food, and broader environmental problems. Students so trained should have broader choices in selecting careers.

Hereafter is the course outline in Plant Protection--Bachelor of Science in Agriculture.

COURSE		CREDITS
Agriculture 203	Environmental Pollution	3
Agriculture 400	Seminar	1
Agriculture 499	Plant Protection Practicum (directed 4 week summer study, junior year)	4
Agricultural Economics 101	Agr. & Its Social & Economic Environment	3
Agricultural Mechanization 112	Engineering Applied in Agriculture	3
Bacteriology 250	General Bacteriology	4
Biology 201	Introduction to the Life Sciences	4
Biology 202	General Zoology	4
Biology 203	General Biology	4
Biology 331	General Ecology	3
Botany 241	Systematic Botany	3
Botany 432	Plant Ecology	3
Business 365	Business Law	3
Chemistry 111	Principles of Chemistry	4
Chemistry 112	Inorganic Chemistry & Qualitative Analysis	5
Chemistry 277, 372	Organic Chemistry I, II	6
English 101	English Composition	3
English 201	Language and Literature	3
Entomology 211	General Entomology	4
Entomology 322	Economic Entomology	3
Fish, Wildlife, Range Mgm't. 314	Fish & Wildlife Population Ecology	3
Geology 401	Atmospheric Environment	3
Math 140	College Algebra	3
Plant Science 303	Principles of Plant Pathology	3
Plant Science 338	Weed Control	3
Plant Science 404	Plant Disease Identification & Control	4
Plant Science 405	Biology of Weeds	3
Soils 205	General Soils	3
	Humanities & Social Sciences	14
	Physical Education Activities	2
	Speech	2
	Elective Credits	23
	TOTAL SEMESTER CREDITS	136

## MINUTES OF THE BUSINESS MEETING

MARCH 14, 1974

President Burgoyne called the meeting to order at 8:06 a.m. with thirty-nine members in attendance. Minutes of the 1973 WSWs business meeting were accepted as printed in the Proceedings of WSWs, Vol. 26 by unanimous vote.

### Nominations Committee Report

K. W. Dunster, H. P. Alley, T. Hall

Chairman Dunster reported that 171 members cast ballots with the following results:

President-elect ----- W. L. Anliker  
 Secretary ----- J. O. Evans  
 Chairman-Elect, Research Section ---- R. L. Zimdahl  
 Chairman-Elect, Education Section ----- R. J. Burr

#### Constitutional Amendments:

- a. Article III, Section 3—the designation of Honorary Members will be changed to “Fellows”. (passed)
- b. Article VIII, Section 2—in the event of dissolution of WSWs, assets will be dispersed in conformity to IRS regulations for non-profit organizations (passed).

The appointment of D. E. Bayer to complete A. P. Appleby's term as WSSA Representative was announced.

### Treasurer-Business Manager Report

Treasurer-Business Manager Anderson presented the financial statement of WSWs from March 1, 1973 to March 10, 1974.

#### Income

On hand March 10, 1973 .....	\$4,567.08
Registration, Spokane Meeting (223) .....	657.00
Dues, members not attending Spokane Meeting .....	93.00
Spokane luncheon tickets .....	456.00
1973 Research Progress Report .....	1,380.10
1973 Proceedings .....	1,518.50
Sale of old publications .....	198.00
Payment of outstanding accounts .....	30.10
Industry contributions for coffee .....	100.00
Advance order payments .....	32.00
Interest on savings .....	17.24
	\$9,490.02

#### Expenditures

Annual meeting incidental expenses .....	\$ 443.91
Spokane luncheon .....	447.93
1973 Research Progress Report .....	1,325.00
1973 Proceedings .....	1,525.00
Office supplies .....	140.88
Business Manager Honorarium .....	250.00
Postage .....	318.60
Plaques for Fellows, Past Presidents .....	258.00
	\$4,709.32

### Liquid Assets

Savings .....	\$2,600.00
Checking Account .....	1,719.70
Cash on hand .....	20.00
Accounts Receivable .....	39.00
Potential Net Worth	\$4,378.70

### Finance Committee Report

G. Massey, W. L. Gould, L. W. Jordan

Chairman Massey reported that an audit of the Financial Report indicated that the books were in good order. The Financial Statement and Auditing Committee Report was accepted unanimously by members present.

The increased registration fees as determined by the Executive Committee were announced. The Registration Fee was increased from \$5.00 to \$10.00 and the cost of the Proceedings and Research Reports remain the same at \$5.00 each. There is a \$2.00 membership fee for those who are unable to attend the WSWs Meeting.

### Site Selection Committee Report

In the absence of Chairman A. Ogg, the selection of Sacramento as the site of the 1977 meeting was announced. Other locations will be Phoenix in 1975 and Portland in 1976.

### Local Arrangements Committee, 1975 Site

F. Arle, Chairman of the 1975 local arrangements, announced that the meeting will be held at the Del Webb Townhouse on March 18, 19, 20.

### Resolutions Committee Report

H. Kempen, D. Hall, W. Anliker

W. L. Anliker, substituting for Resolutions Committee Chairman Kempen, presented three resolutions for consideration by the WSWs membership.

#### Resolution No. 1

WHEREAS: weeds reduce efficient food, feed and livestock production, impair human and animal health as well as despoil recreational waters, parks and wildlife habitat, and

WHEREAS: most serious weeds are introduced from foreign lands as a result of foreign commerce and travel, and

WHEREAS: such weeds are not subject to interception or eradication by U. S. Department of Agriculture inspectors at our ports of entry, as is the case with insects, plant diseases and nematodes,

THEREFORE, be it resolved that the Western Society of Weed Science, at convention at Kaanapali, Maui, Hawaii, support the provisions of Senate Bill 2728, a bill which provides for regulatory measures against importation and interstate movement of noxious weeds as well as suppression, control or eradication of any newly introduced noxious weeds of foreign origin.

The resolution was adopted unanimously by the WSWWS membership present to be sent to the Chairman of the Senate Committee on Agriculture and Forestry, Senators of the 12 western states and the WSSA.

#### **Resolution No. 2**

WHEREAS: weed scientists of the Western Society of Weed Science have conducted extensive research on the effectiveness, economic value and potential for environmental side effects of the herbicide 2,4,5-T, and

WHEREAS: usage for vegetation management in forests and rangeland, or on roadways, railroads, utility rights-of-way and all other previously registered uses has shown no undue hazard to human or animal health after 25 years of usage, and

WHEREAS: loss of the herbicide 2,4,5-T would increase fire hazards, reduce grazing capacity of rangeland, profoundly affect efficient timber production, increase maintenance costs and reduce management options for wildlife management,

THEREFORE, be it resolved that the Western Society of Weed Science, at convention at Kaanapali, Maui, Hawaii, communicate to officials of the Environmental Protection Agency responsible for evaluating 2,4,5-T, that the Society feels that the public interest is best served by continued registration and usage of 2,4,5-T and requests this resolution be made part of the 2,4,5-T hearing record.

This resolution was accepted unanimously by the members present after a minor amendment. Senators of the 12 western states, WSSA and participants in the EPA hearings on 2,4,5-T were designated as recipients of this resolution.

#### **Resolution No. 3**

WHEREAS: the Western Society of Weed Science has had the privilege of having their 1974 meeting at the beautiful Royal Lahaina Hotel, and

WHEREAS: the services provided by personnel of the hotel and Island Holiday Tours were exceptional,

THEREFORE, be it resolved that the Western Society of Weed Science express its appreciation to those who made the stay so pleasant, namely: Mr. Bill Baker, Manager of the Royal Lahaina Hotel; Stephanie Hoe, Convention Coordinator; and Claudia Wood, Supervisor of Conventions.

This resolution was adopted unanimously by the WSWWS membership present.

#### **The Ad Hoc Editorial Committee Report**

**G. Lee, E. Schweizer, J. Evans and R. Comes**

Chairman Lee presented recommendations of the committee regarding papers submitted for the Progress Report. The WSSA accepted common names for weeds and chemical names will be used and an index of chemical names will be provided in the Progress Report. An explanation of the new editorial rules will be sent out with the call for papers. Members submitting papers will be advised of the receipt of these papers by the Project Chairman to avert problems due to loss in the mail.

#### **WSSA Representative Report**

Representative Appleby reported that the 1974 meeting of the WSSA was held at Caesars Palace Hotel in Las Vegas, Nevada. A record 907 persons registered for the conference and 225 ladies were registered for the ladies program.

The Board of Directors met on February 11 with President Earl G. Rogers presiding and again on February 14 with the new President, E. L. Knake, presiding. Other new officers of WSSA are President-elect, C. R. Swanson and Vice-President, A. P. Appleby, with R. D. Ilnicki continuing as Secretary. New members of the Board of Directors are Robert Sweet, Member-at-Large; W. F. Donnelly, Northeast Representative; M. G. Merkle, Southern Representative; J. L. Williams, North-Central Representative; W. J. Saidak, Canada Representative; and M. K. McCarty, Chairman of the Constitution and Operating Procedures Committee.

A summer meeting of the Executive group of the Board of Directors is planned for mid-July.

WSSA had another successful financial year with \$30,000 added to the reserve fund. Fred Slife will retain the office of Treasurer of the Society, but many of his former duties will be assumed by a new Executive Secretary, Mr. Claude Cruse, who will be located in Urbana, Illinois.

T. J. Sheets will serve as Editor of the Society, D. E. Davis will become the new Manager-Editor of WEED SCIENCE, and G. A. Buchanan remains as Editor of WEEDS TODAY. WEEDS TODAY is continuing to grow and appears to be on a firm financial base. The possibilities of incorporating WEEDS TODAY for business reasons is being investigated. The third edition of the Herbicide Handbook is expected to be available in mid-May 1974. A new monograph on "Surfactants and Herbicides" is projected for publication in approximately February 1975. The WSSA Newsletter is well established and well received by the members. Input from all members of items of interest to WSSA is solicited.

A new logo has been adopted and will appear on publications and stationery of the Society.

Awards for outstanding work in teaching, research and extension were presented to J. D. Nalewaja, D. E. Davis and H. A. Friesen, respectively. The outstanding paper award went to J. T. Daniel, G. E. Templeton, R. J. Smith and W. T. Fox of the University of Arkansas for their paper entitled, "Biological Control of Northern Joint Vetch in Rice with an Endemic Fungal Disease". R. H. Beatty was given a special Founders Award for contributions made during the formation of the Society. Special awards were presented to Mr. and Mrs. Fred Slife and Mr. and Mrs. T. J. Sheets for extraordinary contributions to the Society in past years. Beginning next year an award will be presented to an outstanding graduate student in weed science.

The 1975 WSSA meeting will be held in the Statler-Hilton Hotel in Washington, D. C. on February 4-6. Future meetings will be held in Denver, Colorado in 1976; St. Louis, Missouri, 1977; Dallas, Texas, 1978, San Francisco, California, 1979 and probably Toronto, Canada in 1980.

## Education and Regulatory Section Report

Chairman Lange reported briefly on the activities of this section. The discussions on weed control recommendations indicated a trend toward guidelines rather than specific recommendations. C. Elmore will be Chairman in 1975 and R. J. Burr is Chairman-elect.

## Research Section Report

Chairman E. Schweizer briefly summarized the activities of the seven project meetings and commended the Project Chairmen. Results of the elections of new Project Chairmen were as follows:

Project 1. Perennial Herbaceous Weeds—1975 Chairman, A. Gale; Chairman-elect, D. Swan.

Project 2. Herbaceous Weeds of Range and Forest—1975 Chairman, R. Schirman; Chairman-elect, W. Cooley.

Project 3. Undesirable Woody Plants—1975 Chairman, S. Radosevich; Chairman-elect, R. Stewart.

Project 4. Weeds in Horticultural Crops—1975 Chairman, H. Kempen; Chairman-elect, D. Peabody.

Project 5. Weeds in Agronomic Crops—1975 Chairman, D. Brown; Chairman-elect, J. Orr.

Project 6. Aquatic and Ditchbank Weeds—1975 Chairman, F. Oliver; Chairman-elect, V. Bruns.

Project 7. Chemical and Physiological Studies—1975 Chairman, A. Ogg; Chairman-elect, G. Booth.

### Project 1 Report — Perennial Herbaceous Weeds — Warren Purdy, III.

The project met for two hours Wednesday afternoon, March 13, 1974. Over 45 people were in attendance during the presentations made by Dr. Robert Osgood of the Hawaiian Sugar Planters Association Experiment Station, and Dr. David Williams of Maui Land and Pineapple Company.

Major topics covered were current weed control practices in the two major Hawaiian crops as well as research into new compounds available for perennial weed control.

Adaptive research on glyphosate, metribuzin and asulam in sugar cane were discussed at some length. Dr. Williams touched on the problems of gaining clearance of herbicides in minor crops such as pineapple.

Chairman for 1975, Alvin F. Gale of University of Wyoming; Chairman-Elect, Dean Swan of Washington State University.

### Project 2 Report — Herbaceous Weeds on Range and Forest

Dr. Sheldon Whitney, Department of Agronomy, University of Hawaii, was the guest speaker. He described and discussed the various ecological zones in the Hawaiian Islands and the characteristics of the rangelands in each zone.

A short discussion on the uses of Asulam in forests for control of bracken fern and on rangelands for control of some problem weed species was conducted by Wayne Cooley.

A discussion on the uses of atrazine in rangeland improvement was held with contributions from Dale Christensen, Roland Schirman, Larry Baker and Harold Alley.

Mr. A. Wayne Cooley became Chairman-elect to succeed Dr. Roland Schirman, Chairman for 1975. There were 21 people in attendance.

### Project 3 Report — Undesirable Woody Plants

Between 25 and 30 attended the Project 3 meeting. A series of short informed presentations were made covering several new herbicides.

- a. Dr. Al Baber—discussed Krenite covering its potential utility and performance characteristics.
- b. Dr. Jack Warren—discussed Dowco 233 covering its spectrum of activity and some of its environmental advantages.
- c. Mr. Ron Oliver—discussed selective removal of woody perennials using non-selective herbicides.

Subject 2 covered developing guidelines to be used in writing environmental impact statements. It was found that most federal and state organizations already have their own guidelines. Therefore, it was decided it would be inappropriate to develop guidelines at this time.

Subject 3 centered around a discussion expressing the need for a comprehensive study of the presently registered and potential herbicides for woody plant control. It was proposed and seconded that the chairman select a committee to collect the data necessary to compare the various chemicals as their performance relates to specie. The data is to contain percent defoliation, percent top kill and percent plants dead.

Chairman 1975, Dr. Steve Radosevich; Chairman-Elect, Dr. Ron Stewart.

### Project 4 Report — Weeds in Horticultural Crops

Section Meeting Summary — Maui, Hawaii—1974—K. W. Dunster.

Incoming Chairman (1974/75)	Harold Kempen
Chairman Elect (1975/76)	Dwight Peabody

Discussion emphasis was placed on the status and potential of reduced tillage programs and comparative characteristics of dinitroaniline herbicides. Audience participation (44 registered) was excellent in both categories with allotted time rather than interest the limiting factor.

### Reducing Mechanical Energy Requirements—Clyde Elmore

Herbicides are used to a considerable extent to reduce mechanical energy requirements in tree and vine crops. Perennial weeds may become more of a problem as susceptible annual weed competition is removed. Less work has been designed to accomplish reduced tillage programs in horticultural row crops. It was generally agreed that engineering (planting equipment) and production (plant production) aspects must be integrated in the weed control program before non-tillage potential can be adequately assessed.

## **Dinitroaniline Herbicides – Similar but Different – Harold Kempen**

It was generally recognized that herbicides of the dinitroaniline class differ to some extent in terms of crop and weed tolerance patterns and soil residual properties. There was considerable discussion relative to what constitutes adequate control of resistant weed species without reaching common agreement. There is need for continued comparative evaluation to further define strength and weakness of each member of the "yellow chemistry" group under different production regimes.

### **Project 5 Report – Weeds in Agronomic Crops**

Project 5 met on Wednesday afternoon with about 50 participants engaging in lively discussion for the full 90 minutes. Mr. Dean Brown of Monsanto Company will be chairman for the 1975 meeting and chairman-elect is Mr. Jack Orr, University of California at Sacramento.

Dr. Bob Zimdahl gave a report on the wild oat symposium held following the 1974 WSSA conference and led a half-hour discussion on wild oats, and their control or lack of control. There was general agreement that the current high grain prices have completely changed the economic picture.

Dr. L. C. Erickson introduced and led a discussion on weed biotypes and their difference in herbicide tolerance. The group agreed that use of good management practices, including herbicide rotation would keep the problem to a minimum.

Dr. Floyd Colbert led a discussion on safety in weed control research and related government regulations. The general lack of input into these regulations by members of the Society is causing concern. There seemed to be a general lack of knowledge of the best methods of making our thoughts known.

### **Project 6 Report – Aquatic and Ditchbank Weeds—Chairman, N. E. Orto—Attendance Total: 30 members.**

New Chairman-elect elected: Mr. V. F. Bruns, Research Agronomist, Agricultural Research Service, USDA, Irrigated Agriculture Research and Extension Center, Prosser, Washington 99350.

Chairman for 1975: Mr. Floyd Oliver, Management Agronomist, Pacific Northwest Regional Office, U. S. Bureau of Reclamation, Department of Interior, U. S. Courthouse, Box 043, Boise, Idaho 83702.

The project meeting got underway with a presentation of the experiences that the Kekaha Sugar Company, Ltd., Maui, has had, using the herbivorous fish *Tilapia Mossambica*. The introduction of this fish in irrigation and drainage canals on sugarcane plantations has resulted in excellent submersed aquatic weed control that has reduced annual submersed aquatic weed control to zero. Water temperature limits the range of introduction of this fish in canals.

Methodology used by the Agricultural Research Service, USDA, at Prosser, Washington, to study the effects of herbicide residues in irrigation water on crops was the

second discussion subject of the project meeting. Both furrow and sprinkler irrigation methods are included in these studies. Effects of various herbicide residues in irrigation water such as 2,4-D, TCA, dalapon, silvex, dichlobenil, acrolein, xylene, and glyphosate have been evaluated. Much of the information from these tests on crop residues from irrigated agriculture has been used to support registration petitions and establishment of use recommendations.

The status of registration and use of pesticides for aquatic sites was discussed. The Bureau of Reclamation, Department of Agriculture, Bureau of Sport Fisheries and Wildlife, and Corps of Engineers in cooperation with industry have been actively engaged in the past few years to obtain Federal registration of aquatic herbicides used on their projects. Compounds that have recently had tolerances established and/or have been registered by EPA for use in and around aquatic sites are 2,4-D, DMA,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , xylene, and acrolein.

Although some progress has been made in obtaining clearance to use certain herbicides on aquatic sites, many problems have yet to be resolved, including establishment of aquatic herbicide registration protocol.

A brief discussion covered the use of endothal compounds for submersed aquatic weed control. The mono and diamine oxides of endothal have been found to be active aquatic herbicides in pond experiments, but have not yet been evaluated in irrigation canals. These compounds were also reported to show promising results in rice fields. These oxides are of particular interest because they exhibit lower fish toxicity than do the amine salts of endothal.

The use of low-rate copper sulfate applications in western irrigation canals for rooted aquatic weed control was the final discussion subject. A brief history of the development of the technique through present use recommendations was given. The technique of semicontinuous application of dry copper sulfate crystals throughout the irrigation season will suppress rooted aquatic weed growth. The procedure was recently approved for use by establishment of a Federal label.

### **Project 7 Report – Chemical and Physiological Studies**

Between 75 and 100 people attended the Tuesday afternoon session. Previously selected speakers introduced topics for discussion by presenting brief reports. These were followed by general discussion.

Dr. Paul Keeley reported on studies designed to determine the effect of repeated annual applications of dinitroaniline herbicides on their soil persistence. His data show that repeated annual applications do not result in an accumulation of dinitroanilines in soil or a decrease in the rate of degradation. Residues 15 months after the last application were reduced but still injured sensitive plants. After 30 months no phytotoxicity was detected.

The second discussion was related to the first in that it centered on appropriate analytical methodology for soil degradation studies. Several attendees expressed varied opinions. It was generally agreed that there are several approaches to soil extraction and analysis for herbicides. Each

method has its advantages and disadvantages but there have been instances where the methodology employed raises serious questions about the results reported.

Dr. Norris reported on his continued studies with phenmedipham and the apparent but unexplained effect of light on its activity. His preliminary data seem to indicate a greater phytotoxicity when phenmedipham is sprayed in the morning as opposed to the late afternoon.

Dr. Appleby opened the largely unexplored area of herbicide-insecticide interactions and in his work a dramatic increase in phytotoxicity of the herbicide—terbacil. Terbacil has been used successfully for weed control in mint with evidence of phytotoxicity to mint appearing readily, even at high rates. However, when terbacil is applied in combination with the soil applied insecticide—dyphonate (as well as some others) its phytotoxicity is increased and nearly complete kill of mint may result under some conditions. Injury symptoms have been more severe when terbacil was combined with organo-phosphate as opposed to carbamate insecticides.

The last topic concerned life history studies that have been performed on Canada thistle by Dr. Hodgson. Because of time limitations the subject of life history studies that have been or should be conducted on problem weeds of the West was not thoroughly explored. Dr. Hodgson's studies have established the reasons for the greater effectiveness of 2,4-D when applied at the pre bud stage of growth. He has shown that this is the time when root reserves of carbohydrates are lowest and therefore the plant is weakened. The variable lipid content of ecotypes of Canada thistle have also been described.

Dr. Alex Ogg (USDA/ARS, Prosser, Washington) is Chairman of the 1975 meeting and Dr. Gary Booth of Brigham Young University was elected Chairman for the 1976 meeting.

#### **Report of Ad Hoc Constitutional Amendment Committee— A. Appleby, D. Burgoyne and G. Lee**

Chairman Appleby recommended amendments to the constitution and by-laws so that the amended sections would be as follows:

Constitution, Article III, Section 3. Honorary Members are members selected from outside the Society who have significantly contributed to the field of weed science and who are elected by two-thirds majority of the Executive Committee. Honorary Members shall receive all publications and announcements of the Society but will not be eligible to vote or hold office.

Constitution, Article IV, Section 5. The Society representative to the Weed Science Society of America shall serve two years beginning at the WSSA Business Meeting in the year following his election.

Constitution, Article VII, Section 1. There shall be eight standing committees: Program, Finance, Resolutions, Local Arrangements, Nominations, Public Relations, Placement and Nominations of Fellows and Honorary Members, appointed by the President with the advice and consent of the Executive Committee.

Constitution, Article VII, Section 7. The Public Relations Committee shall consist of a Chairman and others as needed

Constitution, Article VII, Section 8. The Placement Committee shall consist of a Chairman and two additional members. Terms of this committee as in Section 3 above.

Constitution, Article VII, Section 9. The Committee for Nominations of Fellows and Honorary Members shall consist of the three most immediate Past Presidents of the Society. The member who is serving his second year on the committee shall serve as Chairman.

By-Laws, Article II, Section 6. The Public Relations Committee shall take every feasible opportunity to inform the scientific community and the general public of the activities and benefits of the Society and of the Weed Science in general.

By-Laws, Article II, Section 7. The Placement Committee shall provide at each annual meeting of the Society a registration service to make information available to potential employers and employees in cooperation with the Weed Science Society of America.

By-Laws, Article II, Section 8. The Committee for Nominations of Fellows and Honorary Members shall prepare nominations for these awards under the provisions of Article III, Section 3 of the Constitution and Article V, Section 1 of the By-Laws. They shall prepare biographical data for publication in the Proceedings and shall work with the Public Relations Committee in preparation of news releases concerning the award recipients.

By-Laws, Article V, Section 2. Fellows of the Society are members who have given meritorious service in Weed Science and who are elected by two-thirds majority of the Executive Committee. No more than two Fellows shall be selected each year. A cumulative list of Fellows shall be published each year in the Program and in the Proceedings.

By-Laws, Article V, Section 3. Honorary Members shall be selected as set forth in Article III, Section 3 of the Constitution. Persons selected as Honorary Members prior to 1974 shall continue to receive publications of the Society. They shall be listed annually in the program and in the Proceedings under the heading Fellows (formerly Honorary Members).

A motion to accept the amendments to the Constitution and By-Laws was made, seconded and passed unanimously.

Outgoing WSWS President Burgoyne expressed his appreciation to those whose efforts were responsible for a successful year, and the membership extended a vote of thanks to President Burgoyne for a job well done. The duties of the President were turned over to incoming President Lee, who adjourned the 1974 Western Society of Weed Science Business Meeting at 9:45 p.m. March 14, 1974.



**WESTERN SOCIETY OF WEED SCIENCE**  
**CONSTITUTION AND BY-LAWS**

With revisions and additions as adopted by  
the membership on March 14, 1974

**ARTICLE I – Name**

Section 1. The name of this organization shall be the "Western Society of Weed Science", hereinafter called the "Society". It shall include the states of Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming, and persons of the western provinces of Canada and of other states and nations as may wish to become members.

**ARTICLE II – Objectives**

The objectives of the Society shall be:

Section 1. To foster cooperation among state, federal and private agencies in matters of weed science in the Society area.

Section 2. To support the Weed Science Society of America and foster state and regional organizations of persons and agencies interested in weed control.

Section 3. To aid and support commercial, private and public agencies in the solution of weed problems.

Section 4. To foster and encourage education and research in weed science.

Section 5. To support legislation governing **beneficial** weed control programs and weed research and educational programs.

Section 6. To assist in the development of uniform weed control and eradication legislation and weed seed quarantine legislation and regulations.

**ARTICLE III – Membership**

Section 1. Membership shall be open to anyone interested in the objectives of the Society. Two types of membership are provided (1) active and (2) honorary.

Section 2. Active members are individuals who are interested in weeds or their control and who have paid their annual dues to the treasurer. Active members may attend all Society meetings, vote on Society matters, hold office and receive official notices of all meetings.

Section 3. Honorary members are members selected from outside the Society who have significantly contributed to the field of weed science, and who are elected by two-thirds majority of the Executive Committee. Honorary members shall receive all publications and announcements of the Society but will not be eligible to vote or hold office.

**ARTICLE IV – Officers and Executive Committee**

Section 1. The officers of the Society shall be:

- (1) President
- (2) President-elect who serves as Program Chairman
- (3) Secretary

Section 2. The Executive Committee shall be composed of:

The President  
President-elect  
Secretary  
Immediate Past-President  
The Representative to WSSA  
Chairman of the Research Section  
Chairman of the Education and Regulatory Section  
One member chosen at large by the President with the consent of other members of the Executive Committee.

Section 3. The President, President-elect, and Secretary shall begin their duties at the close of the regular business meeting at which they are installed and shall remain in office until the close of the next regular Society business meeting. Other members of the Executive Committee shall begin their term at the close of the meeting at which they are installed.

Section 4. The Chairman of the Research Section and the Chairman of the Education and Regulatory Section shall serve a one year term beginning at the close of the business meeting at which they become chairmen.

Section 5. The Society Representative to the Weed Science Society of America shall serve two years beginning at the Western Science Society of America Business Meeting in the year following his election.

Section 6. The Executive Committee may elect a Treasurer-Business Manager to serve as they may direct.

**ARTICLE V – Society Sections**

Section 1. In promoting a full exchange of ideas and information on weed science and to facilitate programming of meetings, there shall be two general sections as follows:

- (1) The Research Section, and
- (2) The Education and Regulatory Section.

Section 2. These two sections may have sectional programs, project meetings and informal discussions of research reports and other pertinent information. Such meetings shall be at the regular meeting at a time designated by the Program Committee.

Section 3. The chairman of each of these sections shall be a member of the Society Executive Committee and shall be elected as stated in Article VI, Section 3.

**ARTICLE VI – Election of Officers**

Section 1. The Nominating Committee shall be appointed by the President, with the advice and consent of the Executive Committee. They shall present their nominations for each office to be filled at the annual meeting. No members name shall be placed in nomination by the Nominating Committee without his prior consent. All candidates for office shall be selected from the Society membership and shall be elected by the majority of the members voting.

Section 2. The terms of office shall be as follows: the officer moving through the office of president-elect, president and past president shall be a member of the Executive Committee for a three-year term, the Secretary

shall serve a one-year term but shall be eligible for re-nomination as secretary or as any other officer.

Section 3. The Chairman-elect of each of the two sections shall be elected by the Society and serve a one-year term. Following this, they shall succeed as chairman of their section for an additional one-year term. The Chairman-elect shall serve as Chairman if the Chairman is unable to serve his term.

Section 4. If any elected officer cannot serve the full term, the vacancy shall be filled for the interim by appointment by the President with the advice and consent of the Executive Committee, unless otherwise provided for in this constitution. The President-elect shall serve as President if the President becomes unable to serve. This service shall not constitute his term as President.

#### ARTICLE VII – Standing Committees

Section 1. There shall be eight standing committees: Program, Finance, Resolutions, Local Arrangements, Nominations, Public Relations, Placement and Nominations of Fellows and Honorary Members, appointed by the President with the advice of the Executive Committee.

Section 2. The Program Committee shall consist of the President-elect as Chairman, the two Section Chairmen and such other members appointed by the Program Committee Chairman as required to give all phases of weed science adequate representation.

Section 3. The Finance Committee shall consist of a Chairman and two members. Terms of these committee members shall be established to expire alternately so that at least two members continue over each year.

Section 4. The Resolutions Committee shall consist of a Chairman and two additional members. Terms of office of this committee shall be as in Section 3 above.

Section 5. The Local Arrangements Committee shall consist of a Chairman and other as needed. They shall be appointed from the previously selected meeting site area.

Section 6. The Nominating Committee shall consist of a Chairman and two members. Terms of this committee shall be as in Section 3 above.

Section 7. The Public Relations Committee shall consist of a Chairman and others as needed.

Section 8. The Placement Committee shall consist of a Chairman and two additional members. Terms of this committee shall be as in Section 3 above.

Section 9. The Committee for Nominations of Fellows and Honorary Members shall consist of the three most immediate Past-Presidents of the Society. The member who is serving his second year on the committee shall serve as Chairman.

#### ARTICLE VIII – Dues

Section 1. The amount of dues and the method of collecting such dues shall be determined by the Executive Committee.

#### ARTICLE IX – Meetings

Section 1. Meetings shall be held at such times and places as may be determined by the President in consultation with the Executive Committee.

#### ARTICLE X – By-Laws

Section 1. The Conference may adopt By-Laws.

#### ARTICLE XI – Amendments

Section 1. The Constitution and By-Laws may be amended by majority vote of the members present at any regular meeting.

### BY-LAWS

#### ARTICLE I – Duties of Officers

Section 1. The President shall be the executive officer of the Society. He shall act as Chairman of the Executive Committee, carry out the spirit of the constitution and the decisions of the Executive Committee, prepare agenda and preside at all meetings of the Society and Executive Committee, appoint designated officers and committees and perform other usual duties of that office.

Section 2. The President-elect shall perform the duties of President if he cannot serve, serve as Chairman of Program Committee, develop program outlines of the Society meetings, assign responsibilities to Program Committee to prepare the programs, issue calls for papers and advise Executive Committee of program status one month before the meeting date and present a copy of the program to the Business Manager for publication.

Section 3. The Secretary shall prepare minutes of Society and Executive Committee meetings, prepare and maintain an up-to-date list of officers including Executive Committee, all standing committees and special committees, perform other duties when designated by the President.

Section 4. The Treasurer-Business Manager will receive and disperse monies of the Society in accordance with prescribed policies, maintain financial records and records of property, prepare records for annual audit and meet with designated auditors, maintain supplies of Proceedings and Research Progress Reports, receive and fill orders for above publications and collect payments for same, maintain standing orders and mailing lists for distribution of publications, arrange for and consummate publications for the Society.

#### ARTICLE II – Duties of Standing Committees

Section 1. The Program Committee shall develop the program for the meetings of the Society. The President-elect who is Chairman, shall delegate duties to members as he deems advisable (see duties of President-elect).

Section 2. The Finance Committee shall analyze the financial condition of the Society and recommend, if needed, immediate and long-range plans for sound growth of the Society, recommend budget policies, recommend policies regarding registration fees and prices of publications, audit the financial accounts at least annually and make a report to the Society.

Section 3. The Resolutions Committee shall develop resolutions and recommendations regarding the general field of weed science within the Society area and put into writing important recommendations that the Society should promote and encourage; they shall report to the annual meeting.

Section 4. The Local Arrangements Committee shall make all arrangements in all matters pertaining to the meeting place. They shall contact Chambers of Commerce or Convention Boards of the city chosen for the conference, choose an adequate hotel, make recommendations to Executive Committee, get agreement of hotel to sponsor no other conventions or competing activities during meetings, reserve meeting rooms, estimate costs, arrange for registration at meetings, name tags, typewriters, receipts, cash box, etc.

Section 5. The Nominations Committee shall nominate at the annual meeting candidates for the offices of President-elect, Secretary, Chairman-elect of the Research Section, Chairman-elect of the Education and Regulatory Section and WSSA Representative when necessary. Such candidates shall be contacted and cleared as set forth in Article VI of the Constitution.

Section 6. The Public Relations Committee shall take every feasible opportunity to inform the scientific community and the general public of the activities and benefits of the Society and of the weed science in general.

Section 7. The Placement Committee shall provide at each annual meeting of the Society a registration service to make information available to potential employers and employees in cooperation with the Weed Science of America.

Section 8. The Committee for Nominations of Fellows and Honorary Members shall prepare nominations for these awards under the provisions of Article III, Section 3 of the Constitution, and Article V, Sections 2 and 3 of the By-Laws. They shall prepare biographical data for publication in the Proceedings and shall work with the Public Relations Committee in preparation of news releases concerning the award recipients.

#### ARTICLE III – Duties of the Section Chairmen

Section 1. The Chairman of the Research Section shall organize sectional and project meetings of those engaged in research in the Society to exchange information and ideas and for improvement of research in weed science. He shall solicit and assemble abstracts of Research Progress Reports from research workers for publication by the Society each year. The Chairman may delegate to the Chairman-elect part of his duties as may be wise.

Section 2. The Chairman of the Education and Regulatory Section shall organize sectional meetings of those engaged in this phase of weed science in the Society for exchange of information and improvement of the work. He shall solicit program reports of education and regulatory work in weed science for publication in the Society Proceedings. The Chairman may delegate part of these duties to the Chairman-elect.

Section 3. The Chairman-elect of each of these Sections may attend Executive Committee meetings but cannot vote.

#### ARTICLE IV – Publications

Section 1. Proceedings and Progress Reports will be published for each annual meeting. Publications will consist of reports and papers to be given at the meetings, reports of the Standing Committees and special committees, minutes of the business meeting and Progress Reports from the two Sections. Research Progress Reports shall be available at the annual meeting. Other publications may be authorized from time to time by the Executive Committee.

#### ARTICLE V – Rules of Order

Section 1. Business at all regular meetings of the Society shall be conducted according to Robert's Rules of Order.

Section 2. Fellows of the Society are members who have given meritorious service in Weed Science, and who are elected by two-thirds majority of the Executive Committee. Not more than two Fellows shall be selected each year. A cumulative list of Fellows shall be published each year in the Program and in the proceedings.

Section 3. Honorary members shall be selected as set forth in Article III, Section 3 of the Constitution. Persons selected as Honorary members prior to 1974 shall continue to receive publications of the Society. They shall be listed annually in the Program and in the Proceedings under the heading Fellows (formerly Honorary Members).

#### ARTICLE VI – Quorum

Section 1. All members of the Society in good standing who are present at any regular meeting shall constitute a quorum.

#### ARTICLE VII – Authorization

Section 1. The adoption of this Constitution and By-Laws shall render null and void all previous rules and regulations of this Society.

#### Fellows of the Western Society of Weed Science

The Constitution of the Western Society of Weed Science, adopted in 1967, provided for the selection of honorary members of WSSW. Prior to the 1974 meetings, the Constitution was amended to provide for the selection of fellows from among the membership. Individuals receiving these honors from the Western Society of Weed Science are:

##### Honorary Members

Robert B. Balcom, 1968	Bruce Thornton, 1970
Walter S. Ball, 1968	Virgil H. Freed, 1971
A. S. Crafts, 1968	W. A. Harvey, 1971
F. L. Timmons, 1968	H. Fred Arle, 1972
D. C. Tingey, 1968	Boysie E. Day, 1972
Lambert C. Erickson, 1969	Harold P. Alley, 1973
Jesse M. Hodgson, 1969	K. C. Hamilton, 1973
Lee Burge, 1970	

##### Fellows

William R. Futick, 1974  
Oliver A. Leonard, 1974

## FELLOWS

### WILLIAM R. FURTICK

William R. Furtick was born on January 8, 1927 in Salina, Kansas. After receiving his B. S. degree at Kansas State University in 1949, he became a county extension agent in Oregon. He subsequently joined the Crop Science Department at Oregon State University and received his M. S. and Ph. D. degrees in 1952 and 1958, respectively. He served as project leader of the weed research program from 1956 until he was named as the first director of the International Plant Protection Center at O. S. U. in 1969. After leaving Oregon State, Dr. Furtick served as senior technical advisor with the United Nations Development Program in New York and is now Chief of the Plant Protection Service of the Food and Agriculture Organization of the United Nations in Rome.

Dr. Furtick has served as major professor for more than 30 graduate students. He has consulted and traveled in a large number of countries throughout the world. He has served as President of the Western Society of Weed Science and the Weed Science Society of America. He has actively participated in these and many other organizations such as American Society of America, British Weed Control Conference, and Asian-Pacific Weed Science Society. He has been named Fellow of WSSA and ASA.

Dr. Furtick has made numerous contributions to the field of weed science. His optimistic outlook, innovative approach, and boundless energy are well-known and respected throughout the world.

### OLIVER A. LEONARD

Oliver Leonard was born on a wheat farm near Pullman, Washington on January 5, 1911. He obtained a B. S. in Botany from Washington State University in 1933 and an M. S. in Plant Physiology in 1935 from the same institution. He continued his studies in Plant Physiology at Iowa State University, receiving his Ph. D. in 1937.

He was an instructor in the Biology Department of Texas A & M University in 1937 through January 1939 teaching general biology and Plant Pathology. He then joined the Agricultural Engineering Department of Mississippi State University and continued in this position through January 1950. While at Mississippi State University he conducted studies on weed control in cotton and corn from 1939 to 1950. He, with Dr. John Presley, formed a Department of Plant Pathology and Physiology, which later became the Department of Plant Pathology and Weed Science. In February 1950 he joined the Botany Department of the University of California at Davis. His primary responsibility at Davis has been on the chemical control of woody plants, but he has also conducted studies on weed control in vineyards. Since 1933 he has conducted a number of basic studies on transport in plants and in detached leaves.

Aside from a sabbatical leave in New Zealand and two sabbatical leaves in Europe, his travels also include an FAO mission to Kenya and Zambia in 1968. In 1948 he helped with the initiation of chemical weed control studies with the Federal Experiment Station in Puerto Rico.

He has held all the Offices in the California Weed Conference (and is now an honorary member) and several Offices in the Western Society of Weed Science. During his career he has authored and coauthored about 250 papers, of which approximately 75% relate in some manner to the area of weed science.

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