1999 CWSS Executive Board

Left to Right: Steve Wright, President; Matt Ehlhardt, Vice President; Lars Anderson, Secretary; Scott Johnson, Past President; Wanda Graves, Business Manager; Louis Hearn, Director; Not in Picture: Pam Geisel, Director

President Scott Johnson (right) receiving award of appreciation from Program Chair Steve Wright.

1999 CWSS Honorary Member - Jack Orr

Jack Orr (right) receiving the Honorary Member Award from Past President Ron Vargas.

Jack received his B.S. degree in Soil Science at Cal Poly, San Luis Obispo in 1962. He then took a position as a Research Biologist at Stauffer Chemical Company's research facility in Mountain View, CA and worked there from 1962 to 1967. Jack returned to school and received a M.S. degree in Plant Science from California State University Fresno in 1969. In 1969, Jack began his career with the University of California Cooperative Extension as a Weed Science Farm Advisor for vegetables and field crops in Sacramento County.

Jack is recognized for his many contributions to Weed Science in tomatoes, alfalfa, wheat, field corn and sugar beets. For years he was the team leader for the U.C. processing tomato weed group which created effective weed management programs for California growers. Jack played a major role in the development and registration of PURSUIT herbicide for use in alfalfa and Shadeout in tomatoes.

In recent years he has also served as County Director of Sacramento County Cooperative Extension Office while maintaining and active research and educational program in weed science. He also served as a mentor to many U.C. Farm Advisors in the Sacramento Valley. Jack served as President of the California Weed Science Society in 1990 and over the years has been an active participant in the society as presenter and committee services. Jack has also been involved in the Western Society of Weed Science and the Weed Science Society of America. Through his record of accomplishments, Jack is recognized by his peers as a forthright, hard working individual who has made significant contributions to California agriculture. He is truly deserving to be named an Honorary Member of the California Weed Science Society.

1999 CWSS Honorary Member - Jack Schlesselman

Jack Schlesselman (left) receiving receiving the Honorary Member Award from Past President Ron Vargas.

Jack received his B.S. at Fresno State University in Zoology in 1971 and immediately went to work for Dr. Art Lange at the UC Kearney Ag Center in Parlier. He worked on Dr. Lange's weed science project for the next eight years. While working at the Kearney Ag Center, Jack was also pursuing his Master's Degree at Fresno State University in Weed Science which he completed in 1979. In 1980 Jack accepted a position with Rohm and Haas Company as a Field Research & Development Representative where he is currently employed.

During his career as a field biologist at Rohm and Haas, Jack has made many significant contributions. His knowledge, expertise and professionalism in the area of field research have led directly to business success for the company. Jack has been instrumental in the continued development of Goal Herbicide as an important tool for western agricultural. He has led many efforts to expand and enhance uses for Goal. He has also sought out and conducted work to develop many new and interesting opportunities for Goal in minor crops. His early work with Goal on onions for example has earned him the affectionate title of "Captain Onion" within Romn and Haas. Jack's commitment to the development of Goal on both large and small acreage crops has been at the heart of his success. More recently he has played a key leadership role in the development of the new herbicide Visor for the California TNV market and has conducted a great deal of field research on two new development insecticides, Confirm and Aphistar.

Jack has been very active in the California Weed Science Society. The most successful "What's New in Industry" is a direct result of Jack's untiring dedication to weed science as well as our Society. Jack's interest in photography has not only benefited the disciple of weed science but he has become the official photographer of the CWSS allowing us to better record and capture the history of the Society. It is with great pleasure that we welcome Jack as an Honorary Member of the California Weed Science Society.

1999 CWSS Award of Excellence - JOSEPH M. DITOMASO

Joseph M. DiTomaso (left) receiving receiving the Award of Excellence from Past President Ron Vargas.

Joe is a native Californian, raised in the Los Angeles area. He received a Ph.D. in Botany from the University of California, Davis in 1987. After completing a short Postdoc at Montana State University he was hired as an Assistant Professor at Cornell University in 1987. In 1995, he left Cornell to accept his current position as an Extension Weed Ecologist at the University of California, Davis working in noncrop weed control. In addition, Joe also serves as the director of the Weed Research and Information Center and as organizer and moderator of the UC Weed School.

Joe's record as a researcher is truly outstanding, especially considering his short career. He has published over 40 Refereed manuscripts. He received a DANR Distinguished Achievement Award in 1998 for Outstanding Research by a Specialist. His major focus since joining UC Davis has been on yellow starthistle control. He has made major strides in assessing the biology, cultural and chemical control of this problem weed. While at Cornell, he jointly published a weed identification book, which won an award for the best new extension publication. He is currently working on a "Weeds of California" book which will include over 600 weed species.

Joe has been very active in the California Weed Science Society. As a graduate student, he won the Student Paper contest three times (1983, 1984 and 1986). More recently, Joe's students have won the Student Poster contest. Joe also has served on the Program Committee, and has been a regular speaker at the annual meetings of the California Weed Science Society. Joe's accomplishments are truly outstanding and we are fortunate to have a member like Joe in our Society.

1999 CWSS Scholarship Winners

Left to Right: Sergio Casillas and Christina Smith

1999 CWSS Oral Presentation Winners

Left to Right: Stephen Enloe, Annika Midtgaard and Mark Renz

1999 CWSS Poster Presentation Winners

Left to Right: Gerardo Banuelos, Annika Midtgaard and Stephen Enloe

Herbicide Options in the Landscape

Dan Wickham, Zeneca Professional Products

Herbicides are one of the tools available in a weed control program. In a landscape situation, other components, such as nutrition, cultivation, crop competition, mulching, and water management may have limited suitability. Additionally, the close proximity of the public in landscaped areas has direct impact upon our weed control strategies. Herbicides can help reduce equipment and hand labor requirements, result in more efficient use of water and nutrients, reduce potential fire hazards, and increase visibility along rights-of-way. As with any effective pest management system, herbicides should be used according to the label, with application techniques which are appropriate for the situation.

According to a recent survey from Lawn & Landscape Magazine, the most prevalent landscape problems in 1997 were turf weed pests, followed by turf insects, tree and ornamental insects, turf diseases, and tree and ornamental diseases. Turf weed pests represented 34% of total problems, with dandelion, clover, and crabgrass as the most commonly reported weeds. The same survey indicated that product effectiveness is the most important factor influencing pesticide purchasing decisions. Cost, product safety, location, and toxicity were also important factors.

Because of the diverse nature of landscape areas, the potential for off-target damage is relatively high. Proper application techniques should be practiced, including calibration and drift avoidance. Spray droplet size is the most important factor affecting physical drift, and the factor that can most easily be controlled. As droplet size decreases, and spray nozzle height and wind speed increase, there is greater potential for physical drift. A 20 micron droplet takes 4 minutes to fall from a height of 10 feet; in a 1 mph wind, that droplet would travel a distance greater than a football field. By comparison, a 240 micron droplet takes 5 seconds to fall from a height of 10 feet, and would travel 6 feet in a 1 mph wind. Herbicides perform satisfactorily with spray droplets in the 200 micron or larger size range, while at the same time reducing the potential for off-target damage.

Commonly used preemergent herbicides effectively control a broad range of germinating weeds, while providing a high degree of safety to turf and ornamentals.

- Oxadiazon (Ronstar) is a shoot-absorbed, broad-spectrum residual. It has low solubility, forms a barrier near the soil surface, and has no apparent effect on rooting.

- Oryzalin (Surflan), pendimethalin (Pendulum), and prodiamine (Barricade) are dinitroaniline chemistry. They inhibit cell division at shoot and root tips, have generally low solubility, and may inhibit shallow roots. This chemistry generally controls annual grasses and shallow-germinating broadleaf weeds.

- Isoxaben (Gallery) is a long-residual preemergent, with low solubility, which selectively controls broadleaf weeds. Snapshot is a premix of Gallery and Treflan (another dinitroaniline) for broad-spectrum residual control.

All landscape preemergent herbicides require irrigation or rainfall to incorporate and activate.

Knowing the mode-of-action and soil-active characteristics is important in selecting the proper herbicide. A perennial or deep-germinating annual weed may never come in contact with a preemergent herbicide near the soil surface, resulting in a perceived failure of the herbicide. Mode-of-action can determine what type of phytotoxicity symptoms to expect from off-target application. Solubility, soil adsorption, and half-life characteristics will have an effect on the movement of herbicides through the soil.

Selective postemergent herbicides include clethodim (Envoy), and fluazifop (Fusilade II), for grass control. These products control annual and perennial grasses, generally without harming broadleaf plants. They do not control sedges, since sedges are not grasses. Sedges can be controlled with Manage. Triclopyr (Turflon), clopyralid, 2,4-D, and dicamba selectively control broadleaf plants, without harming grasses, with a few exceptions.

Non-selective postemergent herbicides include systemic materials, such as glyphosate (Roundup), and glufosinate-ammonium (Finale), and contact materials, such as diquat (Reward) and pelargonic acid (Scythe). Systemic postemergent herbicides generally require 1-3 weeks for complete control, depending on weed species, and environmental conditions. Contact materials give rapid burndown, and are most effective on annual weeds. For effective control, weeds must be actively growing, and perennials may require retreatment.

Aquatic sites in the landscape present a different set of challenges. There are limited products with aquatic registration. Glyphosate (Rodeo) is a systemic, postemergent herbicide, for emergent weeds only. Diquat, (Reward), is a fast-acting contact, for submersed and emergent weeds. Copper complexes control algae and some submersed weeds. Fluridone (Sonar) is a slow-acting systemic for control of primarily submersed weeds. Environmental concerns with aquatic weed control include:

- Acute and long-term toxicity to fish, birds, and invertebrates.
- Oxygen depletion during algal bloom or weed degradation.
- Potential use of treated water.
- Potential damage to surrounding desirable plants.
- Proper identification of aquatic weeds.

Herbicides are one component in an integrated approach to weed control in the landscape. Knowing the mode-of-action and environmental characteristics is critical in selecting herbicides for a particular situation. Proper use of herbicides can result in cost-effective weed control, resulting in a healthy and attractive landscape, with high aesthetic value.

Weed Control for Home Landscapes and Gardens

Cheryl A. Wilen, Area IPM Advisor, University of California
Cooperative Extension-Southern Region, Statewide IPM Project

Management of weeds in the home landscape or garden is a problem due to the variety of species used in these plantings and the planting often includes both annuals and perennials. Weed control can be accomplished using chemical and non-chemical techniques.

A general plan for weed control in home gardens and landscapes include taking into consideration the following factors:

Management (culture)

A. groundcovers - good choice of groundcover which is competitive with weeds by having a closed canopy will reduce the number of annual weeds by shading the germinating seedlings

B. sprinklers - placement, type

Non-chemical controls

A. mulch - organic (bark, straw, etc.) or inorganic (lava rock, marble chips, etc.), 2-4 inches is best as a deeper mulch may cause root damage due to overwet soil

B. landscape cloth (geotextiles) - does a good job in controlling broadleaves, some grasses but this is a long term method of weed control and does not lend itself to plantings of annuals in the landscape, often used in concert with mulches, non-woven and woven materials are available

C. hand-weeding - time consuming but is often the only choice where plants may be injured by herbicides

Chemical controls (herbicides)

A. Selective or non-selective

Examples:

Selective: Herbicides containing 2,4-D will kill broadleaf species but not harm grasses

Non-selective: Herbicides containing glyphosate will injure or kill broadleaf plants and grasses

B. Preemergent or postemergent

1. Preemergent herbicides

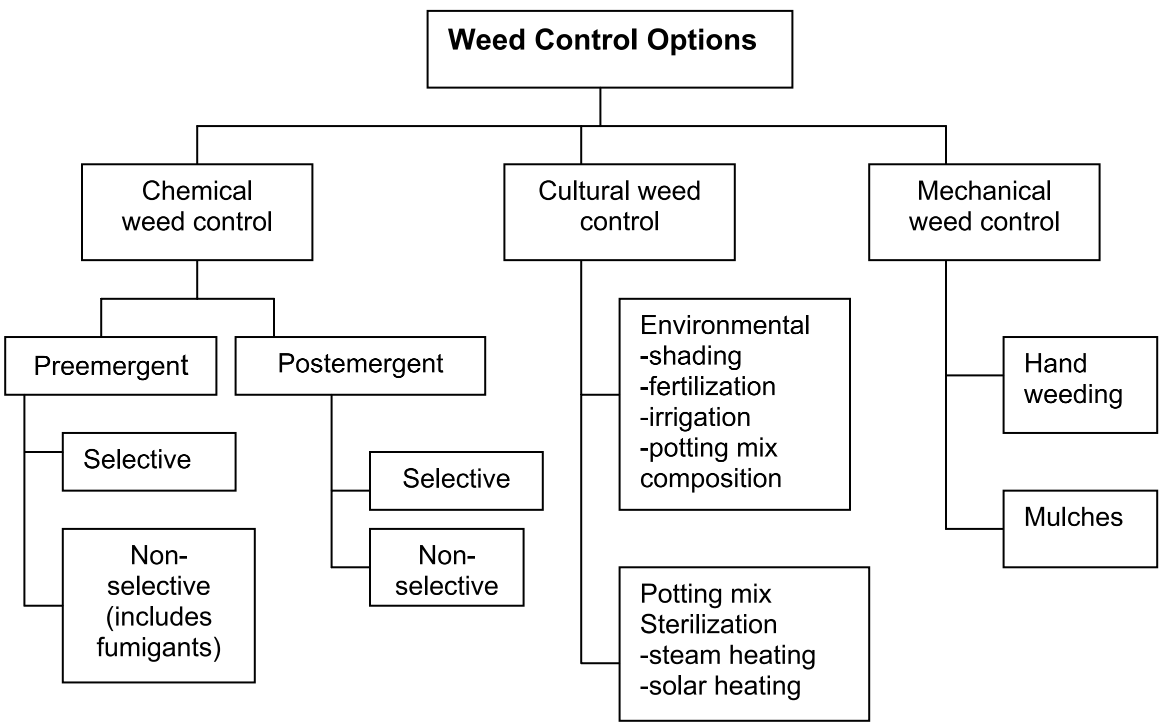
    a. must be applied prior to weed seed germination

    b. applied to soil

2. Postemergent herbicides

    a. applied to weeds that have already emerged

    b. drift onto susceptible plants must be avoided



Biology and Control of Perennial Pepperweed

Mark Renz, Graduate Student, University of California Davis
Joe DiTomaso, Weed Ecologist, University of California Davis

Background

Perennial pepperweed (*Lepidium latifolium* L.) is an invasive weed found throughout California. It is a herbaceous perennial that produces stems up to 1.5 meters in height in dense stands. These stems originate from large desiccant-resistant rhizomes or semi-woody crowns beneath the soil surface. Features such as these help perennial pepperweed infest a variety of environments or ecosystems throughout the west including rangelands, wetlands, meadows, pastures, marshes, riparian areas, flood plains, roadsides, irrigation channels, and even agricultural fields (alfalfa). In these areas perennial pepperweed can outcompete nearly all other species.

Perennial pepperweed is native to Africa, Europe and Asia (2). Initial infestations in California were suspected to have originated from a sugarbeet seed contamination in the 1930s (8). This noxious weed has been rapidly spreading since, and is now found in every county in California except Del Norte, Humboldt, and Imperial. It has also been documented in every state in the western United States except Arizona (10). Perennial pepperweed poses a serious threat to many native ecosystems and previously disturbed areas returning to their native conditions (3). In these environmentally sensitive habitats perennial pepperweed can displace threatened and endangered species, such as the salt marsh harvest mouse (9) or interfere with the regeneration of important plant species such as willows and cottonwoods (10). Due to its invasiveness the California Department of Food and Agriculture (CDFA) has rated perennial pepperweed a class B noxious weed and the California Exotic Plant Pest Council (CalEPPC) categorized this weed as A-1 (most invasive wildland pest plant).

Biology

Very little information is known about the biology of this pest. Germination rates are high when seeds are exposed to fluctuating cold/warm temperatures (3). However, seeds do not seem to be capable of surviving long periods in the soil (lack a hard seed coat), thus seed viability may be short. This suggests that reinfestation by seed may not be a problem once control is achieved (3).

Vegetative growth appears to be the primary mechanism for spread in California. Excavation of below ground organs revealed that 19% of all roots and rhizomes were present in the top 10 cm of the soil, with 85% in the top 60 cm (5). These below ground organs constitute 40% of the plants overall biomass (5). This large underground root and rhizome system is thought to enhance the below ground competitiveness of perennial pepperweed for water and nutrients while increasing the carbohydrate reserve important for rapid shoot development in the spring (1,4,5,6,7).

Control

Long-term management of perennial species is often difficult. Perennial pepperweed is no exception. When used alone, non-chemical control methods, including disking (11) and mowing (5,6,7,9), are not effective. Limited success has however, been documented with the use of herbicides. Young et al. (11) found that two years of control was obtained with the use of chlorsulfuron at 0.11 kg/ha. Unfortunately, this herbicide is only registered in non-crop situations in California. Herbicides approved for use in environmentally sensitive areas vulnerable to infestations (2,4-D, glyphosate, triclopyr) provide poor control of perennial pepperweed 1 year after treatments (see table) (7). Thus, many riparian and wetland areas which are highly susceptible to invasions lack an effective control strategy for perennial pepperweed.

Research

The goal of this study is to develop perennial pepperweed control strategies for sensitive wetland and riparian areas. Research is focusing on understanding important biological processes of this weed and using this information to develop integrated control strategies. Our current efforts are centered on determining the seasonal translocation patterns into rhizomes and crowns of perennial pepperweed and evaluating the affect mowing has on this process. With this information, we can determine the optimal timing of control strategies such as herbicide applications and/or mowing. From our initial results we have found that integrating mowing and herbicides can significantly enhance long-term control of perennial pepperweed (6,7). We are currently pursuing the mechanisms responsible for improved control and optimization of this integrated approach.

From earlier studies, we reported that minimum energy is stored in the rhizomes when the plants are at the bolting stage (6,7), indicating the optimal time to mow stems. Perennial pepperweed quickly recovers from mowing and produces leaves from previously dormant buds. These leaves quickly expand and reestablish a positive carbon budget for the plant. This was shown to require less than 14 days (unpublished data) and can explain why mowing alone is not an effective control strategy.

We have also found that perennial pepperweed begins allocating large amounts of photosynthate to the rhizomes and crowns during the flower bud stage. Translocation to below ground structures is maximal from throughout the flowering to seed filling stages (7, unpublished data). Assuming that herbicide movement parallels carbohydrate movement, herbicide applications during the flowering to seed filling stages would be expected to maximize herbicide accumulation in the rhizomes and thus provide more effective long-term control. Previous reports however, have determined the optimal timing for herbicide applications to be the flower bud stage (1,9,11). Why is control maximized when using herbicides at the flower bud stage? We hypothesize that coverage and absorption of herbicides is much greater during the flower bud stage than the flowering to seed fill stages. During the flowering to seed filling stages plants developed many flowers, stems and fruits not present during the flower bud stage. We hypothesize that these organs reduce the interception of herbicide by leaf tissue. We also hypothesize that these organs cannot absorb herbicides to the same degree as leaves. Leaf abscission during flowering also reduces leaf area. Although translocation rates are not maximized in the flower bud stage, increased coverage and absorption may allow greater accumulation of translocated herbicide into rhizomes and crowns. We plan on quantifying this hypothesis next year.

By integrating mowing and herbicides, dramatic increases in the control of perennial pepperweed have been demonstrated (6,7). This control strategy involves mowing stems when minimum energy is stored below ground, followed by a herbicide application to recovering stems when translocation patterns favor accumulation in rhizomes and crowns. One year control data showed all different mowing regimes evaluated (control, mowed once, mowed twice and chemically mowed) increased the effectiveness of herbicides in controlling perennial pepperweed stems compared to unmowed plots with and without herbicide treatments (see table) (6,7). Glyphosate provided an 89% increase in control 1 year after treatments, compared to 20% in unmowed areas (see table). We are currently determining the mechanisms responsible for this increased control.

We did not find any differences between seasonal translocation patterns into rhizomes and crowns in unmowed and mowed plants. This indicates that mowing did not alter seasonal translocation patterns or rates and is not responsible for increased control. Herbicides were applied to mowed areas later in the season during periods of maximal translocation. This could have increased herbicide accumulation into rhizomes and crowns thereby enhancing control. Stem and leaf morphology and architecture also differ dramatically between mowed and unmowed stems at the time of application. Leaves of unmowed plants were small and often perpendicular to the ground while leaves from mowed plants are much larger and parallel to the ground. Mowing can reduce stem density (64 stems/m^2 in mowed plots compared to 142 stems/m^2 in unmowed plots) and stem height (49.21 cm in mowed plots compared to 96.42 cm in unmowed areas) at the time of application (5,6,7). These factors may increase coverage and absorption of the herbicide, resulting in increased accumulation in rhizomes and crowns.

Conclusions

Even though perennial pepperweed has low carbohydrate levels stored in rhizomes and crowns during the bolting stage, it can quickly reestablish a positive carbon budget. This limits the use of mowing as a sole control strategy. Herbicides registered for use in wetland and riparian areas also show limited control, but mowing appears to dramatically increase their control (see table). This increase is not due to a shift in the seasonal translocation pattern or an increase in translocation rates to the rhizomes and crowns. Mowing may change the stem and leaf morphology and architecture of recovering perennial pepperweed, enabling greater coverage and absorption of herbicides. Later applications also appear to coincide with maximal basipetal translocation rates, potentially increasing herbicide accumulation in rhizomes and crowns. Future research efforts will examine the physiological mechanisms involved in optimize this integrated approach.

Table. Percent Visual Control of Perennial Pepperweed - 1 Year after Treatment

Herbicide	Rate (kg ai/ha)	Unmowed	Mowed Once	Mowed Twice	Chemically mowed*
Chlorsulfuron (Telar®)	**0.052**	**57.50** (CDE)	**87.25** (AB)	**99.50** (A)	**88.75** (A)
Glyphosate (Roundup®)	**3.33**	**20.00** (DEFG)	**88.75** (A)	**81.67** (AB)	**86.67** (A)
Imazapyr (Arsenal®)	**0.14**	**35.00** (CDEFG)	**76.25** (AB)	**87.50** (A)	**80** (AB)
2,4-D (Weedar 64®)	**2.11**	**13.75** (EFG)	**2.5** (G)	**45.00** (CD)	**58.33** (BC)
Untreated	**-**	**0** (G)	**0** (G)	**10.00** (FG)	**12.50** (FG)

*Plots were chemically mowed by applying 2,4-D (2.11 kg/ha) at the flower bud stage. Herbicide treatments were applied to stems after they recovered to the flower bud stage.

Table: Data taken from a roadside area in Woodland California 1 year after treatments were applied. Mowed treatments were cut when plants or recovering plants reached the flower bud stage. Herbicides were applied to unmowed plots: 4/29/97, mowed once plots: 5/28/97 and mowed twice & chemically mowed plots: 8/8/97. Different letters indicate a significant difference between all treatments (tukey's $p<0.05$).

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The Evaluation of Carfentrazone in Salinas Valley Lettuce

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Introduction

Weeds can have a detrimental effect on the yield and quality of lettuce. Before the development of effective herbicides such as pronamide, severe weed infestations sometimes resulted in complete crop losses (Harry Agamalian[1] personal communication). The current weed management systems used in California lettuce production include an effective combination of mechanical tillage, herbicides, cultivation, and hand weeding. The cost of Pronamide, cultivation, and hand weeding represents a significant portion of the total production cost per acre of lettuce (1). However, factors are in motion that may force changes in current weed management systems. The provisions of the Food Quality Protection Act (FQPA) of 1996 require the US Environmental Protection Agency (EPA) to reassess all pesticide tolerances by the year 2006. During the first phase of the tolerance reassessment, the EPA plans to review the tolerances of pesticides classified as carcinogens. Pronamide and bensulide are used on 79% and 5% of the California iceberg lettuce acreage respectively, and will be reviewed during the first round of tolerance reassessments by the EPA (2,3). The loss of pronamide and bensulide would leave benefin as the only soil-applied herbicide for lettuce (4). Benefin must be incorporated in the soil with power incorporation equipment, which would lengthen the time required to establish a lettuce crop and increase costs. Furthermore, benefin is not active on many of the weeds that commonly infest lettuce plantings such as burning nettle (*Urtica urens*), hairy nightshade (*Solanum sarrachoides*) and shepherdspurse (*Capsella bursa-pastoris*), whereas pronamide controls all of these weeds. The loss of pronamide and bensulide would likely increase the cost of lettuce production since producers would be more dependent upon hand weeding. FQPA transition strategies include the use of new low-rate herbicides. Previous studies have found that lettuce was tolerant to carfentrazone (Fennimore and Richard 1999). The objective of this study was to further evaluate the tolerance of lettuce to carfentrazone as well as the weed control activity.

Materials and methods

Field plots were established on August 12, 1998 at the USDA/ARS Hartnell Farm near Salinas, CA. Two lettuce varieties included in the study, 'Salinas' and 'Medallion', were iceberg and romaine types, respectively. The plot sizes were four 40-inch beds wide by 40 feet long arranged in a randomized complete block with 3 replications. One line of each variety was planted per bed, i.e., two seed lines were planted per bed. Treatments included carfentrazone at 0.05, 0.075 and 0.1 lb ai/A, pronamide at 1.5 lb ai/A and the untreated check. All herbicides

[1] Farm Advisor Emeritus, Monterey County UCCE

were applied preemergence and incorporated with sprinkler irrigation. Assessments taken were: stand counts, crop biomass and weed densities. Mean separation was performed using Fisher's protected LSD at $\alpha = 0.05$.

Table 1. **Lettuce stand counts in iceberg and romaine lettuce [a]**

		No. plants / m	
Treatment	**Rate lb ai/A**	**Iceberg**	**Romaine**
Carfentrazone	0.050	24.3	20.3
Carfentrazone	0.075	23.7	26.7
Carfentrazone	0.100	21.7	25.7
Pronamide	1.500	29.3	27.0
Untreated check	--	20.0	22.3
LSD	α = 0.05	6.1	ns

[a] Data taken August 31, 1998

Table 2. **Lettuce biomass yields for iceberg and romaine lettuce [a]**

		Fresh weight / head (g)	
Treatment	**Rate lb ai/A**	**Iceberg**	**Romaine**
Carfentrazone	0.050	110	266
Carfentrazone	0.075	171	241
Carfentrazone	0.100	146	238
Pronamide	1.500	159	298
Untreated check	--	190	158
LSD	α = 0.05	ns	ns

[a] Data taken October 23, 1998

Table 3. Number of burning nettle and shepherdspurse plants per meter of row [a, b]

		No. plants / m	
Treatment	**Rate lb ai/A**	**Burning nettle**	**Shepherdspurse**
Carfentrazone	0.050	5.7	6.2
Carfentrazone	0.075	6.7	1.7
Carfentrazone	0.100	4.8	2.2
Pronamide	1.500	2.3	8.3
Untreated check	--	10.5	23.2
LSD	α = 0.05	5.6	15.5

[a] Data taken August 27, 1998
[b] Number of plants in a band 5 in. wide by 1 m (39.4 in.) long

Results and discussion

Relative to pronamide at 1.5 lb ai/A, carfentrazone at 0.05 and 0.075 lb ai/A did not reduce iceberg lettuce stand, but carfentrazone at 0.1 lb ai/A did result in a slight stand reduction (Table 1). None of the treatments affected romaine stand. None of the treatments affected lettuce head weights in either variety (Table 2). Carfentrazone at 0.1 lb ai/A reduced burning nettle density relative to the untreated check as did pronamide at 1.5 lb ai/A (Table 3). All carfentrazone rates reduced shepherdspurse densities relative to the untreated check, but pronamide at 1.5 lb ai/A did not reduce weed densities compared to the untreated check.

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Field Bindweed Control with Touchdown or Roundup Ultra in Walnuts

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Field bindweed (*Convolvulus arvensis*) is a herbaceous perennial weed which is difficult to control. Previous studies have noted that high rates of Roundup or Picloram provided the best control when evaluated one year after application. Generally, other workers have found that 3.0 lbs/a or higher rates were needed for reductions in field bindweed to persist into the second year. However, these studies have been done in the Midwest, where crops are grown without irrigation, and thus the results may not be applicable to California conditions. Other work has found that Fall applications provided the most consistent field bindweed control. Since the top portion of the plant dies back to ground level each Fall, energy from the top portion of the plant moves into the roots for storage during this time. Previous work has also noted that water stress reduces control, and thus applications should not be made when plants are stressed for water. Touchdown is scheduled to be registered in California in 1999. This study was performed to compare Touchdown and Roundup Ultra in terms of field bindweed control.

Touchdown and Roundup Ultra were each applied at three rates (2 lb/a*, 3lb/a, and 4 lb/a) in addition to each herbicide at the 2 lb/a rate plus Banvel at 0.25 lb/a. Another treatment combined ammonium sulfate at 13.2 lbs/100 gal with 2 lb/a of Touchdown or Roundup Ultra. These treatments were all compared to an untreated check plot. Treatments were applied on August 7, 1998, approximately one week after the area had been mowed. Three days prior to treatment, the area had been irrigated. Field bindweed was 6 to 24 inches in length and actively growing at the time of treatment.

At one week after treatment, the treatments which contained Banvel had the best control (Table 1). The treatment which included Banvel was approximately 18% better control than the comparable treatment of Roundup Ultra or Touchdown, alone. At two weeks after application, treatments plus Banvel were still providing better field bindweed control than Roundup Ultra or Touchdown applied alone. At four weeks after treatment, the higher rates of Touchdown or Roundup Ultra were providing equivalent control of field bindweed compared to either herbicide plus Banvel.

The 3 lb/a or 4 lb/a rates of Touchdown gave better control of field bindweed at one, two and four weeks after treatment, than did the 2 lb/a rate, but differences were not evident at later evaluations. Some slight differences in activity between Roundup Ultra and Touchdown were noted at the last evaluation with Touchdown seeming to provide better control, however, Touchdown and Roundup Ultra generally did not differ significantly in their control of field bindweed.

Adding ammonium sulfate generally increased field bindweed control, with Roundup Ultra benefiting the most from this addition. It appeared that adding ammonium sulfate increased the burndown rate, but did not influence control at the last evaluation. Quicker burndown is often beneficial, if long-term control is not sacrificed.

Table 1. Field bindweed control at 7, 14, 28, 49 and 65 days after treatment.

	Days after treatment				
Treatment and rate	**7**	**14**	**28**	**49**	**65**
	-------------(% control)------------				
Roundup Ultra					
@ 2 lb/a	64	72	71	46	35
@ 3 lb/a	65	84	87	62	50
@ 4 lb/a	71	82	85	60	38
@ 2lb/a					
+ Banvel @ 0.25 lb/a	81	94	92	65	35
+ Amm. Sulf. @ 13.2 lb/100gal	70	81	85	65	35
Touchdown[1]					
@ 2 lb/a	62	76	76	62	48
@ 3 lb/a	79	88	92	62	50
@ 4 lb/a	74	88	91	54	45
@ 2lb/a					
+ Banvel @ 0.25 lb/a	81	88	86	72	50
+ Amm. Sulf. @ 13.2 lb/100gal	65	76	81	55	52
Untreated	0	0	0	0	0
LSD $_{.05}$	9	10	12	18	18

[1] A nonionic surfactant was added to all Touchdown treatments at 0.5% v/v.

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The Food Quality Protection Act (FQPA)

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The Food Quality and Protection Act was signed into law by President Clinton in 1996. The major goal of the act is to protect consumers (mainly infants and children) from harmful pesticide exposure through food products. Implementation decisions being made by the Environmental Protection Agency (EPA) will affect agricultural industries greatly. It is important to be informed on the issues surrounding the FQPA and to understand the ramifications of this revolutionary piece of legislation.

The EPA has set a goal of implementing the act by the year 2006. The act mandates that residue levels in all food must be determined by the EPA as “safe”, indicating that there is “a reasonable certainty that no harm will result from aggregate exposure." Organophosphates and carbamates will be the first pesticides reviewed. Eventually every registered pesticide formulation (about 20,000) will be evaluated. It has been estimated that as many as 30 to 50% of pesticides could be banned from the market, ultimately affecting every area of agriculture.

The loss of registered pesticides could cause decreased crop yields in the majority of crops in the United States. Chemical manufacturers may not be able to invest capital into research for new, safer chemicals on minor-use crops, due to the extensive and costly requirements of maintaining EPA registrations. The pesticides used on major crops are more lucrative and with the new “risk cup” method of the FQPA, companies may be forced to cancel minor-use pesticides to remain profitable. This could be detrimental to California agriculture, considering the abundance of vegetables, fruits, and specialty crops produced exclusively throughout the state. Growers may be forced to find more expensive, less efficient alternatives to pesticides that have been relied upon.

The EPA, USDA, and chemical manufacturers are cooperating to ensure fair implementation of the law, re-registration of current pesticides, and the development of new compounds. The EPA has established committees to process the concerns of agriculturists, environmentalists, consumers, and other lobbyists. A web site has also been established to keep people informed on the latest developments of this important issue. Grant funds have been authorized by the USDA to generate data to support minor use registration. USDA and university researchers are currently testing compounds and different use rates of pesticides with hopes of discovering alternatives to the chemicals that will be phased out.

The agricultural community can influence the EPA’s decisions and future legislation regarding pesticides by voicing opinions and concerns. Because congressional leaders respond to the reactions of the public and officials are elected to serve the public, the voice of united agriculturists can be heard in government. The EPA has begun to implement forums and advisory committees to hear the opinions of agricultural professionals in the reviewing process of pesticides.

The Food Quality and Protection Act will heavily influence the types of pesticides that will be used in the near future. The United States relies upon pesticides to produce high yields and exceptional food quality. With the implementation of this act, many common practices in farming will have to change radically. With awareness, knowledge, and the will to influence government, the agricultural community can help the EPA develop a plan to review pesticides that will be sympathetic to all involved.

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Integrated Management of Yellow Starthistle on California Rangelands

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Introduction

Yellow starthistle (*Centaurea solstitialis* L.) is an aggressive Mediterranean invader that currently infests over 10 million acres in California. It reduces rangeland productivity and carrying capacity, decreases land value, and threatens biodiversity (Maddox and Mayfield 1985). Yellow starthistle is well adapted to California's annual grasslands, which are comprised primarily of introduced annual grasses and forbs. Yellow starthistle minimizes competition with annual grasses by utilizing deep soil moisture and entering its reproductive phase after annual grasses have senesced. There are currently few sustainable and economically viable management strategies available to rangeland managers in California for controlling yellow starthistle and increasing rangeland productivity. Burning, mowing, and certain herbicides, such as 2,4-D and dicamba, have been somewhat successful. However, long term management requires depleting the yellow starthistle soil seedbank and establishing competitive plant species in the niche yellow starthistle occupies.

Clopyralid is a selective broadleaf herbicide recently registered for use in California pastures, range, and wildlands. Initial studies in California have indicated clopyralid provides excellent pre- and postemergence yellow starthistle control (DiTomaso et al. 1999). There is, however, some concern that continuous use of a single management approach, such as clopyralid, may lead to selection for other noxious weeds, such as medusahead (*Taeniatherum caput-medusae*) or barb goatgrass (*Aegilops triuncialis*). Therefore, the objective of this study was to determine the effectiveness of utilizing clopyralid for yellow starthistle management in an integrated approach incorporating reseeding with a competitive perennial forage grass and an annual clover.

Materials and Methods

The experiment was conducted on yellow starthistle infested range near Yreka, California. Treatments consisted of three factors: clopyralid applied in the spring for 1, 2, or 3 years, range reseeding of 'Luna' pubescent wheatgrass (*Thinopyrum intermedium*) in the early spring the first year, and rose clover (*Trifolium hirtum*) seeding in the fall following the last clopyralid application. Range reseeding of wheatgrass consisted of a glyphosate application on February 29, 1997 followed by wheatgrass (12 lb/A) drill seeded the first week of March with a no-till range drill. Rose clover was broadcast seeded at 10 lb/A in September. Spring clopyralid applications were made on March 18, 1997 (1.0 oz ae/A) and March 17, 1998 (1.5 oz ae/A). Treatments were applied to 50 by 50 ft plots and arranged in a randomized complete block design with four replications.

Treatment evaluations consisted of the following: late spring vegetative cover evaluations of yellow starthistle, wheatgrass, annual grasses, and other forbs; and summer evaluations of yellow starthistle plant height, density, biomass, and seedhead production. Vegetative cover was determined by five random 1 m^2 quadrats per plot for a total of 20 quadrats per treatment. Yellow starthistle plant height, density, biomass, and seedhead production were determined by harvesting three 0.25 m^2 quadrats per plot, for a total of 12 quadrats per treatment.

A complete factorial analysis was performed on the data. Multiple comparisons (α=0.05) were done at the level of the highest order interaction. Data were pooled where main effects were not significant. All values are reported in original form.

Results and Discussion

In the 1997, yellow starthistle (YST) cover was significantly reduced in plots treated with clopyralid, with or without wheatgrass, to 14 and 4%, respectively (Table 1). Wheatgrass established only in plots treated with glyphosate and clopyralid. Additionally, there was a dramatic increase in other forb cover in plots treated with clopyralid compared to the control. The primary forbs were red-stem filaree (*Erodium cicutarium*) and tumble mustard (*Sisymbrium altissimum*). Annual grass cover significantly increased to 8% in plots treated with clopyralid alone. These findings suggest significant forb and annual grass suppression by yellow starthistle and the necessity of glyphosate for wheatgrass establishment.

In 1998, wheatgrass cover increased to 16-18% in plots treated with either one or two years of clopyralid. Yellow starthistle cover was less than 1% in plots treated with clopyralid for two years, but increased to 40-43% in plots treated with clopyralid only in 1997 (Table 2). Forb cover was significantly higher in plots treated with clopyralid for two years compared to plots treated for only one year. Annual grass cover was significantly higher in plots receiving clopyralid alone compared to the control and the clopyralid (1 year) + wheatgrass treatment. There was also a notable trend in decreased annual grass cover where both YST was controlled and wheatgrass was established. Annual grass cover was 16% in plots treated with clopyralid (2 yr) + wheatgrass compared to 32% where clopyralid was used for two years alone. However, this trend was not significant.

There was also a very apparent trend in yellow starthistle's response to clopyralid applied only in year one. Yellow starthistle biomass, plant height and seedhead production all tended to be greater in plots treated with only one year of clopyralid compared to all other treatments, including the control (Table 3). This "thinned out" population appeared more vigorous than the highly dense controls.

The data may also suggest some suppression of yellow starthistle by pubescent wheatgrass. YST biomass and seedhead production was significantly lower in plots where wheatgrass was established compared to the control. Additionally, YST biomass and seedhead production was significantly lower in plots treated with clopyralid (1 yr) + wheatgrass compared to clopyralid (1 yr) alone. However, YST late spring cover was not significantly different between these two treatments. This may suggest that the wheatgrass is providing late season competitive suppression when yellow starthistle is in the reproductive phase.

These findings indicate that clopyralid may be used as an effective management tool for yellow starthistle. However, long term management may require a minimum of two years clopyralid use. When clopyralid was used for only one year, YST seedhead production was comparable to the control in the second year. There was also a significant release of annual grasses and forbs when YST was controlled with clopyralid alone. There is concern that this strategy may result in a long-term shift to other undesirables, such as medusahead. However, this did not occur in the second year. Pubescent wheatgrass provided significant suppression of YST seedhead production and tended to suppress other annual grasses, such as downy brome (*Bromus tectorum*). Pubescent wheatgrass has been successfully used to suppress downy brome in other areas (Whitson and Koch 1998). This study will continue for the next two years to determine the long-term effectiveness of this integrated management strategy for yellow starthistle control. Additional monitoring not discussed here includes water infiltration and erosion potential, soil moisture depletion and profile recharge, and yellow starthistle seedbank dynamics.

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Table 1. Spring cover (1997) of yellow starthistle, other forbs and annual grasses.

Treatment[a]	YST	Other forbs	Annual grasses
	------- % cover[b] -------		
Control	58 A	2 B	2 B
Clopyralid	4 B	26 A	8 A
Clopyralid + glyphosate + wheatgrass	14 B	29 A	3 AB

[a]Evaluations taken approximately 110 days after clopyralid treatment.
[b]Means within columns followed by the same letter are not significantly different (α=0.05).

Table 2. Spring cover (1998) of yellow starthistle, other forbs and annual grasses.

Treatment[a]	YST		Other forbs		Annual grasses	
	----------------------------		% cover[b]		----------------------------	
Control	83	A	3	B	4	C
Clopyralid (1 yr)	43	B	20	B	28	AB
Clopyralid (1 yr + wheatgrass)	40	B	17	B	11	C
Clopyralid (2 yr)	0	C	56	A	32	AB
Clopyralid (2 yr + wheatgrass)	0.1	C	40	A	16	BC

[a]Evaluations taken approximately 100 days after 2nd year clopyralid treatment.
[b]Means within columns followed by the same letter are not significantly different (α=0.05).

Table 3. Yellow starthistle response (1998) to clopyralid and wheatgrass.

Treatment[a]	Yellow starthistle parameter[b]					
	Biomass (g / 0.25 m^2)		Seedheads (# / 0.25 m^2)		Plant height (cm)	
Control	66	B	173	AB	29	B
Clopyralid (1 yr)	95	A	215	A	51	A
Clopyralid (1 yr + wheatgrass)	25	C	78	C	23	B
Clopyralid (2 yr)	0.2	C	0.4	D	0.8	C
Clopyralid (2 yr + wheatgrass)	0	C	0	D	0	C

[a]Evaluations taken approximately 130 days after 2nd year clopyralid treatment.
[b]Means within columns followed by the same letter are not significantly different (α=0.05).

Roundup Ready Cotton in California

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In 1998, 7000 acres of DP-6100 Roundup Ready Cotton were grown in California through private and public agronomic testing under the direction of the San Joaquin Valley Cotton Board. Grower experiences in the first year of commercial use were very positive, with excellent weed control and few if any problems with cotton injury or loss of yield due to improper application timing. One of the greatest advantages indicated by growers was the reduction, and in some cases, complete elimination of hand hoeing resulting in considerable cost savings.

It should be noted that Roundup Ready (or any other herbicide tolerant) cotton has given the cotton grower nothing new, but rather has provided another option or tool for weed control and an additional system to be used in resistance management. Previously, available options which have provided effective control include selective grass herbicides Poast, Fusilade and Prism and the over the top broad leaf herbicide, Staple. Preplant dinitroaniline herbicides will remain the foundation of any weed management system including Roundup Ready cotton. Monitoring weeds, field by field, sprayers and sprayer calibration as well as proper application timing will remain important concerns. Application timing becomes more important with the use of the Roundup Ready system. Another important point to keep in mind when considering the use of Roundup Ready cotton is to select varieties with proven agronomic traits, then select the technology. It is not a good choice to select a variety with the Roundup Ready gene which has poor yield potential or no verticillium wilt resistance for example.

Besides the grower acreage grown in 1998 a number of research studies were conducted to evaluate cotton tolerance to both over the top and post directed applications and evaluate efficacy of various weed species. A summary of the results are as follows:

Roundup applied to seedling annual morningglory provided excellent season long control through harvest when applied over the top of 2 to 3-leaf DP6100RR cotton and followed by one post directed treatment when the morningglory had 10 to 15-inch vegetative runners. Results of the 1998 studies are similar to 1997 and again show that one over the top application of Roundup is not adequate to effectively control annual morningglory.

Studies in 1998, as in 1997, continue to indicate the extreme importance of limiting over the top applications of Roundup to no later than the 4-leaf stage. Final plant mapping data indicated mishapened bolls and reduction of boll retention, especially at the 9 and 12-leaf stage of application. Seed cotton yields showed a significant reduction at the 9 and 12-leaf stages.

Evaluations of post directed treatments of Roundup (following over the top applications at the 2 and 4-leaf stage) at the 6, 8, 10, 12, and 14-leaf stage indicated yield reductions with the greatest reductions occurring with two post directed treatments of Roundup at the 8 and 10, 8 and 12, and the 10 and 14-leaf stage. Single post directed treatments did not reduce yields as great as the post directed treatments, but all post directed treatments reduced yield to some degree. Results of this study indicate that post directed treatments of Roundup should be applied with a hooded spray to minimize spray coverage to the lower part of the cotton plant. It appears small amounts of Roundup on the lower portion of the cotton plant is enough to translocate into fruiting structures, causing pollen sterility and ultimately yield reductions.

When Staple was applied over the top in combination with Roundup to DP6100RR cotton in the 2 to 3-leaf stage there was no adverse effect to cotton growth, development and yield. All treatments containing Staple produced the same visual symptoms as when applied to non Roundup Ready varieties. There was no advantage in tank mixing Staple and Roundup for the control of nightshade and shepherds purse. One hundred percent control of each weed species was achieved with Staple and Roundup alone and as a tank mix. Roundup provided acceptable control of nutsedge when applied alone or in combination with Staple. Staple has no activity on nutsedge.

CWSS Presidential Address
The World Is Run By Those Who Show Up!

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Good afternoon and welcome to the Fifty-First Annual Conference of the California Weed Science Society. I want to thank CWSS Vice President Steve Wright and his Program Committee for developing an excellent program. I want to thank Past President Ron Vargas for giving me advice and calming my nerves when things got confusing. I want to thank the other CWSS officers, directors and committee members for all their hard work that makes CWSS such a successful organization. And, of course, I wish to thank our Business Manager, Wanda Graves, for keeping all of us on track.

I would like to share some thought with you about what I believe will be important parts of "Tomorrow Land for Weed Control". At first it was hard to come up with something that hadn't been said here before. I asked my predecessor, Ron Vargas, what I should talk about. His answer was simple — "Anything you want to talk about!" That really narrowed it down for me.

I consider myself a weed scientist, but not a researcher. So, I won't discuss technical weed science developments today. Ron discussed much of what is coming "tomorrow" for weed science in his Presidential address last year. I won't repeat that.

Using a technique that has served me well in the past, I looked at this year's CWSS Conference program for inspiration. We will have presentations from fifty-four different speakers. They include eighteen speakers in the historical topics of weed control in food and fiber crops — a number very consistent with the Conference's average over the past twenty years. Nine are on turf and ornamental topics. One is strictly on industrial vegetation management and two are on aquatic topics. Nine are related to range and wildland issues, including noxious and invasive weeds — a number that indicates a high interest level in this growing problem. That adds up to thirty-nine presentations on actual vegetation management.

There also three adjuvant talks and two photography presentations that span all weed control areas. Now we are at forty-four speakers.

What is different about this program? The answer is that there are ten presentations on public policy issues. What is also different is that they are spread throughout the program. They are not just in the general session or the Laws and Regulations session. They include three talks on public perceptions related to pesticides, four talks on food safety or the Food Quality Protection Act (FQPA), Two on the Endangered Species Act, and one talk on Surface water issues related to the Clean Water Act. That means that almost one-fifth of the Conference is essentially devoted to learning how to deal with situations imposed on us by other people.

This significant element of the Conference helped me decide on the message I want to leave with you. By necessity it is a very personal message, but I am positive that I am not the only person who could (or would) give you the message. It is quite simple — SHOW UP!

There is a scene in an old Woody Allen movie where two men are talking. One man is complaining about how badly life has treated him. The government is making his life miserable, his business is bad, and he feels as if he had no control over his life. The other man in the scene simply says, "The world is run by those who show up." I don't remember who told me that story, but I have taken it to heart as one of the guiding principles in my life. I make a decent living in this industry and I feel an obligation to give something back. I do that by showing up. I show up at industry meetings. I show up at legislative and regulatory hearings. I show up at conferences like this. I was scared at first and I thought that no one would listen to me. I realized after a while, though, that I didn't die when I showed up. That was good. Eventually people in charge started asking me my opinion. Eventually I started giving them my opinion. They even took my advice.

We have a new governor in Sacramento. Things will be different than they have been the past sixteen years. Laws and regulations that we are familiar with may now be interpreted differently by new administrators in the California Environmental Protection Agency, the Resources Agency, and the Department of Food and Agriculture. Since the Governor and the majority of the legislature are of the same party, vetoes are less likely than in the past. Is this bad? Maybe it is. Is this good? Possibly. Whatever your point of view is, please SHOW UP. Take the time to learn the issues and act on them when they affect you, your business, and California agriculture.

What has this got to do with "Tomorrow Land for Weed Control"? The answer is that, just like our CWSS Conference program, we will be spending more and more time in the future dealing with laws, regulations, and public perceptions we may not totally agree with. If you show up, you can become involved in drafting the public policies of the future. If you don't show up, someone else will — someone who may not have your best interests at heart. If you truly can't show up, then support those who show up for you. Write letters, make phone calls, and send e-mails. Your representatives and regulators do listen. You just have to take the time to give your input. I promise you your efforts will pay off.

Thank you for coming to this year's Conference. I'm sure you will find the speakers both educational and entertaining. Steve Wright got the program accredited for 26 hours of Continuing Education, including an unprecedented 3.5 hours of Laws and Regulations. That's a great benefit for all of you who have pesticide licenses or certificates. I only ask that if you want to claim all 26 of those hours, please SHOW UP!

Consumer Food Safety Perceptions

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Consumer confidence in the safety of food in the supermarket has increased in the last ten years. In 1989, 81% were mostly or completely confident in the safety of food in the supermarket. By 1992, confidence dipped to 72%. It gradually increased to 83% in 1997 (Abt Associates, 1997; Opinion Research, 1990).

Comparison of Food Safety Concerns

Microbiological contamination is consumer's greatest concern, followed by chemical contamination, such as pesticide or animal drug residues. Nationwide surveys by the Food Marketing Institute indicated more people volunteer concerns about microbiological hazards than any other potential food safety issue. From 1992 to 1997, volunteered concern about microbiological safety increased from 36% to 69% (Abt Associates, 1997). When concern about contamination by bacteria or germs was specifically asked, 82% acknowledge it as a serious hazard. More consumers consider this a serious hazard than any other potential food risk.

Although pesticide residues continue to generate concern among a large segment of the population, only 65% ranked it a serious hazard in 1997, a significant decreased from 82% in 1989.

Concern about other food safety areas has also decreased. Those expressing serious concern with antibiotics and hormones used in poultry or livestock decreased from 61% in 1989 to 43% in 1997. Those rating the use of nitrites in food as a serious hazard decreased from 44% in 1989 to 28% in 1997. Those rating use of additives and preservatives as a serious hazard decreased from 30% in 1989 to 21% in 1997.

Natural toxicants seldom generate high levels of concern. Natural is often equated with safe and wholesome. In a California survey, people were surprised when they heard that common foods like peanut butter or organic apple juice may contain natural toxins (Bruhn et al, 1998). That pesticides or herbicides may prevent the development of hazardous natural toxins was new information and not believed by some consumers.

Pesticide Concerns

Concern about pesticide or herbicide residue contamination seems logical since these chemicals are used for their toxic effect. Several attitude studies noted that concern about residues was higher among those with lower income and less formal education (Packer, 1992; Center for Produce Quality, 1992; Eom, 1992). Consumers with less than $15,000 income were willing to pay a higher price premium to reduce the risk of pesticide residues, $0.83 per unit compared to $0.64 and $0.58 per unit among persons with income of $15,000-45,000 or more than $45,000 (Eom, 1992).

Concern also could impact produce consumption. In anticipation of a report from the National Academy of Science, consumers were asked what they would do if pesticide regulations were considered inadequate to account for Children's risks (Center for Produce Quality, 1992). Most consumers, 93%, indicated they would wash produce better, many, 63%, would peel skin off produce, however 15% said they would reduce the amount of produce served. This response, which is not consistent with recommendations to increase the consumption of fruits and vegetables, was highest among those with the lowest income. Of those with income less than $15 thousand per year, 33% said they would reduce produce served, compared to 8% among those with income above $50,000. Less formal education was also related to the tendency to reduce produce consumption, with 20% of those with a high school education or less reporting this response, compared to 8% for those with post graduate schooling. Response also differed by race with 25% of non-Caucasians indicating they would reduce consumption compared to 12% of Caucasians.

Concern centers on personal health and environmental risks (Bruhn et al, 1992a; Chipman et al, 1995). Consumers generally believe that pesticides are overused in agriculture. Urban consumers are more likely than farm families to believe that not enough is being done to reduce pesticide use. People also believe they had little personal control over their own exposure to pesticide residues (Chipman et al, 1995).

Addressing Pesticide Concerns

Some believe organic production is the most appropriate response to consumer concern Many consumers perceive organic as a pesticide-free production method (Jolly et al, 1989). Recommendations developed by the National Organic Standards Board and the USDA proposal indicate that organic is a not a pesticide-free claim, but rather a system of managing crops and livestock which emphasized natural feeds, medications, pest control methods and soil inputs (Food Chemical News, 1996). It will be interesting to see if this concept is acknowledged in marketing and if consumer attitudes change based upon a more accurate understanding of organic production.

Messages advising consumers to wash or peel produce were not effective because they did not completely addressed consumer concern (Bruhn et al, 1992a). Focus group research indicates people want to know the risks and benefits of chemical use, how a problem is being addressed, and what options were available (Chipman et al, 1995). A simple message, here are the risks and benefits, you decide, with no options presented was not acceptable because it provided too little information. Also unacceptable was the message, “don't worry, the risk is minimal.” People were angry at this style and equated it with a “big brother” approach.

When consumer concerns are acknowledged and information provided on how risks are being addressed, consumer outrage is reduced. This was applied in a California study which exposed consumers to information on the environmentally responsive integrated pest management approach to farming. This communication approach resulted in significant change in attitudes toward food safety, farming practices, and university efforts to help farmers (Bruhn et al, 1992b).

Biotechnology

Consumers are receptive to new technologies which offer benefits. Although few consumers are knowledgeable about biotechnology, many have heard of the technology and consumer attitudes are generally positive. Studies conducted by the Food Marketing Institute indicate a very small percentage of consumers express serious concern about biotechnology. In a 1997 study, almost 80% of Americans said they were aware of biotechnology, more than half (54%) said biotechnology has already provided benefits to them, and 78% predicted they will benefit from biotechnology in the next five years (IFIC, 1997). Nearly half of survey respondents realized foods produced through biotechnology were already in supermarkets. Almost two-thirds, 62% indicated they were very or somewhat likely to buy a product modified to taste better or fresher with 17% of these very likely (Abt Assoc., 1996). Additionally 74% were very or somewhat likely to buy a product modified to resist insect damage and require fewer pesticide applications.

Response to biotechnology internationally is varied. Most Australians believe genetic engineering is a "good idea" with as many as 90% supporting medical and environmental applications, 80% interested in tastier foods, and about two thirds indicating they will eat products modified by biotechnology (Kelly, 1995). Almost all, 93%, Japanese consumers interviewed believed biotechnology will provide benefits to them or their family in the next five years, with the greatest interest in environmental applications (Hoban, 1996).

When asked about the severity of potential food risks, 44% of Europeans considered genetic engineering a serious risk (Tordjman, 1995). This is about in the middle of potential food risks, with bacterial contamination at the top with 85% of consumers and sugar at the bottom with 12%. Response varies by individual countries with more consumers in Scandinavian countries, Germany, and Austria perceiving biotechnology as risky compared to other countries (Hoban, 1997). With the exception of Austria and Germany, half or more European consumers indicate they would purchase a product modified by genetic engineering.

Effect of Biotechnology Information on Attitudes

To test the effect of information on attitudes, the Center for Consumer Research produced a ten minute video tape which addressed questions previously identified as important (Bruhn and Mason, 1996). The video draws an analogy between traditional practices of plant selection and breeding and more specific and controlled techniques of recombinant DNA technology, and highlights potential uses of rDNA technology to enhance healthfulness of food products, improve taste, or produce food crops in a more environmentally benign manner. Concerns that these changes could generate new risks and the existence of a regulatory framework to address and control risks are mentioned. The video was shown to over 300 consumers in California and Indiana.

Consumers were initially positive toward biotechnology, with 66% believing biotechnology offered society some or a lot of benefits. After viewing the video this percentage increased to 96%. Before the program, 46% felt biotechnology presented society with potential risks. After the program this increased to 68%. This is consistent with the video message in which it is acknowledged that any process involves both risks and benefits. The percentage of participants that felt biotechnology would have a positive effect on human health and well being increased from 72% before the program to 90% afterwards.

Influences on Consumer Perceptions

Concerns are shaped by the media, the food industry, and the consumer's own knowledge and perception. Surveys indicate people obtained most of their information about food safety from the media with television first followed by newspapers and magazines (Bruhn et al 1992; Hoban, 1994; Hoban and Kendall, 1993). Other people were also a significant source of information. Many people were skeptical about stories in the media and evaluated information sources to judge credibility. Consumers consider how frequently they heard a message, the credibility of the source, and if the information was reasonable to them.

Trusted sources are described as knowledgeable, concerned with public welfare, truthful, and with a "good track record." Less credible sources are characterized by exaggeration, distortion, and vested interest (Frewer et al, 1996). Consumers considered health authorities, such as the American Medical Association or the American Dietetic Association, as the most credible, followed by university scientists and regulatory groups like FDA. The food industry, activists groups, and retailers were considered least credible (Bruhn et al 1992; Hoban, 1994). No source was believed by everyone.

Conclusion

Consumers are concerned about the environment as well as personal health and safety. People make reasonable judgments based upon the information they receive and their personal value system. We need to find interesting ways to demonstrate that scientists and farmers share the same concerns as the public and are working to produce safely in an environmentally sound fashion.

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Digital Imagery

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There are several "new" digital tools that can be very helpful to Weed Scientists. Whether it is in preparing snap shots, slide presentations, posters, written summaries, documenting the performance of various weed control measures, or just plain fun, digital images offer another dimension in picture taking. The following contains a review of some of the equipment that is available and that I have found to be useful.

A good computer (cost about $2,000 - Pentium II, 400 mhz with various options) is the back-bone of the system. Whether one prefers a "Mac" or a "windows" machine is not important. What is important is that the machine have a relatively fast processor and enough memory to run the graphics software needed to work well with digital images. Currently the most popular system is a Pentium processor with a clock speed of at least 400 megahertz, 64 megabytes of RAM memory, high quality video out-put and monitor, a hard disk with 6 gigabytes of memory, a CD drive, and a large capacity removable storage device such as a "zip" drive or a read/write CD. The storage devices are necessary to store images and graphics files. These files are often 20 to 40 megabytes in size. A "zip" drive ($200) disk can hold 100 megabytes and a read/write CD drive (about $600) CD can hold 650 megabytes. The "zip" disks (about $10 ea.) or CDs (about $10 ea.) can be transferred from computer to computer (e.g. the slide scanners, image software, and camera software may be on one computer and the slide imager or high density color printer on another).

Scanners are helpful to create digital images from photos or slides that can then be printed or imported into graphics software like PowerPoint for preparation of presentations. Slide scanners can be obtained for between $800 - $2000 (I use a Nikon LS –20 Coolscan II). Slide scanners can be used to digitize and archive valuable slides for later use. Slide scanners can be obtained that have stack feeders for digitizing large batches of slides. Flat bed scanners are useful for scanning prints and page graphics (about $500). There are many formats for storing scanned images. One has to be careful in selecting a format, which makes the most efficient use of memory while still compatible with the intended graphics software. It is relatively easy to have some files of more than 15 megabytes.

Digital cameras are a relatively new and exciting addition to our camera bag. A Camera can be purchased which will produce images of 1536X1024 pixels resolution for around $800 (add about $200 for additional flash memory if you intend to take a lot of high density pictures). Images from these cameras can be viewed directly on the camera screen, projected on TV screens, printed on a color printer, or imported into a graphics software package and used in a slide, written, or computer presentation. The resolution is not quite as good as an ordinary slide or photograph, but in many cases it is difficult to distinguish the difference. The key is the speed and ease with which images can be taken and imported. This is much easier than taking a 35mm shot, developing the image, digitizing the image, and then importing it into the graphics software. It is also much cheaper given the cost of slide digitizers. Once the image is taken it can be altered digitally to improve contrast, color balance, remove unwanted background, resized, etc.

Other sources of images include videotape, stored images on CDs, and the Internet. Images may be downloaded from these sources and utilized in publications, printed, or inserted into slide or computer presentations.

Color printers (about $400 for a really good one) can be used for preparing color "prints" of digitized images or slide presentations. Epson has several in this price range which can print at a resolution of 1440X720 dots per inch. This is particularly useful in the preparation of posters. Color posters can be made as a large, one-sheet, printout on expensive large-scale color printers. These posters are easily transported to meetings and merely tacked to the poster board as a single sheet. This makes poster presentations considerably simpler. Unfortunately the large-scale printers are very expensive. However, if one has access to one through a commercial print shop or a university or government shop, they make excellent use of graphics software.

A slide imager (about $5,000) is a device that (we have an older Montage FR-2) allows the computer to print the graphics that have been produced by graphics software to a camera in order to produce 35-mm slides for presentation. Polaroid and Montage are two of the brands available. Generally the higher the resolution, the higher the cost of the imager. A resolution of 4,000 lines or better gives good results.

Slide development equipment is usually not necessary as "E6 one hour" or at least over-night developing is available in many areas. Should one need to develop and mount slides, a good developing system can be purchased for about $1,000 (we use the Jobo CPE-2 plus system with GEPE slide mounter and mounts). After purchase of the equipment, slide development costs are about $4 a roll with mounts. Slide developing and mounting with such a system usually takes about one hour. The system we have develops two rolls at a time.

Success depends on the user. All of the above equipment will give one the potential for preparation of some very nice and sometimes sophisticated slide, computer, or hard copy presentations. Experimentation with the graphics software should produce desirable backgrounds, interesting ways to present data, excellent talk outlines, and imported pictures to augment the presentation. Thorough familiarization with the software manual should allow one to realize what the potentials are. A little work and a lot of imagination can result in beautiful results.

Photography: An Educational Tool in Weed Science

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Introduction

The use of photography in weed science, or agriculture in general, should be a rewarding experience that can add immeasurably when documenting field research. Photography may also be used to visually record various agricultural situations that will help understand what was happening. These slides or photographs can be used in many ways; in conjunction with an oral presentation to better understand the subject matter, stock photography to be used by a company or university to put together slide sets of various crops and/or pest management problems/situations, and private industry may use these slides/photographs in advertising literature. No matter how it is used, photography is a useful "tool" in agriculture and bringing a camera along while at work can also make a job more interesting.

Understanding the basic principles in photography is important in order to capture the image as the photographer wants others to see it. In this day of "auto-everything" cameras, it sometimes takes the creativity away from the photographer and leaves the image completely up to the whim of the camera. Realizing that most results from a completely automatic camera will be satisfactory much of the time, there is still a need to understand what is going on when a photograph is "shot". Separating a "photographer" from a "picture-taker" sometimes means switching that camera from automatic to manual and understanding what is going on when you depress that shutter button. A knowledgeable photographer will also make the right decision when choosing the appropriate lens and film to obtain that desired result.

With a basic understanding of certain photographic concepts such as exposure and depth-of-field, an individual may be challenged to take the camera off the automatic mode and attempt some creativity by manually operating the camera.

Exposure

In everyday photographic terms, exposure means the picture taken on a roll of film (ie: a 36 *exposure* roll). **Defined another way, exposure is a quantity of light or the amount of light (intensity x time) that reaches the film, reproducing a desired image.** Exposure is a function of three variables; film speed, shutter speed, and aperture. An almost infinite combination of these variables will produce the quantity of light necessary for a correct exposure. The photographer has the freedom to decide how these variables will be used. Of course today's high tech automatic camera is programmed to decide for the photographer the best all around exposure, but a whole new photographic world is opened up when that same camera is switched to manual. Creativity is what separates the photographer from the picture-taker.

Film Speed

The film speed is based on the film's sensitivity to light and is identified by an "ISO" number. Fast films (high ISO numbers) are more light-sensitive than slow films (low ISO numbers). Fast films require less light to expose the film. Slow films usually have an ISO rating up to 100 (ie: Kodachrome 25, Kodachrome 64, Sensia 50). A medium speed film would be from ISO100 - ISO200 and would include Elite II 100 and Sensia 100. Films that are considered fast have ISO numbers between 200-400, and the extra-fast films are above ISO400.

The sensitivity of ISO400 film is twice that of ISO200 film and requires 1/2 the light to obtain an equivalent exposure. For example; if ISO400 film requires a 1/500 second exposure, then the ISO200 film would require a 1/250 second exposure, and an ISO100 film would have successful results with a 1/125 second exposure.

Selection of the right film speed depends on the intent of the photographer. Films of medium speed (ISO100-ISO200) are the most common for everyday photography. Films with faster speeds (>ISO200) are generally used under low light conditions.

Shutter Speed

The shutter speed is the length of time the camera's shutter remains open, exposing the film. Typical shutter speeds are usually indicated by the reciprocal number in seconds; 1000 = 1/1000 second, 500 = 1/500 second, 250 = 1/250 second, 125 = 1/125 second, etc.. Slow shutter speeds would be effective to show movement (ie: the blurred walnuts or almonds as they are being shaken from the tree at harvest). A fast shutter speed could include a stop-action shot of a crop duster. Most cameras also have a bulb (B) setting for timed exposures. In the case of the bulb setting, the shutter remains open for a predetermined amount of time based on manually holding in the shutter button or a preprogrammed time on an automatic camera.

Aperture

The aperture is simply the lens opening, and is commonly referred to in "f/stops". A typical range of apertures for a lens would be f/22, f/16, f/11, f/8, f/5.6, f/4, f2.8, and f/2. For these apertures, f/22 is the smallest opening and f/2 is the largest. There is also a direct correlation between apertures; the amount of light received doubles at each f/stop increase. If one unit of light passes through the f/22 aperture, two units of light would pass through the f/16 aperture, four units of light would pass through the f/11 aperture. Based on this scenario, by the time the lens was opened up to an aperture of f/2, 128 units of light would pass through the lens.

Remember that when changing one of the three exposure variables like aperture, there must be a corresponding change of the shutter speed and/or film speed to obtain an equivalent exposure. Of course the camera may already have done that automatically.

Depth-Of-Field

When viewing photographs, some appear to be in sharp focus from front to back, while others only part seems to be sharp. This is called the depth-of-field, and it is the distance range where everything will be in sharp focus. The depth-of-field is variable and directly related to the lens aperture. **The smaller the aperture, the greater the depth-of-field.** For example, with a standard 55mm. lens focused on an object 10 feet away, the depth-of-field at the f/2 aperture will total only two feet (9.5' to 11. 5' from the camera), at f/11, the depth-of-field is 16 feet (7' to 23' from the camera), whereas at the f/22 aperture, the depth-of-field will be from five feet to infinity. Depth-of-field is one of the most important considerations in photography. It appears that in many photographic situations, maximum depth of field is preferred. That means being aware of the aperture, and making sure to use the smallest aperture possible.

If maximum depth-of-field is the objective in a scene out to objects at "infinity" as indicated on the camera lens, there is a way to insure that depth-of-field is maximized. It's called **hyperfocal distance**. When the lens is focused at infinity, the near limit of depth-of-field for the preset aperture is called the hyperfocal distance (There is usually a depth-of-field scale shown on the lens barrel with markings for the various apertures). By moving the focus to that distance will result in the maximum depth-of-field for that aperture. If maximum depth-of-field is preferred and this hyperfocal distance technique can't be remembered, there is an easy way to obtain the best sharpness possible rather that just guessing: Set the camera on the smallest aperture possible and focus about 1/3 into the field of view. This technique should result in pretty good depth-of-field in most situations.

As stated earlier, the smaller the aperture, the greater the depth-of-field. However, the depth-of-field for a given aperture will vary depending on the focal length of the lens. For a given aperture, a wider angle lens offers a greater depth-of-field. For example, at an aperture of f/16, the depth-of-field for a 135mm lens is from 50 feet to infinity, whereas the depth-of-field for a 28mm wide angle lens is from three feet to infinity.

In close-up photography, where the subject is being magnified, the depth-of-field becomes very limited and critical. At a 0.1X magnification using a f/16 aperture, the total depth-of-field is 104mm. However, when a subject is magnified to 1.0X (life-size), the total depth-of-field is down to only 2mm.

Manipulating the depth-of-field is important to obtain the desired result. Maximum depth-of-field may not always be wanted. By using **selective focus**, a large aperture will narrow the depth-of-field and highlight a sharp subject from an otherwise confusing picture. By focusing only on the subject (i.e.: weed seedling) and blurring the cluttered background, the subject will stand out and therefore be easily identified.

Slide Films

Only slide film is being discussed for two reasons: First, most individuals in weed science research will use slides more often than photographs. Secondly, photographs are easily and relatively economically made from slides. The most common and readily available slide films on the market are Kodak's Kodachrome 64 (ISO64) and Elite II 100 (ISO100). Fuji's Sensia 100 (ISO 100) is also a very popular slide film that has only been on the market for a couple of years, but has become one of the industry standards.

Kodachrome 64: It seems like this film has been around forever, at least 40+ years. Although the colors are somewhat muted, they are quite consistent whether in full sunshine or used under overcast skies. This film can definitely use a polarizing filter to help exhibit some brighter color. Flesh tones are true with Kodachrome 64 and it is not too contrasty. Kodachrome 64 is a good all around slide film, but not very exciting.

Elite II 100: This new Ektachrome film shows promise. Comparison tests have shown this film to have excellent bright color qualities, but should be underexposed (about 1/2 f/stop) to match the bright colors found in Fujichrome film. Color suffers slightly under overcast skies, but results are still acceptable. Elite II 100 is not hampered by too much contrast. It is an excellent choice and readily available.

Sensia 100: This is a fairly new film, replacing the colorful Fujichrome 100. It's dramatic color is no match for the Kodak films. However, it does tend to be quite contrasty, and the flesh tones can come out rather red. Under overcast skies, the color shifts to a cool "blue", indicating the need for a warming filter (#81A). Even though there are some problems (although correctable) associated with Sensia 100, it is still the first choice for many outdoor photographers.

Cameras and Lenses

Anyone who has visited a camera store or browsed through a photography magazine recently has to be overwhelmed at the number of cameras on the market. Just 20 years ago it seemed like each manufacturer had a small line of cameras and they looked and worked just like their competitors. But today, with all the high tech gadgetry, there are a myriad of choices that boggles the mind. Viewfinder cameras have come a long way since they were all fixed focal length and usually resulted in photographs of marginal quality. These cameras don't "see" through the lens, but have a straight through area to view the subject. The current viewfinder cameras have elaborate zoom lenses that range from 28mm to 140mm, and have many features, resulting in good photographs. There are a couple of problems with this type of camera. They are not very good for close-up photography since a person can't see exactly what's in the lens and that is important for proper composition. Another problem with viewfinder cameras is that since there's no manual override, results are at the mercy of the automatic mode, and that might not be what is desired. They can also be quite expensive for what they do.

If there is a choice in selecting a camera, the single lens reflex (SLR) is the only way to go. It's important to see exactly what the picture area will be and through-the-lens viewing is what a SLR is all about. Interchangeable lenses is a big plus when comparing SLRs to viewfinder cameras. No serious photographers would limit themselves to only one lens (well, maybe a fullrange zoom, which may have questionable quality considerations). These new cameras have autoeverything, which is fine, especially the auto-focus for people whose eyesight is beginning to become somewhat unreliable. Generally, the auto-everything cameras will give very good results most of the time, but there still should be a manual override for those who really want to get creative.

Lens selection is as important as the SLR camera body being purchased. Wide angle lenses (35mm, 28mm, and even the super-wide 20mm) are very effective in encompassing areas so a person doesn't have to back up several hundred feet to get everything in the photograph. Wide angle lenses are also good for that low angle, dramatic shot of a harvester, sprayer or whatever the photographer wants to capture. Since there can be considerable distortion with the wider angle lenses, care should be taken to not overdue it. The telephoto lens (105 to 200+ mm) can be useful, but is not used nearly as much as a wide angle lens. A telephoto lens is good for photographing people when approaching them too close may result in losing that "candid" effect. Telephoto lenses are useful when a sprayfig is in operation and getting too close may result in unwanted spray deposits on the camera and photographer. Compressing subjects are easily attained with a telephoto lens. Using a long lens to photograph a nearby subject with mountains in the background will result in a picture that looks like the subject is almost touching the mountains. A zoom lens, like a 28-105mm or 35-135mm will probably encompass most needs of a photographer in the weed science field. Using a zoom lens is also a lot easier than continually changing lenses.

The final lens in the photographer's arsenal should be some kind of close-up lens, to allow for photographing small subjects like weed seedlings, insects, and close-ups of plant diseases. Some zoom lenses have "macro" stamped on the barrel or state "close-up" on their advertising literature, but in reality only magnify a little larger than the standard lens, which isn't much. For real close-up work, a lens should be capable of magnifying up to somewhere between 1/2 to full life-size (in other words, filling the viewfinder with a subject up to the size of the film (1" X 1 1/2"). Generally these are fixed focal length close-up lenses of anywhere from 50mm to 105mm. The 50mm lens forces the photographer to be just inches away from the subject, whereas the 105mm lens allows more working distance from the subject. A problem with a longer working distance between lens and subject is there's more area for unwanted clutter to interfere with getting a clear shot of the subject.

Conclusion

Understanding the basics of photography is important if the photographer wants to capture the subject on film exactly as desired, with the fight lens, film, lighting, and composition. This is also very important in purchasing the fight equipment for what and how subjects are to be photographed. Probably the most important factor in great photographic results is time. If a person doesn't want to or can't take the time necessary for quality results, then they become just a person taking pictures and can't expect many eye-catching results.

Poa annua Control in Bermudagrass Fairways

Mark M. Mahady
Mark M. Mahady and Associates

Introduction

Annual bluegrass is a genetically diverse weedy grass species that exhibits both annual (*Poa annua ssp. annua*) and perennial nature (*Poa annua ssp. reptans*) and is well adapted for germination and growth across many climatic regimes. Annual bluegrass proliferates under the extreme conditions found in the deserts of Southern California's Coachella Valley as well as the moderate Mediterranean climates found in the Monterey Peninsula of central coast California.

Annual bluegrass seed germination is greatest during the late summer and early fall. In California significant increases in annual bluegrass populations are generally observed from October to December. Regular sprinkler irrigation plus late fall and early winter rains enhance the potential for successful germination and development. Maximum seedhead proliferation is most often observed in Southern California from February through April. Optimum germination of annual bluegrass has been observed with maximum temperatures of 75-80 ^{o}F, moderate minimums and the presence of light, however, field observations would indicate that specific biotypes are well adapted to germinate and grow at higher and lower temperatures.

Surface disruption enhances the potential for annual bluegrass invasion. Cultural management practices such as aeration, vertical mowing and drill seeding which are designed to enhance surface quality may actually create a more favorable environment for annual bluegrass germination while reducing the short term competitive nature of the existing turf stand. The percent germination of annual bluegrass seed increases following mechanical operations which open the turf canopy and allow light to penetrate. In those cases where overseeded bermudagrass fairways or solid stand perennial ryegrass fairways are utilized, these management practices will enhance the problems associated with annual bluegrass invasion.

An example of the tenacity and competitiveness of annual bluegrass can be observed on golf courses in Palm Springs, California with overseeded bermudagrass fairways. In preparation for overseeding bermudagrass fairways many superintendents (a) reduce irrigation to dry down the surface, (b) allow bermudagrass to grow to 3/4"to 7/8", (c) flail mow to open the turf canopy, (d) sweep, (e) scalp to 1/4", (f) sweep, and (g) broadcast perennial ryegrass at rates of 600-700 pounds per acre.

Based on field observations conducted in the Southern California desert region of Palm Springs, it appears that the dynamic surface disruption that occurs during preparation for overseeding may be the trigger that activates annual bluegrass germination.

The objective of this research was to review both postemergent and preemergent philosophies for the control of annual bluegrass in overseeded bermudagrass fairways.

Materials & Methods

Through the cooperative efforts of the Hi-Lo Desert GCSA Tournament Research Committee, Novartis Crop Protection Inc. and AgrEvo USA Company, four *Poa annua* control field research trials were conducted on three golf courses in the Coachella Valley during the summer and fall of 1997 and the winter and spring of 1998.

Replicated field trials were deployed at Desert Dunes Golf Club, Desert Princess Country Club and Resort and The Springs Club. Timing and rate studies were deployed with Prograss 1.5 EC (ethofumesate: AgrEvo USA Company) and Barricade 65 WG (Prodiamine: Novartis Crop Protection Inc.) prior to, during and following perennial ryegrass overseeding.

Individual treatment plots measured 10' x 10' with a 5' x 10' in plot check and 24" aisleways. Treatments were replicated four times in a randomized complete block design. A calibrated $C0_2$ propelled spray system pressurized to 26 psi and equipped with 11004LP Tee-Jet nozzles applied treatments at a spray volume of 65 gallons per acre.

Field plots were prepared for perennial ryegrass overseeding from October 1 to October 11, 1997. Sites were flail mowed, swept, scalped and swept. The perennial ryegrass overseeding rate varied per site from 320 to 700 pounds per acre.

Treatment evaluations were conducted once per month from August 1997 to May 1998. The following evaluations were conducted during each rating date: percent perennial ryegrass cover versus the in-plot check, perennial ryegrass injury, percent annual bluegrass cover and control. Data were summarized and statistically analyzed. Differences between means were determined via LSD.

Results and Discussion: Barricade 65 WG (prodiamine) Field Trial

The concept behind this field trial was to determine the rate and application timing for the use of Barricade prior to and/or after perennial ryegrass overseeding for preemergent control of annual bluegrass without significantly influencing the stand density and surface quality of perennial ryegrass.

I. Preemergent Control of Poa annua with Barricade: The Springs Club

Table 1. The Influence of Barricade 65 WG on Germination and Density of Perennial Ryegrass. The Springs Club: Mike Kocour, Supt. MMM & Associates. 1998.

Treatments	Rate lb AI/A	4 WAOVS Percent Cover
♦ Untreated check	*	100.0
♦ Barricade: 8 weeks before OVS	1.0	91.3
♦ Barricade: 8 weeks before OVS	0.75	95.0
♦ Barricade: 6 weeks before OVS	0.75	86.9
♦ Barricade: 6 weeks before OVS	0.5	91.3
♦ Barricade: 4 weeks before OVS	0.5	93.8

- **Take Home Message: Barricade and Perennial Ryegrass Density**

  - *With proper irrigation stand density is reduced by less than 10% after 6-8 weeks.*

  - *Barricade combined with dry conditions during seed establishment will slow grow-in and reduce stand density.*

  - *A 2X overlap safety margin has not yet been established.*

Table 2. Evaluation of Barricade 65 WG for Control of *Poa annua* in Overseeded Common Bermuda Fairways. The Springs Club: Mike Kocour, Supt. MMM & Associates. 1998.

Treatments	Rate lb AI/A	March 30,1998 Percent Poa Control
♦ Barricade: 6 weeks before & 6 weeks after OVS	0.75/0.5	92.5 f
♦ Barricade: 8 weeks before & 6 weeks after OVS	0.75/0.5	89.8 f
♦ Barricade: 6 weeks before OVS	0.75	89.8 f
♦ Barricade: 4 weeks before & 6 weeks after OVS	0.5/0.75	86.4 f
♦ Barricade: 8 weeks before OVS	1.0	84.7 f
♦ Barricade: 8 weeks before OVS	0.75	76.3 ef
♦ Barricade: 6 weeks before OVS	0.5	72.2 def
♦ Barricade: 4 weeks after OVS	0.5	20.3 ab
♦ Barricade: 4 weeks after OVS	0.75	40.7 bc
♦ Untreated check	*	0.0

- **Take Home Message: Preemergent Control of *Poa annua* with Barricade**

  - *Under these soil and turf conditions and under these timing and rate formats, Barricade provided the best preemergent control of Poa annua when applied six or eight weeks prior to overseeding at rates of 0.5 to 1.0 pound of active ingredient per acre. Applying Barricade four weeks after overseeding resulted in very poor control.*

  - *Sequential treatments of Barricade applied six weeks before (0.75 lb AI/A) overseeding and six weeks after (0.5 lb AI/A) exhibited the best control.*

  - *Single treatments of Barricade applied 6 weeks (0.75 lb AI/A) or 8 weeks (1.0 lb AI/A) before overseeding exhibited very good control.*

  - *Single treatments of Barricade applied at rates of 0.5 and 0.75 lb AI/A four weeks after overseeding show 20.3% and 40.7% control, respectively. From these data it would appear that 60% to 80% of annual bluegrass germination occurs before the four week after overseeding date (November 24) at The Springs.*

Results and Discussion: Prograss 1.5 EC (ethofumesate) Field Trial

I. Control of Poa annua with Prograss 1.5 EC: Desert Dunes and Desert Princess

The concept behind these field trials was to determine the rate and application timing for the use of Prograss 1.5 EC (ethofumesate) as a postemergent herbicide for the control of annual bluegrass without causing damage to common or hybrid bermudagrass. Bermudagrass exhibits poor tolerance to Prograss applications.

Table 3. Evaluation of Prograss 1.5 EC for Control of *Poa annua* in Overseeded Bermudagrass Fairways. Desert Princess Country Club, Ken Graves, Supt. and Desert Dunes Golf Club, Bill Kostes, Supt. MMM & Associates. 1998. Overseeding Conducted October 1, 1997

		Percent Poa Control 4/20/98	
Treatments	**Rate**	**D. Princess**	**D. Dunes**
♦ Prograss: Single Application 11/13	0.5 gal /A	2.6	17.6
♦ Prograss: Single Application 11/13	0.75 gal/A	-10.3	0.0
♦ Prograss: Single Application 11/13	1.0 gal /A	-2.6	35.3
♦ Prograss: Seq. Appl. 11/13 & 12/29	0.5 gal/A	12.8	47.1
♦ Prograss: Seq. Appl. 11/13 & 12/29	0.75 gal/A	28.2	68.2
♦ Prograss: Seq. Appl. 11/13 & 12/29	1.0 gal/A	67.2	88.2
♦ Untreated check		0.0	0.0

- **Take Home Message: Control of *Poa annua* with Prograss, 1.5 EC**

  - *Significant variability in percent control was observed between locations.*

  - *Under these soil and turf conditions, these timing and rate formats, and this localized weed pressure, Prograss provided the best postemergent control of Poa annua when applied as sequential treatments at a rate of 1.0 gallon of product per acre on November 13 and December 29, 1997.*

  - *As Poa pressure increases more escapes are observed as the Prograss application rate is decreased from 1.0 gallon per acre to 0. 75 gallons per acre. The severity of escapes will also be influenced by the genetic diversity in the stand, the percentage of annual or perennial biotypes, and the sensitivity of these biotypes to Prograss applications.*

  - *The Prograss rate and application timing should be based on (a) local knowledge at your particular course, (b) turf type, common or hybrid bermudagrass, (c) occurrence of the first and second frost, and, (d) historical annual bluegrass pressure.*

- **Take Home Message: Bermudagrass Injury Potential with Prograss 1.5 EC**

  - *Prograss caused injury to common and hybrid bermuda. Common recovered more rapidly than hybrid. No injury was noted with common during the spring/summer* *transition. Hybrid (328) bermudagrass showed greater sensitivity to Prograss. Only minor injury was noted on 328 during the spring and summer transition. Additional research work to more thoroughly define the susceptibility of hybrid types to Prograss injury is recommended.*

Table 4. Evaluation of Turf Injury on 328 Hybrid Bermudagrass Fairways with Prograss 1.5 EC. Desert Dunes Golf Club: Bill Kostes, Supt. MMM & Associates. 1998.

Treatments	Rate	6/28/98 Injury 0-10 Scale
♦ Prograss: Single Application 11/13	0.5 gal/A	1.5
♦ Prograss: Single Application 11/13	0.75 gal/A	2.0
♦ Prograss: Single Application 11/13	1.0 gal/A	2.0
♦ Prograss: Seq. Appl. 11/13 & 12/29	0.5 gal/A	2.0
♦ Prograss: Seq. Appl. 11 / 13 & 12 / 29	0.75 gal/A	2.0
♦ Prograss: Seq. Appl. 11/13 & 12/29	1.0 gal/A	2.3

II. Control of Poa annua with Prograss and Barricade: Desert Dunes Golf Club

Table 5. Evaluation of Prograss 1.5 EC and Barricade 65 WG for Control of Poa annua in Overseeded Bermudagrass Fairways. Desert Dunes Golf Club: Bill Kostes, Supt. MMM & Associates. 1998.

Treatments	Rate/A	March 30,1998 Percent Poa Control
♦ Barricade: 6 weeks after OVS	0.5 lb ai	-7.1 a
♦ Barricade: 6 weeks after OVS	0.75 lb ai	19.6 b
♦ Barricade: 6 weeks after OVS	1.0 lb ai	10.7 ab
♦ Prograss: 6 weeks after OVS	0.75 gal	19.6 b
♦ Prograss: 6 & 12 weeks after OVS	0.75 gal	90.4 c
♦ Prograss+Barricade (Single) 6 WAOVS	0.75 gal/0.75 lb ai	72.5 c
♦ Prograss+Barricade (Seq) 6 & 14 WAOVS	0.75 gal/0.75 lb ai	86.8 c

♦ Take Home Message: Control of *Poa annua* with Prograss and Barricade

- ➢ *Under these soil and turf conditions and under these timing and rate formats, Prograss provided the best postemergent control of Poa annua (90.4%) when applied as sequential treatments six and twelve weeks after overseeding at a rate of 0.75 gallons of product per acre.*

- ➢ *Single treatments of Prograss applied six weeks after overseeding resulted in unacceptable control (19.6%).*

- ➢ *A tank mix of Prograss plus Barricade applied once six weeks after overseeding significantly enhanced Poa annua control (72.5%) when compared to a single application of Prograss alone (19.6%).*

Turf and Ornamental Weed Management (from the turf and ornamentals panel discussion)

Dave Cudney
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Fortunately, there are many informational resources available to turf and ornamental managers to aid them in their efforts to control weeds. I will deal with only a few of the public sector sources.

University of California

There is a Cooperative Extension Office located in each county of California with Farm Advisors available to help with the questions and problems associated with crop (including turf and ornamentals) production and management. In many urban areas there is also a program, Master Gardeners, which is staffed by University trained volunteers who help to alleviate the load on Farm Advisors by answering telephone calls, giving demonstrations, etc.

Specialists are located on both the Davis and the Riverside campuses of the University that support Farm Advisors efforts and develop and publish information on production and management of turf and ornamentals.

There are many different types of University publications, each county office maintains lists of available publications. In some cases there is a charge for these publication depending on their length and printing costs. Visit the office nearest you and become familiar with this wide array of information. These publications include:

- Farm Advisor newsletters
- County publications
- University bulletins
- IPM circulars and bulletins
- Identification manuals and books

Farm Advisors and University Specialists hold and participate in informational conferences, seminars and field meetings that deal with production, management, and economics of turf and ornamentals. Make sure that you are on the various county and University mailing lists for these meetings.

The Internet

The Internet is a vast resource of information on almost any subject. One has to be careful, however, when interpreting this information. Much of it comes from entirely different geographic regions with different climates, soil types, and turf and ornamental varieties. The University of California has several internet sites which can be very beneficial (these include IPM, WRIC, and the UCR Botany home pages). The UC IPM group at UC Davis has a homepage (www.ipm.ucdavis.edu) with lots of good information. It has Pest Notes, IPM Guidelines for various crops including turf, weed pictures, and more. Pest Notes is a new publication which has identification and control information on several important weed pests. The crops guidelines section has information on the management of many pests including weeds on most crops. WRIC is a new homepage (wric.ucdavis.edu) of the Weed Research and Education Center in the Vegetable Crops Department at Davis. The Botany Department at Riverside has a homepage (cnas.ucr.edu/~bps/hcoopext) which contains descriptions of several weeds, a thorough review of the nutsedges, and the world's largest susceptibility chart (72 weeds and 62 herbicides for over 4400 ratings). The susceptibility chart may be downloaded as an EXCEL chart.

Weed Science Organizations

The California Weed Science Society has an annual Conference, a textbook (*Principles of Weed Control in California)*, and is helping to sponsor a new weed identification guide by Joe DiTomaso which will be published in the next few years.

The Western Weed Science Society has an annual educational conference, publishes *Weeds of the West* (a popular weed identification guide), and a biological control guide. They have a homepage with more information (www.wsweedscience.org). There are other regional Weed Science organizations from the South, Northeastern, etc., that publish useful guides and books.

The Weed Science Society of America has an annual educational conference, publishes two journals (*Weed Science* and *Weed Technology*) which contain the latest information on pertinent weed science investigations in the world. The Society also publishes many useful reviews and guides including the Herbicide Handbook which is the best single informational guide on herbicides – a must for every Weed Scientist. The web page for the WSSA is extensive and contains links to other useful pages (ext.agn.uiuc.edu/wssa).

Weed Control Problems Using Greenwaste

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Introduction

The Integrated Waste Management Act of 1989 mandated 25% diversion of recyclable materials from landfills by 1995 and 50% reduction by 2000. To meet these stringent requirements, communities all over California have initiated recycling programs for green materials wastes (greenwastes). Curbside collections of greenwaste are brought to central locations, ground (usually with a tub grinder), screened, stockpiled and disbursed as mulch material. The cost and quality of greenwaste mulch materials is variable depending on the sources (feedstocks) and processing performed at the collection site.

Weed control with mulch treatments has been well studied and is a generally accepted practice (see the review by Robinson, 1989). Yet the advent of curbside collected ornamental yard trash is a new concept in California and given the wide range of ornamental plants and weeds that could enter the greenwaste stream; there is doubt about many qualities of such greenwaste products. Horticultural professionals have questions about the allelopathic nature of feedstock components such as eucalyptus wastes, the possibility of feedstock contamination with weed seeds and whether the processing of greenwaste adequately resolves these concerns.

Composting is an effective seed treatment that kills most weed seeds in greenwaste; however, moisture content must be adequate to insure control (Egley, 1990). Dry materials are not easy to compost, but even if temperatures reach 60^{o}C many weeds will survive for up to 7 days. If moisture levels are higher (~20%) most weeds are killed after only 6 hours of exposure to 60^{o}C. Willen and Elmore (1997) found that most weed seeds tested were completely killed after only 3 hours of exposure to the inside of an active compost pile. Thus, provided that a compost pile is kept moist and frequently turned to facilitate mixing, weeds can be controlled preventing contamination of mulch products. Unfortunately, legitimate composting facilities are difficult to start up due to regulatory burdens and cost. Thus "stockpile" operations that simply hold materials until sale, may partially compost their greenwastes but the results are in no way guaranteed. There is also some evidence that freshly chopped organic materials and immature composts which are rich in short-chain organic acids (acetic, propionic, and butyric) are more suppressive to seedling growth than finished compost (Ozores-Hamptom, 1998). Thus, although composting may kill weed seed contaminants, it may also reduce the natural ability of fresh organic matter to suppress seedling germination.

Anyone can place whatever green materials they want to in a greenwaste container for curbside pickup. Hand weeding is a common practice in urban, residential landscapes and the waste if often deposited in greenwaste disposal containers. Regardless of the proclivities of gardeners, there is little documented evidence that weeds are a problem in municipally collected greenwaste. Hartz and Giannini (1998) did find that municipal yardwastes contained one weed seedling per 2L sample and that California burclover (medicago hispida Gaertn.) accounted for most of the weeds discovered. We have observed in several trials using municipally ground tree wastes that viable seeds of Palm (*Washingonia robusta* H. Wendl.) and various species of Eucalyptus can be spread with yardwaste applications. Other fruit producing trees such as loquat (*Eriobotrya* spp.) and avocado (*Persea americana* Mill.) have contaminated yardwastes with viable seed.

This paper highlights preliminary results of several mulching trials conducted in Ventura County over the last several years. Presented here are data regarding composting of eucalyptus and its effect on seedling germination, the effects of mulch thickness on seedling germination and the longevity of mulch treatments in a field plot.

Eucalyptus Mulch Studies

Many horticulturists believe that eucalyptus derived mulch materials are toxic to landscape plants. Because of this perception, we conducted two experiments to determine the effectiveness of eucalyptus mulches as weed seed germination inhibitors. The allelopathic potential of eucalyptus in California landscapes was discussed by Baker (1966) and further demonstrated by del Moral and Muller (1969). Since many of the studies were done on seedlings we wondered if eucalyptus trimmings would be toxic to seedlings under the mulch and if composting would destroy the toxicity. A large study using seven sources of eucalyptus and 100 seeds each of 9 herbaceous annual plants was conducted in nursery propagation flats in randomized complete block design with 5 replications. Flats were seeded with the 900 seeds and covered with composted or fresh eucalyptus mulch or container media (2cm thick). Flats were irrigated from above to wash potential toxins into the media and allowed to grow for 60 days. Plants were harvested sorted, counted and weighed. Fresh eucalyptus mulches retarded germination and growth of most annuals tested; however, composted eucalyptus mulches stimulated growth and yield. *Eucalyptus globulus* Labil. was the least inhibitory species tested and *E. sideroxylon* A. Cunn. ex Wools was most inhibitory to seedling germination (Table 1). While freshly chopped eucalyptus mulch provides some weed control (at 2cm application depth), composted eucalyptus of the same species can increase germination of some herbaceous annuals.

This study was continued in the field with native weed populations. In the field study (also a factorial RCB with 5 replications), 1m plots were covered with various depths of either *E. globulus* or *E. sideroxylon*. All mulches were fresh. Mulch source did not affect germination percentages of emerging weeds (Data not shown). Thickness of mulch controlled the germination percentages. The 7.5cm treatment suppressed 98% of the weeds emerging in unmulched plots (Table 2). This is consistent with observations in other mulching trials in lemons where the threshold for excellent weed control was achieved at 7cm depth (data not shown).

It was our hope to find a species of eucalyptus that would suppress weeds when applied in thin layers. In fact, just the opposite was found to be true. Thin applications of eucalyptus mulches were slightly stimulatory to germination. The mulches acted as a seed cover helping to disperse and hold moisture. Thin mulches should be avoided.

Mulch degradation

Organic materials degrade over time as a consequence of their attack from many microorganisms that use the organic material as a source of carbon and energy. In a mulch study of yardwaste effects in a citrus orchard, we measured mulch depths monthly for several years. There is an initial rapid loss of mulch depth that is likely due to settling of mulch loft. Thickness reductions in the later 2/3 of the year follow a constant and slower rate. On average 75% of applied yardwaste mulches were degraded at the end of the 12 month measurement period. As mulch degrades, weed seeds in underlying soils are exposed to light and are able to germinate. To prevent weed problems in mulched landscapes, re-applications must be made on regular intervals before mulches degrade to layers less than 2cm thickness.

Mulch Texture

Mulch texture is an important quality to consider if weed control is a required from the mulch application. In a study of various mulches on the growth of California sycamore we discovered that a fine textured mulch (biosolids compost) allowed the growth of numerous weeds, while the coarse textured mulches in other plots retarded the growth similar species of weeds (Table 3). Weeds dispersed into biosolids mulched plots grew there because of the fine texture and moisture holding qualities of the biosolids mulch. Coarse textured mulches are advantageous for weed control because they hold small amounts of water and weed seeds will not germinate and grow in them.

Conclusions

Although mulch feedstock and processing (composting) are important factors in the performance of mulches as weed control tools, these factors are not as important as the amount of mulch applied. Coarse, fresh mulch applied at 10-15cm depth will provide adequate weed control in most circumstances. Problems will occur when using un-composted mulch that is heavily contaminated with weed seeds or if mulch texture is fine, creating a favorable seedbed for seeds dispersed onto mulch surfaces by wind. Fresh mulches chopped from fruiting trees should be avoided to minimize tree-weed problems.

Table 1. Abundance of nine weed species under fresh or composted Eucalyptus mulches

Mulch Source[1] Age[2]	Germination percentage[3]										
	CF	AL	PT	AM	BW	CP	CG	BG	BYG	misc	TOT
E. globulus											
fresh	52.0	13.2	5.2	9.6	25.4	38.0	31.2	1.8	45.8	13.6	235.8
comp.	75.0	45.0	36.0	46.2	33.6	74.4	50.6	5.2	62.2	12.2	440.4
E. sideroxylon											
fresh	9.6	4.4	1.4	3.6	14.6	18.6	1.6	0.8	1.8	0.2	56.6
comp.	54.6	11.6	7.6	30.0	16.4	57.8	20.8	0.0	33.2	16.0	248
peat	49.2	6.8	7.8	24.8	13.8	39.4	20.8	2.6	35.2	6.0	206
LSD (SXA)	6.1	3.8	3.5	4.5	2.5	6.2	4.4	2.2	5.9	5.2	25.82
Significance[4]											
Source	***	***	***	***	***	*	***	*	***	NS	***
Age	***	***	***	***	***	***	***	**	***	**	***
SXA	***	**	***	***	**	***	***	**	**	NS	***

1. Eucalyptus branches (2-3.5cm diameter) were collected from landscape trees in Ventura CA

2. Branches were shredded with a gasoline powered shredder and composted for 3 months without leaching or used fresh after shredding.

3. One hundred seeds each of the following weeds were planted in a standard nursery propagation flats and mulched 2 cm deep. Numbers are germination percentage means of five replications. CF= Cornflower, Al = Alyssum, PT = Plantago, AM= Amaranth, BW = Bindweed, CP = California Poppy, CG = Smooth crabgrass, BG = Bermudagrass, BY = Barnyardgrass and misc. = various weeds which came up but were not seeded intentionally.

4. Data in table are means for the interactions (SXA) , however significance of main effects (Source and Age factors) are also listed. NS, *, **, ***, Non-significant or significant at alpha=.05, ,01 and .001 respectively.

Table 2. Effect of mulch thickness on weed densities.

Thickness	Total	% reduction
0	238.9A	--
0.38	296.4A	--
0.76	270.9A	--
2.0	129.5B	46
7.6	5.6C	98

Thickness is mulch application depth (cm).
Total is the mean number of all weeds found in plots according to mulch thickness (n=10).
% reduction is the percentage of weed control in the plot compared to the untreated plots.
Column means followed by the same letter not significantly different according to Tukey's honestly significant difference test at P<0.05.

Table 3. Weed densities in mulched and unmulched plots surrounding California sycamore trees.

Treatment	% coverage[1]
	April
unmulched	67.2a
pine bark	7.6c
biosolids compost	32.9b
composted eucalyptus	8.0c
fresh eucalyptus large chips	10.3c
fresh eucalyptus small chips	9.5c

[1]Percent coverage is a visual estimate of the area of the plot covered by weeds. Means followed by the same letter not significantly different according to ANOVA and Tukey's HSD, *P* =0.01.

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Diagnosing Herbicide Induced-Injury

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Diagnosing a tree or vine problem can be fun and/or frustrating. It is difficult to see all situations or be familiar with them and know all possible combinations of things that can happen, thus trying to formulate a plan to obtain all the information available to solve a problem is difficult but rewarding. It can also help the grower, so the problem will not happen again and reduce the need for costly and unpleasant court proceedings. I would like to propose a thinking process to get to the right solution, rather than show all the possibilities.

If there is a need to confirm a diagnosis, especially in court action cases, it is required that there be a chemical analysis of the cause, whether it is herbicide, other pesticide, nutrient excess or deficiency or combinations of these. Laboratory analyses are expensive however, and it is necessary to be close to the right answer, or know the answer, then confirm with the analysis. An additional section could be prepared on what and where sampling is to be taken to show the results necessary. Suffice it to say that if the sample isn't taken and processed (stored, transported and submitted) properly, the results are worthless. It is critical to know if leaves, shoots or roots are needed and where, when and how much sample is to be taken. After the sample results are obtained, one needs to be certain that the quantity found would be able to "cause" the symptom.

It should be remembered that not all symptoms found on plants are caused by herbicides. There are many other causes of disruptions in plant functions that will cause symptoms, some of which may look like herbicides because the same plant functions (photosynthesis, respiration, amino acid synthesis, etc.) will be affected.

What are some of the necessary prerequisites for solving a problem?

- Keep an open mind!
- Ask questions!
- Use tools (shovel, magnifying glass, auger)
- Observe patterns!
- Look at all the plants present!
- Know the "normal" plant!
- Know how different herbicides work in plants!

It is necessary to gather as much information as possible. If one doesn't have all the information, it is easy to make the wrong diagnosis. Often it is desirable to "eliminate possibilities" as it is to go to the right answer. In fact, it is part of the method of reaching the correct answer. Some of the information needed is, conditions before the symptoms developed [temperature, wind (speed and direction), rainfall or irrigation]. The same information is needed at the time of any application of pesticide. The same is true for the time right after the application of a pesticide. One needs to know the location of the problem and characteristics of the site including the soil type (sand, silt, clay) organic matter and pH. It is also helpful to know the conditions of the planting as to whether it is a vigorous orchard or is it currently under stress from some factor(nutrients, water, frost).

At the location there are certain factors that one can look for.

These include:

- Obvious symptoms,
- Patterns (edge, roads, drainage, even distribution by row or by varieties)
- Outside influences or associations with other surroundings such as other fields nearby, railroads, roads, ditches)

Often there are patterns of symptoms in an orchard or vineyard. If there is a single source, this will become apparent as you move from one side of the orchard to the other. If the symptoms are uniform over the total area, then it is likely that a misapplication was made or a pattern from a weather front or inversion occurred.

When looking for patterns there are several possibilities. These include:

- Is it a single plant? Or sporadic plants?
- Is it over the whole orchard? Or single rows, or an edge?
- Is it on a single species or variety?
- Does it occur on a single part or side of the plant?
- Is it associated with a single species of weed?
- Is it related to topography?

Within the site are the symptoms associated with a certain part of the plant such as leaves, or stems(shoots or canes)? If it is found on the leaves, do the symptoms show as

- Marginal chlorosis?
- Spotted chlorosis?
- Veinal or interveinal chlorosis?
- Overall leaf yellowing?
- Marginal necrosis (burning)?
- Spotting necrosis?
- Whole leaf necrosis?
- Petiole or new leaves twisting?
- Stunting-without color change (if anything, they may be greener)

Though it would not be common, symptoms could show on the limbs or canes without showing much effect on the leaves. It is also feasible that you were not able to see the foliar symptom when leaves were on the vine. In limbs or canes do the symptoms appear as:

- Tip dieback?
- Limb dieback?
- Flagging of the stem (a dead area on one side of the stem that causes the stem to turn at an angle)?
- Stems swelling at the nodes?
- Stem cracking?
- Advantageous growth?

Then finally, where are the symptoms in the tree or vine:

- Tops of the canopy?
- A side of the tree (which side?).
- New growth/new leaves
- Old growth/old leaves
- Roots (newly planted trees and vines)

All of these factors can be placed on a form that can be carried into the orchard at the time of evaluation. It can even be used as a check-off list, or to help remember all the components to find the required information. This is not planned to be a complete list and other information should be added as needed.

Often diagnosing a problem is not a simple, straight-forward practice. There should be a logical method of determining an answer but there are always quirks. Some of these would include:

- Species of plants react differently to a herbicide.
- Environmental differences cause response differences.
- Plant growth stages will give different symptoms.
- Plant stress alters plant response.
- Combinations of herbicides may give different symptoms, or some of both materials but doesn't look like either alone.

On perennial crops the symptom on the crop often will be different depending when the contact of the herbicide occurs and the how the herbicide works. Symptoms of contact herbicides will look different on new leaves compared to old leaves. They can even look differently if the leaves are dry when the contact is made compared to wet leaves or if a rain or irrigation occurs shortly after the contact. A translocated herbicides will also show a different symptom if the contact is on new leaves or buds compared to old leaves or woody bark contact. Herbicide symptoms from different herbicides will take a different amount of time from contact to symptom at different times of the year. This difference can be either altered by temperature (high temperature equals faster) and how fast the plant is growing. If the plant is stressed at the time of contact the symptom will be slower in appearing. It may make the symptom more severe if the material is a contact herbicide, but if the herbicide is translocated it often will be less severe.

As an example we could use glyphosate as the herbicide and determine what symptom might occur at different times of application and when and what symptom might occur.

If the application was in the late summer or fall, there might not be any symptom observed until next spring as the plant starts budding. New foliage would show symptoms of feathering (decreased internode length and many new buds pushing). If rates were high in the summer, there could be killing (necrosis) of the mesophyll cells of the leaf giving an appearance of parts of the leaf dying. If the plant was continuing to grow, then new leaves would be affected after the application. If the application was applied in the spring on new growth of the plant, then the new leaves could be chlorotic early with necrotic leaves and stems later. If the rates increase then the stems could be killed with new emerging growth that was not contacted appearing almost normal, or the new growth would eventually be normal, with no lasting effect. The amount of leaf or stem damage would be proportional to the rate.

Another method of analysis could soon be worthwhile as a positive test for an herbicide. This method is with an immunoassay. Currently, several herbicides including 2,4-D, atrazine, simazine, alachlor, metolachlor, triclopyr, imazapyr, chlorsulfuron, metribuzin, metsulfuron-methyl, molinate and paraquat can be found at different levels in water using this method. Though they may not work with tissue currently, it may be feasible to make them work in this manner.

In summary, there are several major factors to keep in mind when working on a diagnosis. First, keep an open mind. Don’t overlook the obvious. Consult or seek advise from others but don’t let someone lead you to a decision which you are not comfortable that it is right answer.

Efficacy and Economics of Weed Control in Lemon Production----Newman Ranch, Ventura County

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Introduction

Several studies have recently detected pesticide residues in wells from 35 California counties. The resulting public concern has created an urgent need for farmers to find pest control alternatives that do not pollute the groundwater. Simazine and other residual herbicides used in citrus have frequently been identified as well-water contaminants. However, growers are reluctant to give up the season-long control of Simazine without knowing the efficacy and alternatives of other weed control measures.

Glyphosate is a broad-spectrum systemic herbicide that readily degrades. Growers frequently apply it as a spot treatment. We are now testing a new surfactant that increases the efficacy of glyphosate. By mixing in a surfactant we can reduce the amount of glyphosate used and thus decrease costs.

An obvious nonchemical weed control alternative for tree fruit production is a cover crop. However, cover crops may also increase costs by additional water usage and other effects on the production system. Further, there are many different species and mixes of species used by growers, but little is known of how effectively they control weeds or whether the additional expense and maintenance of covers can be justified economically.

State law mandates that by 1995 all communities were to have reduced the amount of waste sent to landfills by 25%. An obvious alternative use for yard waste is as mulch in tree crops. The wide row spacing allows mulch to be readily spread in citrus groves. Weed control and improved soil structure have been suggested as potential benefits to growers. Our preliminary data suggests that mulches can control at least some weed species, but the depth of mulch applied is an important factor. The costs of transporting and spreading mulch were considerations in calculating the economic benefits of yard waste as an alternative weed control practice.

This study compares three alternatives to residual herbicides: spot treatments with glyphosate, an oat/vetch cover crop that shades out weeds and is mowed, and yard waste mulch at two depths (3 and 6 inches). Efficacy of control was evaluated by measurements of weed density, biomass, and diversity. Fruit yield and yield loss due to weed interference were measured and used to calculate the economic return of all treatments.

Objectives

Determine the economic return and relative efficacy of weed control with following treatments:

A) No herbicides:
   1) Cover Crop (80 lb oat/vetch seed per acre)
   2) 3 inch mulch (50 tons per acre)
   3) 6 inch mulch (100 tons per acre)

B) Herbicide treatments:
   1) Glyphosate (41%) 4 lb ai per acre
   2) Simazine (DF 90%), 4 lb ai per acre

Procedure

The field experiment was conducted at the Newman Ranch Lemon Orchard in Ventura County. The lemon trees incorporated in this study were eight years old. The plot size was 16'x20', four trees per plot with five treatments replicated nine times. Postemergent herbicides were applied after plots were laid out. Simazine was applied one time. A subsequent glyphosate application was made later in the season. All herbicides were applied with a backpack CO_2 sprayer with 8002 nozzles delivering 20 gallons of spray solution per acre. Mulch treatments were added with hand shovels at three and six inch depth along the tree row, in a 6-foot swath. The vetch/oat cover crop was planted in October 1995. Tree rows in the cover crop plots were maintained weed free with glyphosate.

The trees were drip irrigated. All plots had tensiometers at 12 and 24 inches depth within the wetted zone of the drip irrigation. Although all trees were irrigated in a similar fashion, a moisture release curve was developed to approximate water use by the different treatments.

Plots were monitored for snail activity by counting the snails on tree trunks on a monthly basis.

All plots were visually rated twice for weed control. Visual rating also observed weed control on winter and summer weeds. Weed biomass was measured after visual rating as average of two 0.1 m2 samples taken from each representative plot. (See Newman Ranch Lemon Weed & Mulch Experiment Table 1).

Lemon fruit were harvested twice, August 7, 1996 and February 19 1997. Yield data was fresh weight of lemon fruit in pounds per plot. Yield was sorted for fresh and damaged fruits. Fresh fruit were converted to tons per acre and used to calculate the economic return of all treatments (Table 2). Yields in all plots were lower than the industry standard because they were heavily pruned and two of the customary 4 harvests per year were not obtained.

Cost studies are based largely on Guidelines to Production Costs and Practices, 1997 Lemons Establishment and Production Costs, Ventura County. This reference was selected because our experimental site, production practices, and climate during the season are similar.

Our cost studies differ from this guideline because of differences in yield and treatment practices used in our study. Our analysis is based only on one year of data. The cost and application of the mulch are annualized over 3 years, since it is persistent. The cover crop was mowed at the time of pruning so there is no added charge to this practice.

All weed control data, including herbicide rates as pounds of active ingredient per acre, has been summarized in Table 2.

Results

The following results are based on annual usage of the Orchard. The weed species mostly found at the trial site are listed in Table 1. Table 2 has all weed control data, as well as other cultural costs and yield data. Simazine, 3 inch and 6 inch mulch effectively control all weed species native to the site. Overtime, glyphosate and the oat/vetch cover crop performed least well in controlling the weeds.

A notable effect of the mulches was their reduction in evaporative loss, equivalent to approximately 20% less water use compared to the other treatments. There was also negligible snail activity in the mulched plots. There was higher vole activity in the mulched plots which lead to several tree deaths. Even though only two of the harvests were collected, the mulch plots had a lower fruit yield than the other treatments.

Using yield and price records for Ventura County, the price of fresh lemon fruit was sold for $7.60 per 55 Ibs box. This value was used to calculate each gross field benefit for different practices of weed control. Table 2. presents the summary of lemon yield, benefits, costs and net return (profit) above all costs from weeds control measure for lemons at Newman Ranch in Ventura County. The economic summary table is presented in tons per acre basis.

Economic interpretation is based on profit (net return) above all costs. Profit is the result of subtracting the total costs from the value of net yield on per acre basis. The net returns for all treatment were low when we consider cash and non cash overheads. Each treatment returned a net loss over $400 per acre.

However, when we look at the net benefit (return) of all practices over their respective total operating costs, each practice returned over $1000 per acre. Simazine returned the greatest amount ($1674.09), followed by the cover crop ($1484.04), glyphosate ($1365.37) followed closely by the 3-inch Mulch ($1328.29) and the 6-inch mulch ($1211.53).

The reduced water and molluscicide use in the mulch treatments and their slightly reduced use of glyphosate did not offset the loss in yield. Why there was reduced yield in the mulch treatments is not entirely clear. It may partially be due to the higher soil moisture in the mulched trees leading to a weakened root system. Most certainly the tree deaths due to voles helped skew the results.

Result - Table 1

1995, Visual Count of Weed Species After Treatment

Date of Rating: *Weed species from* ***Newman Ranch Lemons Weed & Mulch Experiment***

March 29

Treatment	**Large Crabgrass**	**Spurge**	**Hairy fleabane**	**Pigweed**	**Stinging Nettle**	**Black Nightshade**	**Composite**
Cover Crop @ 80 LB/A	0.00	12.60	1.00	13.40	0.60	1.00	1.60
Glyphosate 2 % solution	0.00	14.80	1.00	6.80	2.80	0.00	0.60
3 inch mulch	0.60	0.00	0.00	0.00	0.00	0.00	0.00
6 inch mulch	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Simazine @ 4 LB/A	0.00	10.40	0.00	6.40	0.40	1.40	1.80

Date of Rating: May 10

Treatment	**Spurge**	**Hairy fleabane**	**Pigweed**	**Stinging Nettle**	**Black Nightshade**	**Composite**
Cover Crop @ 80 LB/A	12.33	0.33	2.33	0.00	0.22	0.44
Glyphosate 2 % solution	9.44	0.22	2.00	0.33	0.11	0.11
6 inch mulch	0.00	0.00	0.00	0.00	0.00	0.00
3 inch mulch	0.11	0.11	0.00	0.00	0.00	0.00
Simazine @ 4 LB/A	5.33	0.00	1.11	0.11	0.22	0.22

1996, Visual Count of Weed Species After Treatment

Date of Rating: April 2

Treatment	**Malva**	**Stinging nettle**	**Groundsel**	**Sow thistle**	**Lambs-quarter**	**Spurge**	**Pigweed**	**Black-nightshade**	**Com-posite**
Cover Crop @ 80 LB/A	41.22	156.2	32.56	6.33	0.11	0.22	0.33	0.00	0.00
Glyphosate 2 % solution	20.33	277.9	27.56	6.67	0.11	1.22	0.00	0.22	0.00
6 inch mulch	1.56	0.11	1.11	3.00	0.00	0.00	0.00	0.00	0.00
3 inch mulch	2.44	0.44	1.00	6.89	0.00	0.00	0.00	0.00	0.20
Simazine @ 4 LB/A	4.89	6.56	34.78	0.11	0.00	4.22	0.44	0.78	0.20

Date of Rating: September 13

Treatment	**Malva**	**Grass**	**Purslane**	**Sow thistle**	**Pigweed**	**Black-nightshade**	**Spurge**	**Composite**
Cover Crop @ 80 LB/A	3.11	0.33	0.22	0.11	0.67	0.78	2.67	0.44
Glyphosate 2 % solution	2.22	0.33	0.11	0.00	0.67	0.11	4.22	0.33
6 inch mulch	0.11	0.00	0.00	0.00	0.11	0	0.00	0.00
3 inch mulch	0.11	0.00	0.00	0.00	0.00	0	0.00	0.00
Simazine @ 4 LB/A	0.22	0.11	0.22	0.11	0.11	0.22	0.22	0.11

Dry weight of weeds sampled on April 2, 1996

Treatment	**Grams/ 1m sq**.
Cover Crop @ 80 LB/A	41.92
Glyphosate 2 % solution	83.56
6 inch mulch	2.24
3 inch mulch	12.56
Simazine @ 4 LB/A	1.38

Table 2.

NEWMAN RANCH---1997 PIAP MULCH STUDY AND WEED CONTROL ON LEMON PRODUCTION---COST/BENEFIT					
Treatments: Glyphosate 2% solution, Cover Crop, 3 inch mulch, 6 inch mulch & Simazine @ 4 lbs per acre Yield---900 50-lb. Box @ 7.60 source: 1997 Ventura County Agricultural Report					
OPERATION	**Average gross returns, costs and benefit of Lemon picked in 1997 (per acre basis)**				
Benefit	**Glyphosate**	**Cover crop**	**3 inch mulch**	**6 inch mulch**	**Simazine**
Average yield (ton/acre)	6.13	6.36	5.72	5.58	6.67
Adjustment for harvest loss (10%)	5.52	5.72	5.15	5.02	6.00
Gross field benefit ($/acre at 684.00/ton)	3773.63	3915.22	3521.23	3435.05	4106.05
Operating Costs					
CROP MAINTENANCE					
Water:					
Amount	30 Acln	30 Acln	22.5 Acln	22.5 Acln	30 Acln
Unit cost	15.83	15.83	15.83	15.83	15.83
Value of water applied	*475.00*	*475.00*	*356.10*	*356.10*	*475.00*
Customs:					
Prune & Sucker	475.00	475.00	475.00	475.00	475.00
Vertebrate Pest	10.00	10.00	10.00	10.00	10.00
Budmite Treatment	200.00	200.00	200.00	200.00	200.00
Thrips Treatment	100.00	100.00	100.00	100.00	100.00
Gibberellic Acid	55.00	55.00	55.00	55.00	55.00
Snail Control	50.00	50.00	0.00	0.00	50.00
Frost Protection	125.00	125.00	125.00	125.00	125.00
Value of customs	*1015.00*	*1015.00*	*965.00*	*965.00*	*1015.00*
Herbicide:					
Roundup-Row Spray (1Qt) @ 13.25/Qt	13.25	13.25	8.83	8.83	13.25
Roundup-Spot Spray (25.60 Oz) @ 13.25/Qt	12.00	12.00	4.00	4.00	12.00
Value of herbicide	*25.25*	*25.25*	*12.83*	*12.83*	*25.25*
Fertilizer:					
Zinc Sulfate (8Lb) @ 0.35	3.00	3.00	3.00	3.00	3.00
Manganese Sulfate (8 Lb) @ 0.38	3.00	3.00	3.00	3.00	3.00
Soluble N (150 Lb) @ 0.17	25.00	25.00	25.00	25.00	25.00
Value of fertilizer	*31.00*	*31.00*	*31.00*	*31.00*	*31.00*
Fungicide:					
Copper Sulfate Foliar Spray (3 Lb) @ 1.11	3.33	3.33	3.33	3.33	3.33
Lime Foliar Spray (4.50 Lb @ 0.153	1.00	1.00	1.00	1.00	1.00
Value of fungicide	*4.33*	*4.33*	*4.33*	*4.33*	*4.33*
TOTAL VALUE OF CROP MAINTENANCE	*1550.58*	*1550.58*	*1369.26*	*1369.26*	*1550.58*
APPLICATION (PRACTICES)					
Amount Applied	0.74 gal	80 Lb	50 Ton	100 Ton	3.35 Lb
Unit Cost	43.00/gal	0.46/ Lb	0.33/Ton	0.33/Ton	4.00/Lb
Value (money field cost of practices)	31.82	36.80	16.50	33.00	13.40
Cost of Application	11.70	11.70	25.00	50.00	11.70
TOTAL VALUE OF PRACTICES	*43.52*	*48.50*	*41.50*	*83.00*	*25.10*
HARVEST:					
Cost of Harvest (39.00/bin), 1 bin = 900 Lb	478.16	496.10	446.18	435.26	520.28
Labor (machine) 18.41 hrs @ 11.70	215	215	215	215	215
Labor (non-machine) 2.10 hrs @ 11.70	25	25	25	25	25
Fuel-Gas (18.53 gal) @ 1.20	22	22	22	22	22
Fuel-Diesel (12.55 gal) @ 1.15	14	14	14	14	14
Machinery repairs	60	60	60	60	60
TOTAL VALUE OF HARVEST	*814.16*	*832.10*	*782.18*	*771.26*	*856.28*
Total Operating Costs ($/Acre)	***2408.26***	***2431.18***	***2192.94***	***2223.52***	***2431.96***
Net Benefit Above Operating Costs ($/Acre)	***1365.37***	***1484.04***	***1328.29***	***1211.53***	***1674.09***

CASH OVERHEAD COSTS					
Office Expense	100.00	100.00	100.00	100.00	100.00
Liability Insurance	14.00	14.00	14.00	14.00	14.00
Property Taxes	287	287	287	287	287
Invertment Repairs	138	138	138	138	138
TOTAL CASH OVERHEAD COST/ACRE	539.00	539.00	539.00	539.00	539.00
Total Cash Costs/Acre	***2947.26***	***2970.18***	***2731.94***	***2762.52***	***2970.96***
NON-CASH OVERHEAD COSTS (DEPRECIATION & INTEREST)					
Shop Building	65	65	65	65	65
Shop Tools	21	21	21	21	21
Fuel Tanks & Purmps	21	21	21	21	21
Irrigation VCL	91	91	91	91	91
Wind Machines	97	97	97	97	97
Land	936	936	936	936	936
Establishment	160	160	160	160	160
Equipment	160	160	160	160	160
TOTAL NON-CASH OVERHEAD COSTS/ACRE	1551	1551	1551	1551	1551
Total Costs/Acre	***4498.26***	***4521.18***	***4282.94***	***4313.52***	***4521.96***
Net Return Above All Costs $/Acre	**-724.63**	**-605.96**	**-761.71**	**-878.47**	**-415.91**

A Four Year Study of Almond Orchard Floor Vegetation Management Options

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Over ninety percent of California almond orchards are farmed using non-tilled orchard floor management. Strip weed control down the tree rows combined with non-tillage is an efficient system requiring cultural operations in only one direction. Less dust and improved orchard access throughout the year are important benefits of non-tillage.

A smooth, firm, weed free surface facilitates nut drying when nuts are shaken to the ground at harvest. Clean firm middles also provide for an efficient nut pick up operation. Avoiding tree water stress, desirable for flower bud development, is also important during harvest. To avoid tree stress, growers may irrigate between variety harvests which can start a new weed flush. Various methods of orchard middles management are used by growers to achieve desired harvest conditions. Each management system can lead to shifts in orchard weed species composition. Project objectives included evaluating cost effective management programs for difficult to control summer weed species such as common purslane (*Portulaca oleracea* L.) and determining the effect of these selected long term programs on populations of desirable winter annual orchard floor vegetation. This study compared three methods of orchard floor vegetation management over a four-year period.

Materials and Methods

A management team comprised of farm advisors, a project consultant, a pest control advisor, chemical company representatives, an extension weed specialist, and the grower and his foreman was assembled to determine and modify the selected vegetation management programs as needed. The three selected management programs included: 1) mechanical mowing with a supplemental preharvest Roundup 4S or Ultra[2] application at 1-2qt/Ac, 2) chemical mowing applying Roundup 4S or Ultra at 1pt.-1qt./Ac through the spring supplemented with mechanical mowing, and 3) a low rate residual program applying Surflan 4AS[3] at 1qt plus Roundup 4S or Ultra at 1qt/Ac timed just prior to common purslane emergence in the spring supplemented with mechanical mowing. Management programs were arranged in a randomized complete block design employing five replications of approximately one acre per plot.

All herbicides were applied using the growers boom sprayer towed by an all terrain vehicle. The sprayer was equipped with flat fan TeeJet nozzles calibrated to deliver 10 gallons per acre. Summer vegetation counts of common purslane were made annually in each plot. The percentage bareground for each program was estimated before harvest to evaluate the ease of

[2] Roundup and Roundup Ultra are trademarks for glyphosate manufactured by Monsanto Company.
[3] Surflan 4AS is a trademark for oryzalin manufactured by Dow AgroSciences.

harvest operations and the overall program success. Winter vegetation counts of all species were made annually to evaluate a management programs effect on the composition of winter annual vegetation. Cultural practices and actual costs for each management program were tracked and compared.

Results

Summer vegetation management was improved with both chemical programs compared to the standard mechanical mowing. The low rate residual herbicide program most effectively reduced the number of common purslane plants per nine square feet.

Average number of common purslane plants per 9 square feet in June*

Treatment	**1995**	**1996**	**1997**	**1998**	**Average**
Mechanical mowing	8.6	99.6	24.2	11.7	36.0
Chemical mowing	6.9	11.4	1.4	6.6	6.6
Low rate residual	1.5	2.2	0.2	0.3	1.0

* Average of 5 replicates with 6 sub-samples per replicate.

Bareground ratings in July prior to preharvest Roundup applications indicated that the low rate residual program provided better summer weed control and reduced the number of mowings required compared to other treatments.

Percent bareground* in July prior to preharvest Roundup application

Treatment	1995	1996	1997	1998	Average
Mechanical mowing	58	84	58	71	68
Chemical mowing	73	98	86	77	84
Low rate residual	82	99	98	97	94

* Average of 5 replicates with 3 visual sub-observations per replicate.

By harvest time in August there was less difference in percent bareground among the three orchard floor management programs. A preharvest Roundup application applied where required as a clean up spray before the August rating readied all vegetation management programs for a clean harvest operation.

Percent bareground* in August after a preharvest Roundup application

Treatment	1995	1996	1997	1998	Average
Mechanical mowing	91	85	96	72	86
Chemical mowing	81	96	96	79	88
Low rate residual	86	99	100	94	95

* Average of 5 replicates with 3 visual sub-observations per replicate.

Maintenance of winter annual vegetation is an important goal for all programs since a vegetation-covered surface affords needed access to the orchard year around. Annual bluegrass (*Poa annua*) is a major component of the winter ground cover that is desired. Over the course of this study all programs preserved the annual bluegrass population. The low rate residual program using Surflan resulted in an annual bluegrass reduction in the dry 1997 spring but good recovery was seen in 1998.

Average number of annual bluegrass plants per 9 square feet*

Treatment	1995**	1996	1997	1998	Average
Mechanical mowing	246	275	214	347	270
Chemical mowing	246	239	286	260	258
Low rate residual	246	284	98	373	250

*Average of 5 replicates with 6 sub-samples per replicate. Counts in February 1995-97 and March 1998.
** Initial vegetation count, average across the entire trial area.

Other common winter annuals potentially affected by orchard floor management programs include chickweed (Stellaria media(L.)Cyr.), shepherd's purse (Capsella Bursa-pastoris (L.) Medic.), and filaree (Erodium spp.). Of these, the filaree population was relatively unaffected by the selected management programs. The chickweed population experienced a general decline under all three vegetation management programs in this study. Over the course of the study, the low rate residual program resulted in a sharper decline in the chickweed population than did the other programs. Shepherd's purse populations increased under the low rate residual program when the annual bluegrass population was suppressed. In general, the shepherd's purse population increased over the course of the study for all vegetation management programs.

Average number of chickweed plants per 9 square feet*

Treatment	1995**	1996	1997	1998	Average
Mechanical mowing	103	59	21	8	48
Chemical mowing	103	19	29	8	40
Low rate residual	103	19	4	3	32

Average number of shepherd's purse plants per 9 square feet*

Treatment	1995**	1996	1997	1998	Average
Mechanical mowing	1	5	29	27	16
Chemical mowing	1	21	15	14	13
Low rate residual	1	25	31	14	18

* Average of 5 replicates with 6 sub-samples per replicate. Counts in February 1995-97 and March 1998.
** Initial vegetation count, average across the entire trial area.

Total accumulated four-year orchard floor vegetation management costs were somewhat similar among the three selected management programs. Mechanical mowing was the least expensive program followed by the low rate residual program at an intermediate cost. The chemical mowing program was the most expensive of the three management systems. The total number of operations required (trips through the orchard) is the major difference among the three management systems.

Accumulated costs for orchard floor management
January 1995 through August 1998

Treatment	Chemical Cost	Application Cost	Mowing Cost	Total Cost/Acre
Mechanical Mowing + preharvest Roundup	$84 (5)*	$25 (5)	$149(28)	$258 (33)
Chemical Mowing w/Roundup, mechanical mowing, and preharvest Roundup	$136 (11)	$55 (11)	$91 (17)	$281 (28)
Low rate residual w/Surflan + Roundup, mechanical mowing, and preharvest Roundup spot treatment.	$144 (9)	$45 (9)	$75 (14)	$264 (23)

*** (x) = the total number of times the applications or operations were conducted.**

Conclusions

The low rate residual program most consistently managed common purslane, a difficult to control weed. When Surflan 4AS at 1 quart plus Roundup Ultra at 1 quart per acre was applied prior to germination of common purslane, excellent weed control was provided through the harvest season. Common purslane germination must be anticipated so that chemical application can occur shortly before weed emergence. Application timing is therefore critical to program success. A mid to late April spray timing is optimum in the northern Sacramento Valley. Low rate residual program benefits include reductions in the number of mowings and reductions in Roundup use since only spot treatments are needed for preharvest cleanup.

Following the preharvest Roundup treatment, clean, firm ground for harvest was provided by all three management programs. No harvest efficiency differences were noted among the treatments since good nut pickup occurred in all plots.

All three programs also provided good winter annual vegetation management. The low rate residual program could result in shifts away from desirable annual grassy weeds if rate and timing of application is not carefully managed. Adjustment of rates may be needed under some conditions in order to preserve the winter cover. The mechanical mowing and chemical mowing programs provided the least variation in the annual bluegrass population.

Ultimately, all programs resulted in comparable costs averaging about $65 to $70 per acre per year. Of major benefit was a reduction in the total number of applications plus operations (trips through the orchard) that were required by both chemical programs compared to the mechanical mowing. Significant time and labor savings resulted since chemical mowing saved five trips through the orchard over a four year period and the low rate residual program saved ten trips through the orchard during the same period. After two years, our grower cooperators adopted the low rate residual program for their almond orchard floor management. They stated that the main reason for adoption was the reduced requirement for mechanical operations.

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Impact of Sprayer Technology on Weed Management

Richard Stoltz, Patchen Selective Spray Systems

There are a number of methods used to manage weeds in vineyards and orchards. They include manual labor, mechanical cultivation, flaming, continuous sprays of herbicides, controlled droplet applicators (CDA), and selective spraying of weeds by light activated sprayers.

The two methods discussed here are the CDA and light activated sprayers. Both are relatively new methods being used for vegetation management in permanent crops.

The CDA applicator atomizes the spray droplets and places uniform, fine droplets on the weeds. The nozzle is contained within a spray hood that contains the spray drift and protects the crop foliage from spray contact. This equipment can be mounted on various spray platforms. Typically, it is mounted on ATV type vehicles. The application rate can be as low as two gallons per acre. The amount of herbicide applied per acre is based on the manufacturers recommendations. Normally, glyphosate is the only material applied as certain other herbicides require higher application rates of water to achieve proper control than can be achieved with a CDA applicator.

Work by Tim Prather at The UC Kearney Agricultural Center in Parlier, California has shown that the CDA type equipment can be an effective tool in vegetation management in vineyards. Preliminary data from a 1998 Biologically Integrated Vineyard System (BIVS) trial in Kingsburg, California (conducted by T.S. Prather) indicates that the CDA system gave better weed control than flaming. Control was equal to glyphosate applied as a broadcast treatment but not as good as some cultivation treatments or the Patchen selective spray system.

The CDA type equipment can be effective in controlling unwanted vegetation, can reduce the amount of spray drift that leaves the target area, can reduce labor costs by reducing the amount of time needed to refill spray tanks, and smaller, less expensive spray platforms can be used.

The Patchen system is a light activated sprayer that responds to light reflected off of the surface of a chlorophyll producing plant. The system consists of a silicon receptor lens that picks up reflected light wave lengths, two light emitting diodes, and a spray cartridge that contains a solenoid valve that is opened when the reflected light from the plant is read. The result is spraying only where there are weeds. Bare ground is not treated and thus herbicide use is reduced, material is not wasted, and chemicals are not unnecessarily placed in the environment.

The two emitted wave lengths are at 600 (red) and 770 (far red) nanometers. The combined reflection from these two wave lengths are picked up by the silicon receptor and an electrical impulse is sent to the solenoid. The solenoid action then allows the weed to be sprayed. The internal light allows the system to operate at night, as well as in the day time. The solenoid reacts fast enough to allow spraying at speeds of up to 10 miles per hour. Each sensor has a field of view of 12 inches and can see at a distance of up to 30 inches.

Early work by Prather showed that by using the Patchen system when a weed cover of 5% existed, a reduction of spray volume of 86% could be achieved when compared to a broadcast spray or waiting until ground cover was on the order of 80 – 100%. He also determined that when ground cover was 5%, spot spraying would not be efficient or practicable. Typical herbicide use reductions are in the range of 50 – 75%.

Work done by Patchen, in an almond orchard, showed a savings of 87% in total spray usage when compared to the grower's practice. This resulted in a dollar savings of $36.00 per acre and required only the initial fill up as compared to 3.3 fill ups by the grower.

In the BIVS trial mentioned above, three applications were made. The first application was made in mid March when the weed cover approached 100%. The grower uses cultivation only and no herbicide treatments. The second application was made on April 22 when weed cover was almost non-existent. The third application was made on June 6. Marestail was thick and about 6 to 9 inches tall. The total reduction in spray usage with the Patchen system was 37% when compared to a calibrated broadcast rate of 31 gallons per acre. Savings were 74% at the second application and lesser amounts of use reduction were achieved at the first and last applications.

The weed ratings taken on 4/22 showed that the Patchen system gave the best control of any of the methods employed when considering the total weed population. It performed equal to or better than all methods in the control of annual sowthistle, marestail, and outperformed the CDA, glyphosate control, and flaming in control of perennial willowweed.

The Patchen WeedSeekers may be mounted on a wide variety of spray platforms. Typically, small tractors are used but the system can also be mounted on self propelled sprayers. Standard herbicide spray tips are used and most tanks, pumps, plumbing, etc. can be adapted.

Various herbicides can be used in the systems. Roundup, Prism, Goal, Gramoxone, Poast, Fusilade, and some liquid fertilizers have all been used in Patchen systems. Wettable powders, solubles, and other formulations may be used, but only after modifications to the spray cartridge have been made.

While the WeedSeeker systems were originally designed for permanent crop applications, other uses have evolved. These include row crop applications, broadcast spray usage, roadside vegetation management, and uses by water agencies for ditch bank spraying.

The Patchen WeedSeeker is effective at controlling weeds, reduces the amount of herbicide used, reduces dollar expenditures by reducing herbicide costs, reducing labor, reducing the size of application equipment needed, and allows less chemical to get into the environment.

Both systems thus reduce the amount of chemical that gets into the environment, reduce labor costs, reduces the size of spray equipment needed, and are effective tools in managing undesirable vegetation in permanent crops.

Weed Control From a Farm Manager's Perspective

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S & J Ranch farms permanent crops throughout the San Joaquin Valley. We farm our own land and provide farm management and development for other growers as well. We also have a commercial citrus and pistachio nursery.

We approach our vegetation management program with the same IPM strategy that we use in our insect and disease management programs. We use the classical of definition of IPM where it is <u>not</u> equated with biological control. Integrated pest management uses a multi-disciplinary approach including mechanical, cultural, biological, and where necessary chemical tools to control pests. In our cultivated systems, bio-control programs for insects are further developed than those for weeds or diseases. I will touch on a few specific examples of some unique challenges that we face and how we have approached solutions.

Donuts is a term that we use to designate those areas that receive irrigation from micro-sprinklers but are outside of an herbicide treated berm. In a crop such as almonds this situation can be critical if excessive weed growth occurs before harvest as we harvest off of the ground. Options used to address this have been: widen the chemically treated berm, treat the donuts post emergent with a sprayer with one directed spray nozzle, chemical mow the entire middle more frequently, or mow the entire middle more frequently. We have performed economic analysis on the various options and one option does not stand out as being superior. We select our option on a case by case basis in various crops.

Algae on the berms of almonds is a problem in some years. It also interferes with the harvest process. Options for control have included treating with Gramoxone or altering the irrigation schedule to allow more dry time between irrigations. Neither of these has been highly successful.

Puncture vine seems to occur in cycles. Where it is severe we have exercised care to do less mechanical tillage. Post-emergent chemical treatments before seed formation and maintaining constant diligence has seemed to be the best strategy. The stem and seed weevils have helped sporadically in the control of this pest. We have purchased and released the weevils on several occasions. It appears that the bio-control option functions best when the weed gets out of control on an area-wide basis and the weevils can build to high levels.

We have had the circumstance where two pests have controlled each other thus alleviating control measures to be prescribed for the crop. Morning glory can be a severe problem in replanted areas of pistachios. Pacific mite is also an occasionally severe pest of pistachios. Morning glory is a preferred host to pistachios for the spider mites. The spider mites infest the weeds and render them a non-economic pest. The morning glory operates as a trap crop thus saving the trees from a mite infestation. I've observed this same situation in grain sorghum work effectively as well.

Vegetation management in pistachios presents some significant challenges. Pistachio culture is typically bare ground or middles with winter cover crops. These cover crops provide benefits such as supplying organic matter and preventing erosion, and ancillary benefits like being used as a trap crop for insect pests. Encroachment onto the berms can be a significant problem where cover crops are utilized especially if plants such as vetch are present. Pistachios have been increasingly affected by the diseases botryosphaeria and alternaria. These diseases are accentuated by elevated humidity. Elimination of vegetation in affected blocks during the late spring and summer season is recommended thus adding another layer to the vegetation management decision process. In pistachio plantings on the east side of the valley large numbers of replants are present because of tree death associated with Verticillium Wilt. These replant areas may need supplemental applications of pre-emergents in order to properly control the weeds because available light is increased and the smaller trees have a greater sensitivity to a given population. Our arsenal of herbicides in crops such as pistachios is very limited. This makes implementing a proper prescription for each block a daunting task. We perform a weed survey for every parcel we farm 2-3 times a year. Proper monitoring is always the key to any successful IPM program.

Weed ID is at times more difficult than insect or pathogen ID because existent weeds may be subjected to sublethal doses of herbicide altering their phenotypical characteristics. Also identifying weeds in their seedling stage is difficult sometimes even for an experienced weed specialist.

We are constantly faced with the decision of whether to split our pre-emergent applications into a fall and a spring application or a single fall or single spring treatment. In untilled crops such as citrus, a split application is possible in most years if desired. In a tilled crop such as our pistachios, it is very difficult or impossible to access the orchards in the spring in many years. With a bud swell cut off for the application of Goal, a strategy which assumes a spring herbicide application can be risky.

The nursery presents unique vegetation management challenges. Spurge is our most chronic weed problem We are affected by a lack of available tools here as well. Frequent irrigation limits the duration of any chemical control. Once the trees reach 10-12 inches, uniform application inside the pots with either a spray or granular material is difficult. An eradication program in the vicinity of the nursery for all weeds has lowered the available seed bank and has improved our success. In the nursery weeds need to be controlled not only for their allelopathic or competitive affects on the trees but for regulatory purposes as well. Trees can not be legally shipped with weeds present.

Weed management has unique aspects that can make it a very challenging proposition. It is important that all of us (growers, chemical manufacturers and distributors, extension, PCA's, researchers, biologists, botanists, pathologists, entomologists, and regulators) work together as a team to solve the continual bevy of problems which challenge us. Weed management is a critical component towards assuring a bountiful food supply at affordable prices.

Case Study: Alligatorweed Control in Riparian Habitat

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Alligatorweed, *Alternanthera philoxeroides*, is a perennial deep rooted emersed aquatic plant with the ability to survive in dry land habitats. Stems are round and generally hollow in cross section and float on the water surface. The plant spreads by fragmentation and is not known to produce viable seeds in California. Alligatorweed forms large, rapidly growing mats in ponds, waterways and other aquatic habitat, often restricting water flow and impeding boat traffic. It has been found growing at various dry land sites including: schools, golf courses, nurseries, parks and crop lands, where normal cultivation has increased its spread. A native of South America, it was first found in the United States in Florida in the late 1800's. Since that time, it has spread to the mid-Atlantic and southeastern States. In California, it was brought to the attention of the Los Angeles County Agricultural Commissioner in 1956. Infestations in Tulare and Kings Counties, in the San Joaquin Valley, were detected in 1965 and 1966 respectively, in Riverside County in 1996 and in San Bernardino County in 1997. Today, while total alligatorweed acreage in California has been greatly reduced by the efforts of many agencies, statewide eradication programs are still underway. Persistent survey is necessary as young plants are difficult to locate in often weedy and brushy aquatic environments. Historically, endangered species have not affected the survey or treatment of alligatorweed. Surveys are generally done on foot and each plant is individually treated or physically removed. This allows for careful handling of the habitat. Chemical tools have been limited by the plant's aquatic habitat and its resistance to many materials. Historically, however, consistent survey coupled with metham fumigation, dichlobenil or dicamba treatment has provided lasting results.

Case Study: *Spartina alterniflora* (Smooth Cordgrass) Control in a Wetland Environment

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The tidal wetlands in San Francisco Bay consist of a discontinuous fringe of marsh. Land reclamation and the filling of the bay for industrial building and activities has destroyed all but fifteen percent of tidal wetland. This loss of habitat is a significant factor in the decline of marsh species such as the California clapper rail (Rails longirostris obsoletus) and the salt marsh harvest mouse (Reithrodontomys raviventris) which are listed as endangered by both federal and state wildlife agencies. A critical component of the recovery plans for these species is to protect and restore habitat. Ecological preserves have been designated and significant resources have been allocated for the restoration of former marsh land to provide new habitat in hopes of bolstering populations. Now, however, all of these tidal wetland areas are invaded by exotic vegetation and are being radically altered or are immanently threatened by invasion.

Currently, *Spartina alterniflora*, a perennial grass, is the most alarming exotic to establish in the salt marshes. Rapid spread is one reason for concern. In twenty five years, since its introduction, it has become nearly pervasive south of the San Francisco Bay bridge. In 1998, however, the bridge ceased to mark the northern extent of *S. alterniflora* as new populations were reported in Richardson Bay and the Emeryville Crescent. In Cogswell Marsh, Hayward, California, the *Spartina alterniflora* covers over 78 acres of the 250 acre marsh, 46 acres more than just two years ago. Growth and spread at this high rate is significant because *Spartina alterniflora* radically alters the salt marsh in at least three ways. Tall, dense, rigid stems, and a massive underground network of roots and rhizomes work to accrete and stabilize sediment which results in a rapid rise in elevation of the wetland. In some marshes increased siltation in channels has reached a level which allows colonization by *S. alterniflora*. A new network of deeper, narrower channels is being formed. Secondly, *S. alterniflora* not only displaces most native plant species forming monotypic meadows, it is able to hybridize with the native *S. foliosa.* Finally, *S. alterniflora* can grow at a lower elevation and withstand longer periods of tidal submergence than all other native species. Clones are beginning to colonize the tidal mud flats in San Francisco Bay, and without any competition, are expected to quickly form solid stands covering many acres. These tidal flats serve an important link in nutrient cycling of the estuary. They are also the foraging habitat for hundreds of thousands of shorebirds.

In San Francisco Bay, a few agencies have been working to control *Spartina alterniflora.* Efforts have largely been stymied by regulations protecting the California clapper rail. Specifically, no access into the salt marsh is permissible during the breeding season. This effectively closes the marsh for seven months of the year as the clapper rail has an unusually long breeding season. Efforts to control *S.alterniflora* during the period of September - February 1 have proven to be largely unsuccessful although it has resulted in a great deal of knowledge concerning *S. alterniflora*. Regionally, momentum to coordinate between agencies on a baywide scale is gaining. The challenge for resource managers will be to commit to long term, methodical, and coordinated efforts. The presence of endangered species in the marsh will necessitate difficult judgements and probably imperfect solutions regarding the long term health of the estuarine ecosystem. Ultimately, it is in the recovery of these endangered species, of all native marsh species, and the overall estuarine ecosystem that fuels efforts to eradicate exotic *Spartina* species from the San Francisco Bay.

Endangered Species and Pesticides in California

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California Department of Pesticide Regulation

The Department of Pesticide Regulation (DPR) became involved in protecting federally listed species from potentially harmful exposures to pesticides as an extension of the U.S. Environmental Protection Agency's Endangered Species Protection Program (ESPP). The ESPP developed endangered species county bulletins (Bulletins) as extensions of federal labeling to specify additional use limitations specifically to protect listed species. The bulletins that the ESPP drafted originally for California and currently develops for other states, rely heavily on pesticide use prohibitions in habitat areas and buffer zones. For many states with few listed species, or species that occur in areas remote from agriculture, there is little or no conflict between existing pesticide uses and protection of listed species. Use prohibitions therefore create little or no hardship in other states. In California, however, the proximity of endangered species habitats to pesticide use sites leads inevitably to many conflicts, particularly when buffer zones extend onto agricultural lands.

DPR began to cooperatively develop Bulletins for U.S. EPA to resolve conflicts with pesticide users by providing alternative measured approaches to protecting listed species that allow most pesticide uses to continue.

California is second only to Hawaii in number of endangered species. The U.S. Fish & Wildlife Service currently lists a total of 251 species ranging from plants to mammals in California. The wide variety of habitats interspersed with its large agricultural valleys and urban areas, make protection of California's endangered species a challenging undertaking. Pesticide regulation for the protection of endangered species is a very dynamic and complex process. For over 10 years the Endangered Species Project of the Department of Pesticide Regulation, has been developing better alternatives for the regulation of Pesticides that allow their continued use while protecting endangered species.

A key element in DPR's approach has been the emphasis on accurate habitat information, and the implementation of voluntary pesticide use limitations through Bulletins developed by DPR. These Bulletins are categorized into Rodenticides, Insecticides, Herbicides, and Fungicides. They provide alternatives to use prohibitions by taking into consideration factors such as species biology, behavior, range, seasonality; pesticide active ingredients, relative toxicity, method of application, etc. By using these bulletins, applicators can quickly find out which pesticide product is more suitable for their needs while taking into consideration the endangered species that might be found in their County. Although these bulletins are not mandatory, they provide a better assessment of the pesticide and its potential risk to such species in their local setting. To date, the Rodenticide and Insecticide Bulletins have been completed. The Herbicide Bulletins are currently under development, to be followed by a similar series of Bulletins for fungicides.

Another important element in DPR's Endangered Species Program is public outreach. DPR emphasizes applicator training --awareness and avoidance of endangered species habitats--

as a key alternative to use prohibitions. Since 1995, a wide variety of training materials for the identification of Endangered Species and their habitats have been developed for pesticide applicators. These materials are in the form of slide presentations and field identification cards. They are provided free to the public, and distributed primarily through County Agricultural Commissioners' Offices, as well as the Pesticide Applicators Professional Association and the California Department of Fish & Game.

The development of Internet technology has allowed DPR to tap into the Internet as a major conduit for all the above mentioned materials and more. An on-line version of the Interim Measures Bulletin for Rodenticides is currently accessible through DPR's website. This allows for faster data access in easy-to-use menus. The output is in the form of custom printouts for user-selected sections and user-selected chemicals. If endangered species are found in any given section, a table of use limitations for the chemical(s) selected is also included. Additionally, Powerpoint computer presentations covering the basic Biology, behavior, and identification of endangered species can be downloaded from DPR's website at: www.cdpr.ca.gov.

The Effect of Irrigation Practices on the Performance of Lettuce Herbicides

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The herbicides used in lettuce have changed little in more than 30 years. Poast was registered for grass control in the 1980's although preemergent applications of Kerb, Balan and Prefar have been the principal herbicides used in lettuce production since the mid 1960's. Balan was changed from a 1.5 lb./gal. Emulsifiable concentrate to a 60% dry flowable formulation in the mid 80's, Kerb has always been a 50% wettable powder and Prefar is still a 4 lb./gal. emulsifiable concentrate.

Growers are constantly changing cultural practices to improve production or to become more efficient. The change in one cultural practice can, and often does, effect other cultural practices. The use of sprinklers to establish lettuce has become increasingly widespread in the Yuma area over the past 20 years. Kerb and Prefar can be mechanically incorporated into shaped beds although both are commonly incorporated with irrigation water. The change in irrigation practices during stand establishment from furrow irrigation to sprinklers has effected the performance of both Kerb and Prefar. Balan is normally disced into the soil prior to bed formation and is not as effected by irrigation practices during stand establishment.

Four tests are presented in this paper that help explain the effect of irrigation practices on the performance of Kerb and Prefar.

Kerb

Kerb (pronamide) inhibits the growth of developing weed seedlings by disrupting mitosis or cell division. The growth of roots and shoots of small seedlings is stopped. Kerb differs from Prefar and Balan by how it moves both in the soil and the plant. Kerb is readily absorbed into roots and translocated upward. It has postemergence activity on very small weeds. Kerb also will move in the soil when large amounts of water are applied. Prefar and Balan move little in either the soil or plant. Both are strongly adsorbed to the soil where they remain throughout the growing season. Both also are not translocated up into the plant but have a localized effect on those roots or shoots that are contacted.

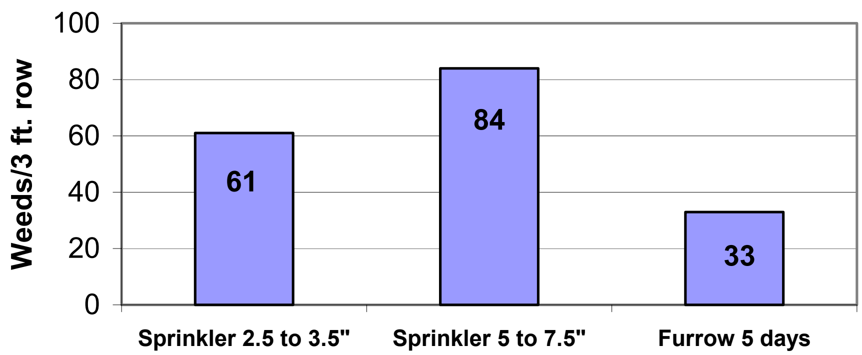
Kerb is normally applied after planting to dry soil and incorporated with sprinkler irrigation. When sprinklers are not used, shallow preplant mechanical incorporation is recommended although Kerb works well when incorporated with furrow irrigation. Prior to the widespread use of sprinklers, Kerb was incorporated with furrow irrigation and worked well. As sprinkler use for stand establishment increased, complaints of poor weed control increased. This lead some users to suspect that the herbicide had somehow changed. A change in the manufacturing process from using xylene to water occurred in the mid 1980's although our tests conducted in 1996-97 indicated that there was no significant difference in weed control produced by the old and new Kerb. Those same tests indicated that there was a significant difference between the weed control produced when Kerb was incorporated with furrow irrigation compared to Kerb incorporated with sprinklers. The Kerb was twice as effective when incorporated with furrow irrigation. (Table 1, Graph 1).

Table 1. Comparison of sprinkler and furrow incorporated Kerb

	Irrigation Type	Irrigation Amount	Weed Control (Seedlings/3 ft.)	
			Grass	Mustard
Kerb –3 lb./a	Sprinkler	2.5 to 3.5	0	61
Kerb - 3 lb./a	Sprinkler	5 to 7.5	0.7	83
Kerb – 3 lb./a	Furrow	5 days	0	33

Notes: Plot size = 15 ft. X 2 beds, 4 replications; Spray volume = 20 gpa
Weeds = Shepardspurse, Annual ryegrass; Weed counts made 26 days after application.

Graph 1. Comparison of sprinkler and furrow incorporated Kerb



This test indicated that a possible cause of the increased failures with Kerb was that the herbicide was being leached below the germinating weed seeds when it was applied prior to the application of large amounts of sprinkler water. It is common to apply between 2 and 5 inches or more of water in 4 to 7 days with sprinklers to establish lettuce in the low desert.

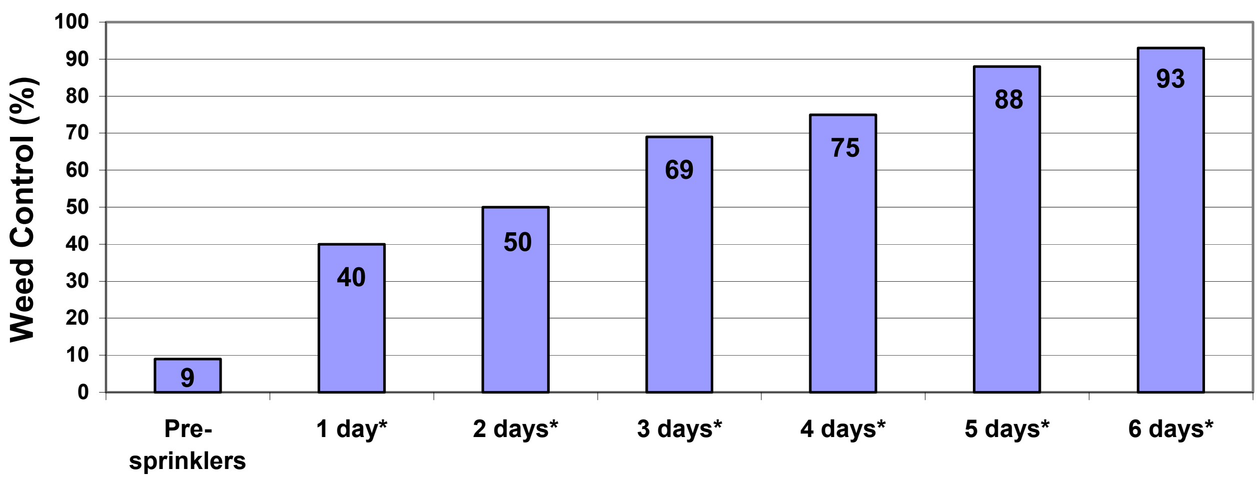
Some growers have recognized the problem of leaching Kerb when incorporated with large volumes of water with sprinklers. One potential solution has been to apply Kerb by air after the sprinklers have been running. This avoids putting large volume of water over the Kerb. The correct time of application has been unclear however. Optimally it has been thought that the correct time would be before the weeds and lettuce had germinated but after all but 0.5 to 1.0 inch of sprinkler water had been applied. Too early and the herbicide will be leached; too late and you risk crop injury and poor weed control. A test was conducted this year and evaluated various times of applications. Treatments included Kerb applied before the sprinklers were started, 1 day after, 2, 3, 4, 5 and 6 days after. (Table 2, Graph 2).

Table 2. Weed control and crop injury from Kerb applied at various times.

Time Applied	Weed Control (%)*	Injury (%)*
Before sprinklers started	9	0
1 day after sprinklers started	40	0
2 day after sprinklers started	50	0
3 day after sprinklers started	69	0
4 day after sprinklers started	75	2.5
5 day after sprinklers started	88	7.5
6 day after sprinklers started	93	14
Untreated	0	0

Notes: Plot size = 6 beds x 50'; Kerb - 2 lbs./a
1st treatment applied on 10/27/98; Last treatment applied on 11/3/98
Spray volume = 20 gpa; Lettuce and wild mustard emerged on 10/30/98
* Average of 4 replications.

Graph 2. Weed control from Kerb applied at various times



- Note: Number of days after sprinklers started.

Weed control in this test ranged from less than 10 percent when applied before the sprinklers were started to almost 95 percent when applied after the sprinklers had run for 6 days and continued to run for only 5 more hours after application. The same rate of Kerb, 2 lbs./a of product on a broadcast basis, was applied to all plots. The best control was achieved after both the lettuce and wild mustard had germinated and begun to emerge. This occurred after 3 days of sprinkler irrigation. Crop injury ranged from 2.5% stunting when Kerb was applied after 3 days of running the sprinklers to a high of 14 percent when Kerb was applied after 6 days of sprinklers and one day before they were shut off. This test clearly demonstrated that Kerb works best when the sprinkler are run for only 1 or 2 days after application even when the weeds had begun to emerge but were still very small. Crop injury was increased but still tolerable. It should be emphasized that results might vary with different environmental conditions and different weed species.

Prefar

Prefar (bensulide), like Kerb, inhibits root growth of developing weed seedlings. It does not disrupt but inhibits mitosis or cell division before it is started. Root growth is stopped without clubbing or other malformation. Prefar differs from Kerb in how it moves in the plant and the soil. Prefar is absorbed only by the roots of plants and does not move upward. Roots that do not contact the herbicide grow normally. If Prefar is not uniformly distributed and incorporated, erratic weed control will result. Prefar also does not move in the soil. It is strongly adsorbed by most soils and will not move downward with irrigation water.

Prefar is normally applied preemergence after planting and incorporated with sprinkler or furrow irrigation. It can also be applied by chemigation through sprinkler systems. Shallow preplant mechanical incorporation is also on the label. Prefar was registered in 1965, the same year as Balan and four years earlier than Kerb. Prior to the widespread use of sprinklers during stand establishment, Prefar developed a reputation of producing erratic and narrow spectrum weed control. More effective and consistent weed control has been achieved in recent years with the use of sprinklers for incorporation. Tests have been conducted over the past few years to evaluate sprinkler and furrow irrigation incorporation with variable volumes of water. Two of these tests are summarized here.

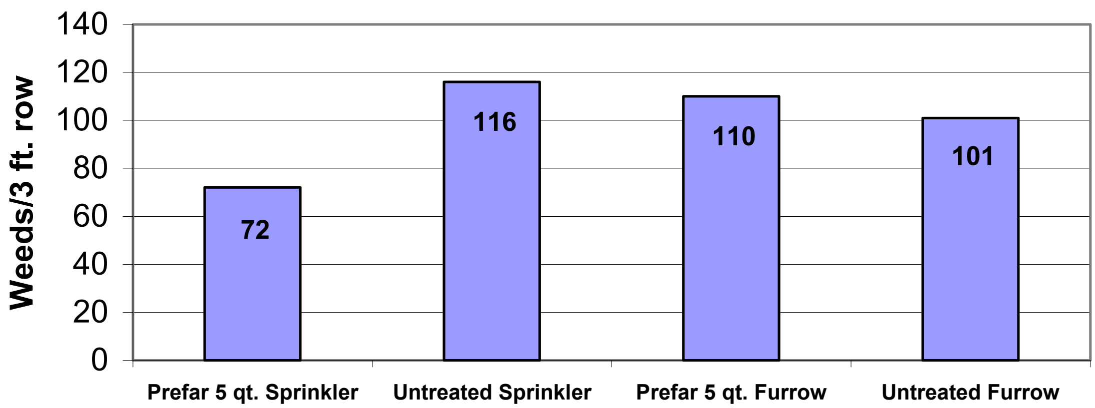
A test was conducted to compare a moderate rate (5 qts./a) of Prefar incorporated with sprinkler and furrow irrigation. (Table 3, Graph 3)

Table 3. Weed control from Prefar incorporated with sprinkler and furrow

Herbicide	Rate	Irrigation type	Irrigation amount	Weeds/3 ft. Row
Prefar	5 qts.	Sprinkler	2.5 to 3.5"	72
Untreated	-	Sprinkler	2.5 to 3.5"	116
Prefar	5 qts.	Furrow	5 days	110
Untreated	-	Furrow	5 days	101

Notes: Plot size = 15 ft. X 2 beds, 4 replications; Spray volume = 20 gpa
Weeds = Shepardspurse, Annual Ryegrass; Weed counts made 26 days after application

Graph 3. Weed control from Prefar incorporated with sprinkler and furrow irrigation



Weed control was significantly better when Prefar was incorporated with sprinklers compared to furrow irrigation. It is unclear why this occurs although it is consistent with grower experience. Grower experience has also demonstrated that Prefar works well when applied through the sprinkler system and has not worked well when mechanically incorporated. Chemigation can be uneven, however, and result in poor weed control or corp injury.

A test was conducted to evaluate the effect of irrigation amount and herbicide rate on the weed control achieved with Prefar incorporated by sprinkler irrigation. Prefar rates of 1 to 6 quarts were incorporated with an overhead sprinkler modified to apply 0.25, 0.325, 0.5, 0.67 and 0.75 inches of water. The one qt. rate was too low to produce weed control although at all rates above 2 qts./a the weed control was improved with increasing amounts of water. (Table 4)

Table 4. Barnyardgrass seedlings counted per 3 feet of row 7 days after Bensulide treatment

Bensulide 4E Rate (lbs. ai/a)	Seedlings/3 ft.				
	Inches Water				
	0.25	0.325	0.5	0.67	0.75
Untreated	18.0	22.3	22.6	27.0	22.0

1.0	29.0	26.0	26.0	28.6	21.5
2.0	16.0	9.6	6.3	2.6	2.5
3.0	2.0	1.0	1.6	0.6	0.3
4.0	3.5	0.6	0.3	0	0
6.0	0	0	0.3	0	0

Note: Plot size = 3 x 25 ft. - 4 replications
Spray volume = 20 gpa

FQPA and IR-4 Registrations and their Effect on Minor Vegetable Crops

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The Food Quality Protection Act of 1996 defined minor crops as those grown nationally on less than 300,000 acres. In California, this definition encompasses every vegetable grown, with the exception of tomatoes and sweet corn. These crops had a farm gate value to California farmers in 1996 of $4.6 billion, so they are a major, not minor, contributor to the agricultural economy. The overall economic impact, in terms of rural employment and businesses is even greater than these numbers suggest; one field of lettuce will employ several more people than the comparable amount of a field crop.

The typical vegetable herbicide is an old product (see Table 1). Most were first registered in the 60's or 70's. Over the years, their use on major crops, such as soybeans or corn, has been supplanted with newer herbicides. In many cases, herbicides such as Lorox, Prefar, or Balan, which once had large sales volume on major crops, now are limited to a few specialty markets. This leaves these herbicides in a precarious position without a large national market to justify the cost of new testing that can be required under FQPA. Prefar, for example, is in the process of review by US Environmental Protection Agency (EPA) because it is chemically an organophosphate pesticide, the only herbicide in this class. In August 1998, the EPA issued the draft Reregistration Eligibility Documents (REDs) on the first nine pesticides, which included Prefar, under review. To quote the Prefar draft, "Vegetable uses with a maximum rate of 6 lb ai/A generally pose a high risk to marine/estuarine invertebrates, although this high risk can be avoided by applying one application per year that is both banded and soil incorporated." The draft goes on to say that, "All types of applications to vegetables pose a risk to marine/estuarine invertebrates that may warrant restricted use classification." And, "Since bensulide is an herbicide, risk to all nontarget plants (e.g. endangered or threatened species) must be assumed in the absence of data." In the case of Prefar, and presumably most other pesticides, EPA is equating toxicity with risk. Risk is a complex interaction of toxicity and exposure, a factor that is ignored in these assessments. How likely is it that Prefar will move from a lettuce field in the desert to an estuarine environment or kill an endangered species after being applied by ground to bare soil? Besides, Prefar has a very narrow spectrum of weed control and the presumption that it places all nontarget plants at risk is unjustified. The EPA risk document also proposed a danger to bees from a herbicide used on bare soil before anything has germinated, let alone flowered.

Because of this review, Gowan Company, the manufacturer of Prefar, is being required to fill in "data gaps" by conducting seven new toxicology and environmental fate tests (see Table 2) to retain registration of this herbicide. Fortunately, Gowan Co. is willing to pay the cost of these tests in order to keep Prefar on the market, but it may become a restricted herbicide and be limited to no more than 6 lb ai/A/year. It does not seem likely that most manufacturers are going to go to this much trouble or cost. If this RED is typical of EPA's concerns about herbicides, Prefar is just the tip of the iceberg. Unless data to prove otherwise are available, all herbicides are assumed to pose a risk to all nontarget plants. Few herbicides have been tested against plants other than crops and weeds. The EPA implies that this information is needed for all of the species of plants present in the US; there are over 8,000 native species in California alone.

Several crop/herbicide combinations vital to growers are at risk because of FQPA (see Table 3). In several cases, the risk exceeds 100% of the crop acreage because of multiple herbicide uses in that crop, either as combinations of 'at risk' herbicides or repeat applications of single herbicides. In most situations, there are no readily available substitutes for the herbicides at risk. If these reviews are conducted as individual actions on herbicides, the situation becomes more problematic. For example, one of the authors (Bell) was asked by US-EPA to list alternatives for Prefar during the review of this herbicide. In lettuce, the principal alternative is Kerb, also scheduled for review in round 1 of FQPA. Is it fair to list one 'at risk' herbicide as an alternative to another 'at risk' herbicide?

Interregional Project 4 (IR-4) has acquired over 4,000 pesticide tolerances for minor crops since its inception in 1963. Since the passage of FQPA in 1996, IR-4 has adjusted their program and goals to deal with the new law. Starting in 1997, IR-4 has become more aggressive in their efforts to seek low risk alternatives to existing pesticides used on minor crops. The new IR-4 Strategic Plan for minor crops/minor uses has four goals: 1) to promote reduced risk pest management, 2) to develop risk mitigation measures for existing pesticide registrations, 3) to assist with the registration of biologically based pest control products, and 4) to register and maintain pesticides essential to IPM. More funds have been made available to the IR-4 program from Congress to aid in this effort, including increased funding for performance evaluation of alternative reduced risk and biologically-based pesticides. In 1996, IR-4 funded 20 field studies with identified reduced risk pesticides; in 1998, that number had increased to 78, which was one half of their studies. The insecticide Spinosad is an example of IR-4's commitment to a more rapid process. IR-4 completed field studies in 1997 and the lab work in May 1998 for Spinosad on potato. The tolerance petition was submitted to EPA in October 1998 and a registration is expected in mid-1999; much faster than the typical five year process from field to tolerance approval. We hope the same efforts will be focused on herbicides in the near future.

Under FQPA, EPA is expected to put together a special minor crops program, which they have yet to do. FQPA also grants special considerations and concessions to manufacturers for registering minor crops, but there is little to show yet for this effort. There are many new herbicides that are or soon will be on the market for major crops such as corn and soybean. However, there is no mechanism at present to identify potential new uses for these herbicides for minor crops. To address this data gap, the authors, along with Milt McGiffen at UCR; Tom Lanini at UCD; and Farm Advisors Bob Mullen and Jesus Valencia have embarked on a project to evaluate several of the newer herbicides on a variety of important vegetable crops in California. Our goal is to identify which of the new herbicides can be used safely and effectively on these vegetables and then submit requests to IR-4 to start the registration process. This research is being funded by a grant from the USDA Pest Management Alternatives Program (which was mandated by FQPA) and has the support of commodity groups and chemical manufacturers. We hope to have some useful results starting in 1999.

Table 1. Year of first US registration for selected herbicides for California vegetables.

Herbicides (year 1st registered in US)	Vegetable Crop
Prefar (1968)	Onion, cole crops, cucurbits
Buctril (1965)	Onions
Dacthal (1970)	Cole crops, cucurbits, onions
Roundup (1974)	Several
Lorox (1961)	Carrot, asparagus
Treflan, etc (1966)	Asparagus, carrot, cole crops, cucurbits, tomato

Table 2. Additional tests required of Gowan Co. to retain registration of Prefar as a result of FQPA review.

Study Type
Freshwater fish early life-stage or life cycle study
Freshwater invertebrate life-cycle study
Seedling emergence study, Tier II
Vegetative vigor study, Tier II
Aquatic plant growth and reproduction, Tier II
Avian reproduction study with the mallard
Acute freshwater invertebrate study

Table 3. Estimated acreage of crops at risk of losing herbicides through FQPA. Acreage values in excess of 100% indicate either multiple applications of single herbicides or combinations of herbicides at risk.

Crop	Percent of acreage at risk: herbicides at risk from FQPA
Dry bulb onion	363: Dacthal, Prefar, Buctril, Prowl, Methyl Bromide, Goal, Gramoxone, Treflan
Snap beans	221: Lasso, Dacthal, Eptam, Sonalan, Dual, Goal, Gramoxone, Prowl, Treflan
Artichoke	149: Goal, Kerb, Princep
Green Onion	138: Buctril, Methyl Bromide, Goal, Dacthal
Spinach	133; Roneet, Antor
Tomato	118: Dacthal, Eptam, Methyl Bromide, Dual, Sencor, Gramoxone, Tillam, Treflan
Cole crops	89: Treflan, Dacthal, Prefar, Goal, Gramoxone, Methyl Bromide
Carrot	78: Goal, Treflan, Methyl Bromide, Eptam
Asparagus	53: Princep, Treflan, Gramoxone, Methyl Bromide, Sencor
Bell Pepper	45: Prefar, Methyl Bromide, Goal, Gramoxone, Treflan, Dacthal
Melons	41: Treflan, Dacthal, Prefar, Sonalan, Prowl, Gramoxone

Advances in Agronomic Weed Control

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Agronomic crops in California are grown over four million acres and generate in excess of three billion dollars annually. The major crops and acreage include:

Alfalfa hay -	1,000,000
Dry beans -	130,000
Corn, grain & silage -	500,000
Cotton -	900,000
Rice -	500,000
Sugar beets -	100,000
Wheat -	550,000
Other hay & grain -	700,000

Source: California Field Crop Review, October 1998, Vol. 19 No. 10

This paper will discuss these crops except for cotton, which will be covered in another presentation. My specific focus will be to address recent advances made during the past year to solve weed problems by utilizing new herbicides, herbicide resistant crops and cultural practices.

Alfalfa

Managing weeds in alfalfa is always of major importance, beginning with establishing a new stand or trying to maintain top hay quality that is desirable to the dairy industry. Two herbicides were registered for use in alfalfa hay in 1998, which will help in both of these areas:

Prism® **-** is a new selective herbicide from Valent Corp that can be used on all ages and growth stages of alfalfa without danger of crop injury. It controls annual and perennial grass weeds. This herbicide will be an important tool for control of yellow foxtail and other grasses occurring in summer months or in seedling stands. It can also be tank mixed with Buctril or Pursuit to expand the spectrum of control to broadleaf weeds.

Zoriel® - is a preemergence herbicide effective on grasses and broadleaf weeds in established alfalfa. It also will suppress nutsedge growth when applied in advance of emergence. Zoriel will need the addition of another herbicide in the spray mixture such as Gramoxone or Velpar to control emerged weeds and to control common groundsel.

Dodder – a parasitic weed that has plagued alfalfa growers for decades. Only preemergence control using trifluralin granular herbicide has been effective and recommended. In 1998, field research trials evaluating Pursuit herbicide applied during the early germination and attachment of dodder (March – May) to seedling alfalfa showed a significant reduction in growth and control. Depending on size and degree of dodder attachment control reached as high as 100% with two applications (Figure 1).

Dry Beans

Dry beans – the most important weed problem common to all bean types (Lima, blackeye, kidney) grown in California is nightshade. Black and hairy nightshade cause problems to beans when allowed to develop seed berries at harvest. The juice released from the berries permanently stain white colored beans such as blackeye and Limas, reducing their value in the market place. The canning industry has also established a zero tolerance to nightshade contamination in beans. The presence of any seed berries will reject the entire lot and loss of payment. Research trials were conducted in several locations by E. Roncoroni, et. al.. to evaluate methods to extend nightshade control season long in blackeye beans. Three strategies were outlined:

1. The application of a preplant incorporated herbicide followed with a mid-season layby application of another herbicide to prevent late season germination.

2. Pursuit herbicide applied in a 12" directed spray pattern on either side of the bean row minimized crop injury and controlled nightshade post and preemergence.

3. The Bezzerides™ cultivator designed with spring type hoe weeder controlled young nightshade plants around and between the bean plants. Several cultivations were needed up until row closure allowing the bean canopy to shade out further nightshade development.

Corn

Corn – weeds are competitive with corn during the first 3-5 weeks following emergence of the crop. Control is important before weeds exceed 6-8" in height and begin to impact yields. Perennial weeds such as Johnsongrass and nutsedge can be major problems and very expensive to control when a preplant herbicide followed by postemergence treatments are needed. The development of herbicide resistant corn varieties for California using broad-spectrum herbicides and combined with existing products offers an additional potential for controlling tough perennials.

Roundup Ready® - glyphosate resistant corn varieties being developed by Monsanto and DeKalb Companies will offer the potential to control annual and perennial weeds more effectively. Results from 1998 field trials showed favorable results in controlling Johnsongrass and other annual weeds (Figure 2). In 1999, 30,000 acres are expected to be planted.

Liberty Link® - glufosinate resistant corn varieties being developed by AgrEvo and Pioneer Seed Company will provide a broad spectrum control of emerged weeds. In 1999, 1,000 acres of experimental testing is expected to begin.

Rice

Rice – weeds reduce yields by competing with rice plants for light, nutrients and space. This competition is most critical at the seedling and tillering stages of rice. The most competitive aquatic weeds include watergrass, sedges and broadleaf types such as arrowhead, duck salad and red stem. There have been two significant occurrences that have recently taken place in affecting the rice industry. Weed resistance to Londax® herbicide developed in 1993 on four broadleaf weed species. In 1997, poor control of watergrass of several rice herbicides was reported. It now has been confirmed that both multiple and cross resistance exist on a number of northern California rice fields.

Progress for registration is being made with two herbicides that will aid in controlling some of the resistant weeds:

Regimen® - postemergence herbicide developed by Valent Corporation for control of watergrass, sedge and certain broadleaf weeds. Used in a tank mix combination with Abolish and applied in a pinpoint flood application provided 95% control of many broadleaf and grasses. Shown control of some watergrass SP that has developed herbicide resistance to other herbicides.

Shark® - postemergence control on a wide range broadleaf weeds. Received a Section 18 in 1998 to control Londax-resistant weeds and use on approximately 20,000 acres. Section 18 is expected again in 1999. Performed well when tank mixed with Grandstand at reduced use rates.

Transgenic rice – Liberty Link, Roundup Ready and Imi- rice are moving forward for California. AgrEvo, Monsanto and American Cyanamid are working in conjunction with public breeders to establish necessary traits in medium grain varieties. The earliest expectation for commercialization is in 2001.

Sugar Beet

Sugar beet – is not a very competitive crop, thus weed control is mandatory. Research has shown weeds to reduce yields by 90% and can result in stand failure. In California, sugar beets are planted from September through June. Weed population and type differ by season and location in the state. Fall planted beets grow slowly and are easily overshadowed by mustards, shepherdspurse, minerslettuce, chickweed and a host of winter grasses. Spring planted beets are more likely to compete with pigweed, lambsquarters, nightshade and barnyardgrass. Therefore, chemical control is needed with mechanical cultivation and often a hand hoeing crew to establish a stand of sugar beets. Weed control operations can reach $100.00/acre.

The development of transgenic sugar beets used with broad-spectrum herbicides offer a great potential to California growers to manage a wide range of weed types under different climate conditions more efficiently. Liberty Link® and Roundup Ready® sugar beets are two leading companies now testing in California and are expected to be commercially available for limited plantings in 2000.

Stinger® - is a selective postemergence herbicide for control of broadleaf weeds. Effective on thistles and legumes, it is expected to complement a tank mix combination with Beta mix® or Progress® to increase the broadleaf weed spectrum. California registration is currently pending for 1999.

Wheat

Wheat – weed control in wheat is important for yield and provides the grower an opportunity to reduce the overall weed population. Broadleaf species are most commonly treated on an annual basis while grass weeds problems are less likely to be addressed that frequently.

The occurrence of grass weeds however, is spreading statewide. A recent survey conducted by UCCE advisors ranked the important grasses populating wheat and the estimated acreage affected by each of the grasses (Figure 3). The most widespread grass problem was wild oat followed by canarygrass, Italian ryegrass and several brome species. The limited availability of grass herbicides one can use in California wheat might account for the increase in grass problems.

Puma® - a postemergence herbicide developed by AgrEvo is expected to gain California registration in 1999. In test conditions Puma has provided good control of canarygrass (Figure 4). and wild oat.

Assert® controls wild oats and mustards in wheat and barley. Developed by American Cyanamid Company, Assert shows a high degree of safety to both red and white Durham wheat varieties. Will be useful in areas were Avenge resistant wild oats have developed. California registration is expected in 1999.

Imi wheat – Imidazolinone resistant varieties are being developed by American Cyanamid in conjunction with public universities. The Imi-herbicide imazamox is anticipated for use in California. The herbicide controls many broadleaves and grasses and will be important in areas where jointed goatgrass occurs. California registration is expected after 2000.

Figure 1. Postemergence Control of Dodder with Pursuit in Alfalfa

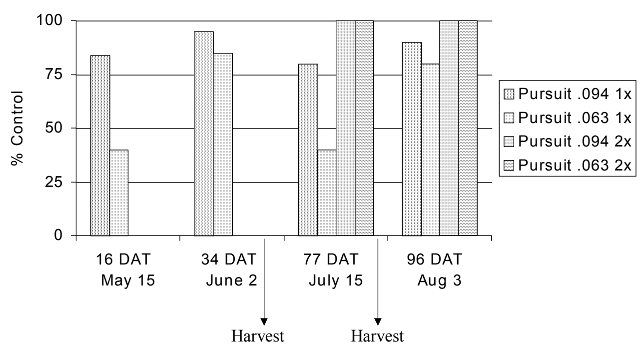


Figure 2. Johnsongrass Control in Roundup Ready® Corn

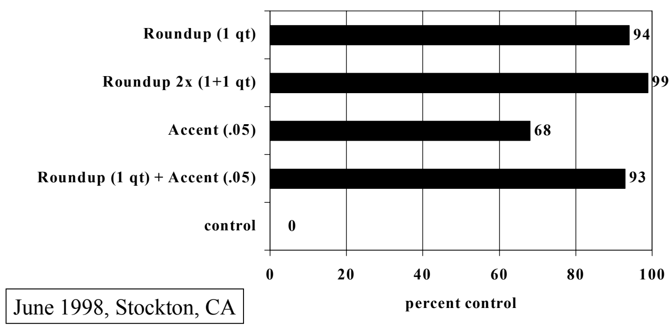


Figure 3. **Estimated Acreage* Affected by Grass Weeds in Wheat**

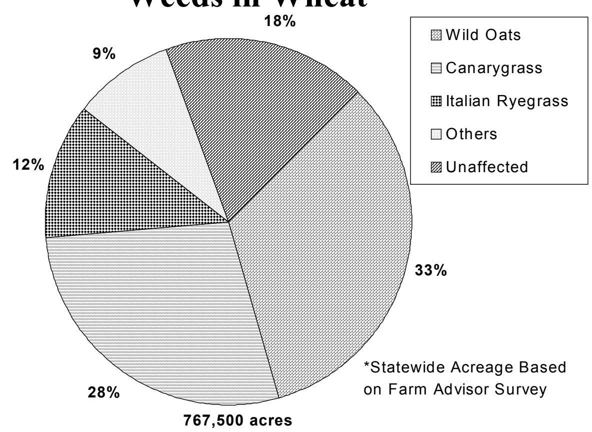
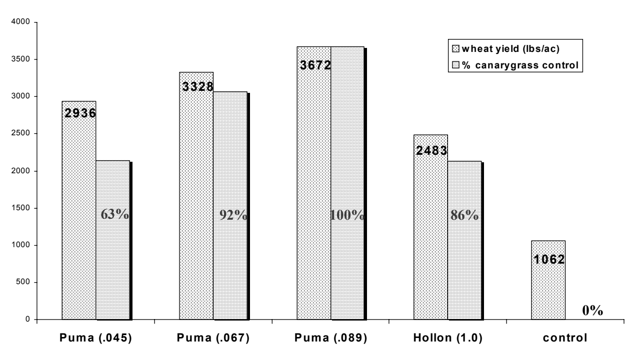


Figure 4. Hood Canarygrass Control & Yields in Wheat with Puma®



Alfalfa Weed Control in the Low Desert
Past, Present and Future

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Weeds in Alfalfa

The problems caused by weeds in alfalfa is a subject that has long been debated. In few crops are the weeds sold with the crop. Weeds can contribute substantially not only to the weight and dollar value of baled alfalfa, but it can, in some cases, also increase its nutritional value. On the other hand, buyers commonly demand weed free alfalfa and heavy discounts in price are often levied. The costs and benefits of weed control complicated by a host of changing variables such as supply and demand, crop rotation, modified cultural practices required both when weeds are present or herbicides are used, and other factors. Weeds are generally considered to be potentially serious pests in the early stages of the crop during stand establishment and the later stages of the crop when stand lose has reduced the competitive advantage of the alfalfa. Although the weed spectrum may have changed over the years, weeds have always been a problem in alfalfa and considerable effort and expense has been devoted to controlling them.

Because of the mild climatic conditions in the lower Colorado desert, weeds are a problem year round. During the summer the predominant weeds are grasses including watergrass, barnyardgrass, southwestern cupgrass, prairie cupgrass, red and Mexican sprangletop and sandbur. Bermudagrass is a perennial that becomes increasingly predominant with the life of the stand. Some broadleaf weeds are also present at this time of the year including pigweed, purslane, jimsonweed and groundcherry. Dodder and nutsedge are two of the most difficult to control weeds during the summer months. Broadleaf weeds are predominant during the winter months and include London rocket, shepardspurse, malva, needleleaf goosefoot, lambsquarter and sowthistle. But grasses, such as wild oat and canarygrass can also be a problem. Some changes in the predominance of certain weeds have occurred over the past 40 years. These changes reflect, in most cases, changes in control practices. These changes are the subject of this paper.

1900 to 1960

Cultural Practices

Prior to 1960, cultural practices were the dominant means used to give alfalfa a competitive edge over weeds. Integrated Pest Management (IPM) was touted in the 80's and now, as a new technique in pest management. It is, however, one of the oldest principles used in weed control and prior to the availability of herbicides, the only technique used. The cultural practices used in the 20's and 30's are some of the same practices growers use today. Planting between peak periods for summer and winter annual weed germination, using weed free seed, properly leveled fields to avoid ponding of water, timed cuttings and clippings to enhance alfalfa vigor and reduce weed competition, crop rotation, weed free borders and ditch banks, and other practices, have always been used to keep weeds in check in alfalfa. Summer fallow and smother crops were used to control weeds more frequently in the early 1900's than they were after herbicides were widely available after 1960. Fallowing during the summer months has always been a viable option on fine textured soils where little, if any, damage is done to the alfalfa stand and summer annual weeds or nutsedge have gotten out of control. Cover crops such as oats or sudan grass have been effective in providing competition against weeds although a good stand of alfalfa has always been considered an effective cover crop by itself during the summer months until August. Sheep grazing during the fall and winter months has long been considered a desirable practice by alfalfa growers particularly where winter annual broadleaf and grass weeds are heavy and widespread.

Chemical Weed Control Prior to the Widespread Availability of Selective Herbicides

Various chemicals were used to control weeds prior to 1960. These were mostly toxic salts, acids and oils, and were largely non-selective vegetation killers used around crop fields rather than in them. They were occasionally used for spot weed control in fields where particularly undesirable weeds were present.

Prior to the jump in petroleum prices, oils were fairly commonly used to control weeds on ditchbanks, levees and other non-crop areas. Early on these were mostly diesel and stove top oils although petroleum companies experimented with, and later made available various other grades of oil for weed control. Crop oils continued to be used for non-selective weed control even after the availability of selective herbicides, but have rarely been used since the increase in petroleum prices in the 1970's. Oils were rarely used in alfalfa fields except as a spot treatment for particularly troublesome weeds such as dodder.

Salts have been over the years some of the most harmful of all substances to agricultural production in the lower Colorado deserts. They were also some of the earliest and most used herbicides. Sodium chlorate and various ammonium salts were some of the earliest herbicides available. These were used mainly around and not in cultivated fields due to non selectivity and soil persistence.

The arsenicals including sodium arsenite, arsenic trichloride, and arsenic acid were commonly used herbicides in the early and mid 1900's. Used often as non-selective soil sterilents, these were sometimes applied to established weeds and translocated to the root system.

Boric, sulfuric and carbolic acids were also used occasionally as non selective herbicides. The rates used of these materials varied considerably depending upon the type and size of vegetation to be controlled.

These early herbicides were used prior to the current emphasis upon worker safety. Worker safety can be over emphasized although these early years were dangerous times to be working on a weedy farm. The chlorates were highly flammable. The arsenicals were some of the most deadly toxicants available to man and animal and the acids were very difficult to handle. These were applied with equipment that by todays standards was extremely primitive.

Low volume precision application equipment was not yet developed and most applications were made in extremely high volumes.

1960 to 1970

Selective weed control with the use of selective herbicides was added to the alfalfa growers cultural practices in this period. Although many of the earliest herbicides were in the developmental stages and tested in the field as early as the 1930's, they were not used commercially on a wide scale until after about 1960. The earliest of these herbicides included 2,4-DB, IPC and CIPC, EPTC, DNBP and Diuron. Only two of these, EPTC and 2,4-DB are used in the lower Colorado desert today. Growers continued to rely on non-chemical control methods although these new herbicides offered them, for the first time, the opportunity to economically remove many weeds from alfalfa fields on a large scale. These were the first of many herbicides that have revolutionized alfalfa production practices and greatly increased the quality of alfalfa produced.

EPTC (Eptam)

This was one of the earliest herbicides used in alfalfa and it is still used today. In 1960, Eptam was used commercially in California as a selective preplant soil incorporated herbicide for the control of annual grasses such as wild oat, volunteer barley, watergrass and some annual broadleaf weeds including pigweed, lambsquarter, purslane and nightshade. Its value in suppressing yellow and purple nutsedge and bermudagrass was already recognized in 1960 and is perhaps its major value today. Only a small acreage of alfalfa was treated with Eptam in the early 1960's and it didn’t see widespread use until about 1964. Its early use was preplant incorporated by discing soon after application. It wasn’t used widely on established alfalfa until water ran application was developed in the mid 1960's. This was the first herbicide ever to be applied by metering into the irrigation water. It was most effective when applied to basin irrigated fields where it could be evenly distributed. Eptam is one of the most volatile of all herbicides and this has reduced it effectiveness over the years. Where alfalfa is irrigated frequently in the summer months, as it is in the lower Colorado deserts, this herbicide will be effective for only two weeks or less. With the continual emergence of summer annual grasses and the rapid reproductive capacity of nutsedge, this herbicide has been less than completely effective. However, Eptam applied in the irrigation water was the most widespread weed control practice in the deserts for the 20 year span from the mid 1960's to the mid 1980's.

Complaints of poor control of summer annual grasses became increasingly frequent in the late 70's and early 80's. Failures were commonly the result of short length of activity, even when applied after every cutting during the summer, and difficulty making even and accurate water-run applications. A granular formulation was introduced in the late 80's and early 90's, first only for preplant use then also for established stands. This formulation allowed the more accurate and even applications as well as spot treatments. Water-run applications of Eptam are still common in some areas, making this one of the longest continually used herbicides in alfalfa.

2,4-DB (Butyrac)

2,4-D was the first of the "phenoxy" or hormone weed killers. In the early and mid 1960's these were found to be selective and effective as translocated herbicides for the control of broadleaf weeds. As one of the earliest selective herbicides, 2,4-D provided the impetus for the discovery and development of other herbicides.

By 1960, 2,4-DB was developed and available for use on alfalfa as butoxone and butyrac 118. 2,4-DB has no effect on broadleaf weeds or alfalfa until it is converted by an internal enzyme system to 2,4-D. Alfalfa and certain other small seeded legumes have a different enzyme structure than many of the broadleaf weeds controlled and do not bring about this change to the same extent and, therefore, remain generally unharmed. In 1960, both amine and ester formulations of 2,4-DB were being tested in the lower Colorado desert. The ester formulation was generally more effective in controlling weeds but could never be used in this region due to its volatility and potential injury to other crops. 2,4-DB was one of the earliest herbicides available in alfalfa and has remained as a standard treatment for postemergence control of many winter annual broadleaf weeds including London rocket, prickly lettuce, goosefoot, lambsquarter and sowthistle. Occasional injury to alfalfa in the form of strapped or thin elongated leaves and weakness in controlling some particularly troublesome weeds such as shepardspurse and malva, have limited its use.

Chem Hoe (IPC) and Furloe (CIPC)

Chem Hoe was one of the earliest selective herbicides and the first carbamate herbicide registered in alfalfa. It was discovered in 1945 but was not used in the lower Colorado deserts until the early to mid 1960's. It was used primarily as a preemergence herbicide for the control of winter annual grasses such as wild oat, canarygrass, and volunteer wheat and barley. It was most active during the cool seasons because of rapid breakdown from high soil temperatures and high volatility. As such, it was weak on summer annual grasses and broadleaves, and had a limited spectrum of weeds controlled. Chem Hoe was used most widely in alfalfa prior to the availability of other herbicides that controlled winter annual grasses and other weeds more effectively. By the mid 1980's, Chem Hoe was no longer used or available. CIPC or Furloe was similar to IPC although Furloe was used effectively to control dodder in alfalfa in cooler regions. It was not as effective for dodder control in the desert regions, again because of high volatility, short residual activity and the continual emergence of new seedling weeds.

DNBP or Dinoseb (Dow General, Sinox, or Contact dinitro)

Dinoseb was one of the earliest and most widely used general contact herbicides used in the lower Colorado deserts. The ammonium salt of dinoseb was used effectively for the control of most annual broadleaf weeds in alfalfa. This was a contact herbicide and was applied in large volumes of water of 40 to 80 gallons per acre to achieve adequate coverage. The tops of weeds are destroyed with this herbicide and small ones were killed. The growing point of grasses is protected and this herbicide was ineffective in controlling them. The most common time of application was after the establishment of new stands, before the first harvest, and when the weeds were small. This family of herbicides, the Dinitrophenoles, were toxic to humans and Dinoseb registrations were canceled by the EPA in 1987 because of suspected long term health effects. Dinoseb was commonly used after about 1962 and was still widely used when registrations were canceled.

Balan (Benefin)

The dinitroaniline herbicides including Balan, Treflan (trifluralin), Prowl (penimethalin) and Endurance (prodiamine) are some of the most widely used in the lower Colorado deserts. Balan was the first dinitroaniline herbicide registered and used in alfalfa in this region and it continues to be used today. Eptam and Balan have always been the two preplant treatments recommended and used in alfalfa in the lower Colorado deserts. Eptam was used shortly after 1960; Balan was first used five or six years later. Balan in used preplant and incorporated by discing. It has effectively controlled annual grasses and some annual broadleaf weeds, but is ineffective on the mustards, sowthistle and malva. Limiting the widespread use of this herbicide has been the potential for injury to the alfalfa whenever it is stressed from moisture deficit, salt or any other reason. In finer textured soils that crack, weeds also will emerge through the cracks.

1970 to 1980

The decade between 1970 and 1980 was an exciting time for the testing and development of new herbicides. Many were tested and some were registered on alfalfa during this period although the non-dormant varieties that were now grown in the lower Colorado deserts limited what could be effectively used without unacceptable crop injury. Many of the new herbicides registered during this period were difficult to use under the conditions present in the desert and while some of them were very effective, none became the persistent standards that Eptam and 2,4-DB had become. The general movement away from a reliance upon cultural practices to control weeds in alfalfa continued during this decade.

Treflan EC (Trifluralin)

The emulsifiable concentrate formulation of Treflan was registered in the region in the late 60's for use on established alfalfa grown for seed only and was used during the 70's under a special local needs registration that permitted water run applications in alfalfa, bermudagrass and citrus. Water run applications were limited to irrigation runs of 660 feet or less because of problems in achieving good distribution with this technique. Treflan does an excellent job of controlling summer annual grasses and some broadleaves such as pigweed, but application difficulties limited its use during this period and the SLN registration was dropped by the end of the decade.

Tolban (Profluralin)

This dinitroanaline herbicide which was similar to Balan, was available and used briefly from about 1975 to 1980 when it was no longer registered. It was used in the same way as Balan as a preplant incorporated treatment and controlled annual grasses and some broadleaf weeds such as lambsquarter, goosefoot and pigweed. Crop injury sometimes occurred when the alfalfa was stressed.

Sencor (Metribuzin)

This herbicide was first registered on alfalfa in the lower Colorado desert in the late 1970's and growers are continuing to learn how to use it today. It is very effective, both preemergence and postemergence, on many difficult to control broadleaf weeds such as malva and shepardspurse but is difficult to use with good crop safety on non-dormant alfalfa. It is registered for use after sheep grazing when little alfalfa foliage is present and regrowth is less than two inches. Serious crop injury can occur if applied to alfalfa that is less than one year old or if excessive foliage is present. It is also registered for and used on alfalfa planted on beds for weed control in the non-planted furrows. Although the lack of crop safety on non-dormant alfalfa has limited the use of this herbicide, growers have continued to try to use Sencor because of the broad spectrum of weeds that it controls including broadleaves and grasses.

Gramoxone (Paraquat)

Interest in paraquat as a contact desiccant on small winter annual broadleaf weeds began in the mid 1970's and it continues to be an option used by some alfalfa growers today. Paraquat is a non-selective contact herbicide that will kill very small seedling weeds and allow established alfalfa to recover. Once weeds reach the rosette stage, control becomes erratic. This herbicide has no soil residual activity and weeds that continue to germinate over the season, as most do in the desert, will not be effectively controlled. The alfalfa is desiccated along with weeds and seedling alfalfa can be killed especially if warm sunny conditions prevail. This herbicide should not be used on alfalfa that has more than two inches of regrowth and the alfalfa cannot be grazed or cut for six days following application. All of these restrictions have limited the use of paraquat for alfalfa weed control in the lower Colorado River deserts although some growers, who like a quick kill of small weeds with some temporary injury to established alfalfa, like this product.

Kerb (Pronamide)

There was interest in Kerb for winter annual weed control in the late 1970's and early 1980's primarily by lettuce growers who were willing to pay the relatively high price for this herbicide to control certain weeds in their alfalfa with little problem from drift to lettuce and other high value crops. Kerb has been used in the lower Colorado River desert primarily as a preemergence herbicide in lettuce to control winter annual weeds. It is registered in alfalfa only for use on established stands or new stands having one or more trifoliate leaves. Kerb is active through the soil and not the foliage and will kill weeds both preemergence and postemergence. Although lettuce growers have used this herbicide to control a good spectrum of broadleaf weeds in the past, it has been ineffective in controlling most broadleaf weeds in alfalfa in the desert. It has been very effective in controlling winter annual grasses such as canarygrass, wild oat, annual bluegrass, and volunteer wheat and barley. Failure on many broadleaf weeds has commonly been attributed to the leaching of this herbicide below the germinating broadleaf weeds.

1980 to 1990

The 1980's saw the introduction of a few herbicides that were to have a greater impact upon weed control in alfalfa than any product since the introduction of the selective herbicides in the early 60's. The highly selective foliar applied grass herbicides including Poast, Fusilade, Select and Assure were registered for many crops during this decade and have truly revolutionized grass control in broadleaf crops. Only one of these, Poast, was registered on alfalfa in the lower Colorado desert and gave growers their first opportunity to safely and effectively control most grasses after they had emerged. Trifluralin 10% granules were introduced about the same time as Poast and have brought about a quicker and greater change in weed control practices in alfalfa than any previous herbicide. No herbicide has ever been as widely or effectively used to control annual grasses in alfalfa in the desert. This has demonstrated the effect that a new formulation of an old herbicide can have.

Poast (Sethoxydim)

When registered in the mid 1980's, Poast gave growers their first opportunity to effectively control most annual grasses after emergence with excellent safety to even seedling alfalfa. Poast is weak on sprangletop and will not control annual bluegrass, but is very effective on all other annual grasses in the region. Poast has little, if any, soil activity and it requires at least two applications to achieve season long control of summer annuals because of the continuous emergence of new seedlings from late February through October. Perennial grasses, such as bermudagrass and Johnsongrass, can be controlled but require multiple applications of the highest labeled rate. The cost of this herbicide is relatively high and this has limited its use on alfalfa where trifluralin granules are applied in a timely manner and effective season long. Where trifluralin granules are weakened because of poor drainage and other factors, Poast has been heavily used, such as in the Imperial Valley.

Trifluralin 10G

Treflan TR10 was introduced in the mid 1980's by Elanco Chemical Company and was accepted quickly by growers. By 1990, Wilbur Ellis and Gowan Company were also formulating trifluralin ten percent granules. Trifluralin is a dinitroaniline herbicide similar to Balan and Prowl that has been around for a long time and used heavily on several crops grown in the lower Colorado desert. Both the emulsifiable concentrate and a granular formulation of Treflan were used or tested in this region in the 1970's. Neither performed as effectively as the 10G formulation developed in the 1980's. Like all herbicides, there are conditions under which trifluralin granules are less effective. Where irrigation water is poorly drained, trifluralin will break down anaerobically and be ineffective or effective for a short period of time. In well drained soils, this product has been effective for six months or more at the highest labeled rates. Organic matter will tie this herbicide up. Although this is not a normal condition in the desert, it has occasionally been a factor in reducing the efficacy of this product. Wheel traffic and other factors that weaken or kill the stand of alfalfa will reduce the performance of trifluralin granules. On well drained soils, one application of the highest labeled rate has given season long control and is preferable to split applications at lower rates. This product is normally applied by aircraft.

Where aerial application is not possible, or growers prefer to make applications by ground, specialized equipment is required to apply these very small granules. Growers have been successful in modifying existing equipment or have purchased specialized equipment for ground application. There are two different size granules now manufactured; a 30-60 and a 24-48 granule and there can be more than a 30 percent difference in application rate if growers do not calibrate equipment for both.

Buctril (Bromoxynil)

This herbicide was registered in parts of the lower Colorado desert in the mid 1980's and is for use on seedling alfalfa. As a contact herbicide for broadleaf weed control, this treatment will cause severe injury and death to alfalfa when temperatures reach 70º F. or higher at or soon after application. It will kill small weeds and only temporarily burn back larger ones. Because of the lack of crop safety, this herbicide has seen limited use in the desert.

1990 to Present

This period saw the increase in selective broadleaf weed control with the introduction of Pursuit. This herbicide had the same impact on broadleaf weed control that Poast and trifluralin granules had on grasses in the 1980's. Grass control continued to improve with the registration of Select/Prism which controlled some grasses that Poast and trifluralin did not. Zorial, an older herbicide, was expanded to alfalfa but was difficult to use in diverse cropping systems.

Pursuit (Imazethyphyr)

In the 1980's, American Cyanamid Company developed a new class of herbicides known as the imadazolinones which are useful in a variety of crop and non-crop situations. One of these, Pursuit, was registered on alfalfa in the early 1900's. Pursuit was first registered for use in soybeans and peanuts and was used, on a very limited scale, on peanuts in Arizona. Pursuit does an excellent job of controlling a broad spectrum of broadleaf weeds in alfalfa, especially some that have been very difficult to control in the region such as shepardspurse, malva and swinecress. Pursuit will not control the composites including sowthistle and prickly lettuce, and will suppress, but not kill, many grasses such as canarygrass, wildoat and the summer annuals. It will also suppress, but not kill, nutsedge. Temporary stunting, as shortened internodes, will be evident to treated alfalfa for one cutting after application. Pursuit has long soil activity and this is both an advantage and disadvantage in the lower Colorado desert. This is an advantage because of the long preemergent activity in a region where weeds continue to germinate over the entire season. It is a disadvantage because of carryover damage to crops grown in rotation with alfalfa. A single application of Pursuit will cause injury to many crops grown in rotation with treated alfalfa such as vegetables, cotton, sugarbeets, grain and others, as long as two years after application. Two or more applications of Pursuit would make it difficult to rotate to many crops for perhaps three years after application. Because of soil persistence, Pursuit will likely be restricted to use only during stand establishment or the first year of an alfalfa crop.

Select/Prism (Clethodim)

This herbicide was first registered in the early 1990's on cotton and soybeans. The label was expanded in the late 1990's to include alfalfa, tomatoes, dry beans and peanuts. It was registered as a 0.94 EC called Prism in some states, including California. It was also registered as a 2 EC formulation called Select in Arizona. This herbicide has the same mode of action as Poast, Fusilade and other grass specific lipid biosynthesis inhibitors. Clethodim is effective in controlling almost all annual and many perennial grasses including two that are not controlled by Poast; annual bluegrass and sprangletop.

Zorial (Norflurazon)

This is an older herbicide that was first introduced by Sandoz in 1968 primarily for use in tree, nut and vine crops. It was registered on some field crops in the low desert in the mid 1990's, including cotton and alfalfa. Norflurazon has attracted the attention of many growers and pest control advisors primarily because of its activity on nutsedge. This herbicide has always been difficult to use in double cropped areas because of its soil persistence and is probably known more for the distinctive white foliage and crop injury it produces then for weed control. Zorial is registered as a 80% DF although a 20 % granular formulation was registered in the late 1990's and available in small quantities.

Future

The arsenal of herbicides for use on alfalfa in the low desert was fairly complete with products available to control most weeds. The testing and registration of new herbicides was slower but continuing with compounds such as Visor. The search continued for effective and selective nutsedge control herbicides.

Visor (Thiazopyr)

Visor was developed by Monsanto and sold to Rohm and Haas in 1994. The 2E formulation is currently registered in citrus although it has been tested in alfalfa and other crops for the past several years. Registration on alfalfa is expected around 2000. Thiazopyr has a mode of action similar to the dinitroaniline herbicides such as trifluralin (Treflan) and Prowl. It inhibits cell division and is used preemergence to restrict root growth in developing seedlings. It has no activity on emerged weeds. Thiazopyr is in the pyridine chemical family. Visor has excellent activity on annual grasses and has produced preemergence grass control in our tests that is as good, and often better, than other available herbicides. The control of many broadleaf weeds including mustards, sowthistle, goosefoot, pigweed, and purslane is less consistent and ranges from partial suppression to good. Both a sprayable and granular formulation are being tested.

Clopyralid (DowElanco®) Demonstration Trial
Yolo County, California

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Introduction

Yellow starthistle (*Centaurea solstitialis*) is an annual weed introduced into California more than 100 years ago (Thomsen, 1996). Its aggressive growth and high reproductive rate have resulted in its spread throughout the state in both wildlands and annual and permanent agricultural areas, where it effectively crowds out less competitive species, including forage crops, introduced rangeland grasses, and native grasses and forbs.

Yellow starthistle (starthistle) is recognized as a significant problem on annual rangeland in California. New and more effective methods for management and reduction of starthistle populations are being actively sought by private landowners, members of the cattle industry, professional organizations, private companies, and UC researchers. To that end, the herbicide clopyralid (Transline® DowElanco) is being tested in California for efficacy for starthistle control. Clopyralid is a selective, broadleaf herbicide that acts as a plant growth regulator. Post-application rains move it into upper soil layers where soil residual may provide extended control. Its effects may go into a second season, depending on the rate of application. Previous research indicates that applications made to exposed foliage may take up to 2 months to show full effects (pers. comm. J. DiTomaso).

Clopyralid is currently registered in 48 of the 50 states to control a variety of weeds in the sunflower, pea, buckwheat and nightshade families. Preliminary investigations and small replicated trials by UC researchers indicate good activity of clopyralid on starthistle with acceptable safety on other rangeland plants (pers. comm., J. DiTomaso).

Subsequent to small plot research, field scale trials can provide valuable input into herbicide performance under natural soil, climate, water and animal use conditions. An objective was to test clopyralid in typical, extensive rangeland conditions to provide public education, to observe field-scale performance, and to compare two different application methods.

Methods

Three unreplicated, field-scale demonstration trials were implemented on one ranch in the foothills of western Yolo County.

Trial #1 was applied by air using a Soloy Turbine Conversion Hiller helecopter at 10 gallons per acre with a 40 ft. boom. Two nozzle types were used: T-jet 45^{o} spinners and T-jet 4 hole 45^o spinners. Applications of two rates of Transline - 2.6 and 5.2 oz per acre (1 and 2 oz ai/A clopyralid) were made to 10 acre plots with an untreated buffer zone between rates and an untreated control immediately adjacent (see map "Transline Trial #1).

Trial #2 was applied by ground using a Honda 350 4-wheel ATV equipped with a Hardy rear-mounted, 50-gallon sprayer, a 30-ft boom and Tee Jet 8002 flat fan nozzles. Herbicide applications were made on three different plots at 25 psi using 5 gallons of water per acre (gpa). Transline was applied at the same two rates as in Trial # 1- 2.6 and 5.2 oz. per acre, and 2,4-D (4.0 lb/gal) was applied at 1 pint per acre. An adjacent untreated control was included for comparison (see map "Transline Trial #2).

Trial #3 was also applied by ground as in Trial #2, but rates of 1.3 and 2.6 oz per acre of formulated clopyralid were applied. The untreated area from Trial #1 was considered sufficiently close to serve as the control for this trial (see map "Transline Trial #3").

Applications for all three trials were made on March 14, 1997. On March 5, pre-treatment weed counts and estimates of percent cover of primary plant species were completed in all blocks except those of trial #3. For this and all subsequent evaluations, one-foot-square quadrats were randomly chosen throughout the central area of each block for a total of 10 locations per block. Percent cover within the quadrat was visually estimated for grasses, yellow starthistle, clover, filaree and other broadleaf weeds. Percent of bare ground was also noted. Total counts were taken of clover, filaree and other broadleaf weeds, whereas starthistle was counted in a specific 1/4-section of each quadrat and the number multiplied by 4. Grasses were considered too numerous to count. Post-treatment counts using similar methods were made on 4/11, 5/9 and 6/23 to track progressive effects on the target plants.

Results/Discussion

Topography and animal use of each trial was slightly different. The area for Trial #1 consisted of low hills moving to steeper hills. The entire field was 90 acres, with 30 acres devoted to Trial #1 and approximately 10 acres to Trial #3 (low rate of Transline). Trials #1 and #3 were adjacent, such that the untreated "Control" area was common to both. This field was lightly grazed starting 1 week post-treatment with approximately 25 head of cattle for 2 weeks. Trial #2, which was 33 acres, was primarily flat with edges moving to low hills. It was also lightly grazed starting, approximately 1 week post-treatment with 8 - 9 heifers for 1 month. Trial #3 bordered a riparian area. The low rate of Transline was applied in the same field as Trial #1. The higher rate in this trial was applied on the opposite side of the fence in an adjacent field that was 300 acres in size. The largest percentage of this field was steep hill country. Fifty cattle that were present there for 6 weeks preferentially grazed the lower portion of the field. Field conditions were considered fairly normal early in the season. Two days post-application (3/16/97), between ½ and 3/4 inches of rain fell. However, no further rainfall occurred beyond that date. Subsequent rangeland conditions were very dry much earlier in the season than usual.

At the pre-treatment evaluation date on March 5, Yellow starthistle plants were in the seedling stage, had an average of 4-5 leaves and were approximately 2 inches in diameter and 3 inches tall. Clovers had an average of 2-4 mature leaves emerged and grasses were 4-6 inches tall.

By 4/11, seedheads were exserted in the wild oats, medusahead and soft chess. A size difference was noted between starthistle in the treated and untreated areas in the aerial trial (trial # 1). In blocks treated with clopyralid, starthistle plants were essentially the same size as on 3/5 (3-inch diameter and 3 inches tall) and were still green. Starthistle rosettes in the untreated areas varied between 6 and 10 inches in diameter and were approximately 6 inches tall. In trial #2, height and diameter differences were not as dramatic, but growth stage differences were apparent (greater number of mature leaves in untreated areas). The already very dry rangeland conditions may have contributed to or amplified herbicidal affects. This same trial, perhaps coincidentally, showed patchy, high concentrations of goatgrass and medusahead.

On May 9, untreated yellow starthistle in the aerial trial (Trial #1, Control) was between full rosette and bolting stage and 8 to 10 inches both in width and height. Where herbicide treatments were made, most starthistle plants had not progressed beyond the growth stage noted on 4/11 and were mostly or completely desiccated. In the trials where applications were made by ground, the dry conditions caused most plants to be reduced in vigor and many appeared to go through early senescence. However, starthistle was essentially absent in the blocks treated with clopyralid, was strongly present in the untreated area, and where 2,4-D was used, some starthistle plants were stunted, dead or dying and some appeared to be unaffected. The latter were likely seedlings that germinated after treatment.

For each evaluation date, simple averages were calculated for each plant category using the data from all 10 quadrats. A standard deviation was calculated for the same data sets. Because these were unreplicated trials, further statistical analyses could not be performed. The calculations for standard deviation indicated a high degree of overall variability; however, the values for estimated percent cover showed less variability than plant counts and may be more indicative of the actual field situation. A larger sample size (more than 10 quadrats) would likely have decreased the overall variability in the data, but time limits were a strong dictator of sample size. Variability in the data decreased as the season progressed and as yellow starthistle began to show full effects of the herbicide treatment.

Trial #1 was applied aerially and showed pre- and immediately post-treatment counts of Yellow starthistle whose averages ranged from 9 to 34.5 seedlings/ft^2, covering between 4.5 and 15.5% of the surface area (Fig 1a. and 1b). Some individual quadrats were almost completely dominated by grass, with no starthistle present. Rangeland grasses were abundant and fairly consistent throughout all plots, with occasional presence of clover and filaree. On the 3 subsequent evaluation dates, percent cover of Yellow star thistle showed a consistent decline for both rates of clopyralid, with none present on the final evaluation date. The untreated control, though starting with low levels, showed an increase in percent cover of Yellow starthistle to a final average value of 22.5% cover. Visual observations in specific Control plots, however, ranged as high as 50% cover. Counts showed a similar pattern of decline in the treated blocks and elevated levels of yellow starthistle in the untreated area.

Although filaree and clovers showed a steady, gradual decline, levels were very low to begin with. This, combined with drought conditions may have masked or confounded the herbicide effects. Although some of the clovers did show slight herbicide symptoms at the 2nd and 3rd evaluation dates, it is difficult to say whether their ultimate decline was due more to the herbicide rate used, the extremely dry rangeland conditions throughout the season, or a combination of both.

In trial #2, applied by ground, initial Yellow starthistle levels were fairly consistent and high throughout the entire field. The average initial cover ranged from 29.3 to 35.9% over all four plot areas (Fig. 2a). Rangeland grasses were similarly consistent and high. Yellow starthistle seedling counts ranged from 79.2 to 105.6 seedlings/ft^2 (Fig. 2b). Variability of data was again high between individual quadrats, but less so in the estimates of percent cover as compared to counts.

Herbicide effects did not begin to show until the second post-treatment evaluation date on May 9, at which time, both clopyralid rate treatments showed effective control of yellow starthistle, with complete control at the high rate and 7.5% cover at the low rate. Although less dramatic the 2,4-D treatment also showed a measure of control at the same date. Weed levels in the 2,4-D plot showed final percent cover values comparable to the clopyralid plots; however, late-season seedlings were emerging in the 2,4-D plot alone. By July, yellow starthistle cover in the 2,4-D treated plots had increased dramatically compared to the low rate of clopyralid (no data taken). Starthistle counts also declined slightly in the 2,4-D and control treatments (Fig. 2b). Based on observations, the decline appeared, in part, to be due to extremely dry rangeland conditions.

Trial #3 used a very low rate of clopyralid (1.3 oz formulated product per acre) along with a standard rate (2.6 oz formulated product per acre), which together could be instructive in understanding rate-related soil residual affects. Inclusion of this trial was determined at a late date so no pre-treatment data were available for the treated areas. However, this trial was conducted in the same field and was adjacent to Trial #1. Pre-treatment data from the untreated control for Trial #1 was thus used for comparison.

Considering mean percent cover and using the untreated control from Trial #1 as a baseline, Yellow starthistle started out at low levels, increased until the second evaluation date and remained high in the untreated area. Starthistle levels dropped to zero in the clopyralid treated areas where the 2.6-oz per acre rate was used (Fig. 3a). Mean counts showed a similar pattern in the control as well as the treated areas, again with the higher rate causing eventual elimination and the lower rate sustaining low numbers of starthistle by the time of the last evaluation on 6/23 (Fig. 3b).

Visual assessment of all of the trials showed dramatic differences by the time of the final assessments on 6/23. Areas treated with clopyralid appeared totally free of starthistle; whereas untreated areas showed dense, green cover of starthistle plants. As the season progressed, starthistle clearly dominated the landscape in untreated areas. Sharp dividing, lines were apparent where treatments stopped or began. Areas treated with 2,4-D appeared to be starthistle- free from a distance, but close examination revealed younger plants - otherwise concealed by range grasses - which produced flowers and seed by late summer.

There is interest and concern over the effect of clopyralid on desirable rangeland forbs. Clovers and filaree were present in these trials only at very low levels, with only the occasional quadrat having 1 to 3 plants. However, observations were made that provide information that the quadrat counts do not illustrate. Filaree was present in numbers too low to comment on. Clovers observed in the treated areas (primarily rose-clover) did show leaf bum and some stunting by 4/11. By the final evaluation date, most of the dried plant remnants that were present had mature seed heads and appeared to have completed their life cycle in spite of some limited damage early on.

The trends shown in these demonstration trials do not seem to differ by method of application. Control of Yellow starthistle was accomplished in both the aerial and ground trials. Reasons for using different application methods will likely depend upon both cost and soil conditions at the time that application is needed. The landowner/cooperator for this trial calculated costs for both application methods, based on an estimated cost for clopyralid. Aerial applications of the 1-oz rate of clopyralid were approximately $ 1.35/acre higher than ground applications. The ground application was in turn approximately $4.70/acre higher than a 1-pint/A application of 2,4-D. In evaluating cost vs. benefit, consideration should be given to efficacy and residual control as well as costs. With landowner permission, these same treated areas will be re-evaluated during the following growing season in the absence of additional herbicide treatment to observe levels of residual control by each of the herbicides as compared to untreated areas.

In spite of the fact that treatments were not replicated, results from this field-scale demonstration trial indicate excellent potential for control of Yellow Starthistle using clopyralid (Transline). Dependence strictly upon chemical control measures can, however, lead to such problems as herbicide resistance. An integrated approach that also includes burning and/or land management techniques is likely to provide the most satisfactory and effective long-term control.

This field-scale application of clopyralid proved to be a very valuable demonstration and education opportunity for researchers as well as rangeland managers. The opportunity to make successive field visits and observations provided insight into starthistle control under normal animal-use conditions and, through a late-season field day, allowed a broad variety of professionals and practitioners to observe results and learn about new methods for starthistle control.

Thomsen, C.D., et. al. 1996. Yellow Starthistle Biology and Control. UC/DANR Publication No. 21541. 19 pp.

Special thanks are given to Henry, Casey and Scott Stone for the use of their ranch for the trial and for their strong support, and also to Tim Baldwin of DowElanco for providing the herbicide, for technical support and for support for the field day.

Figure 1a

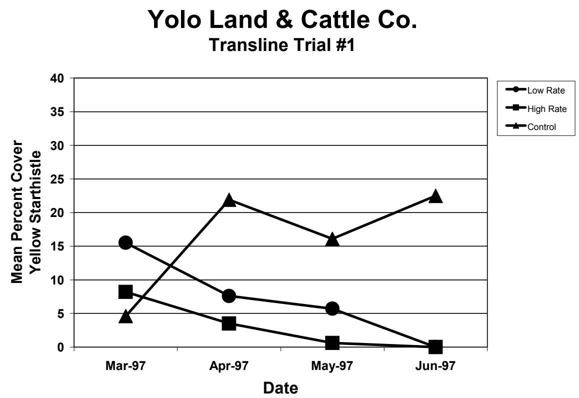


Figure 1b

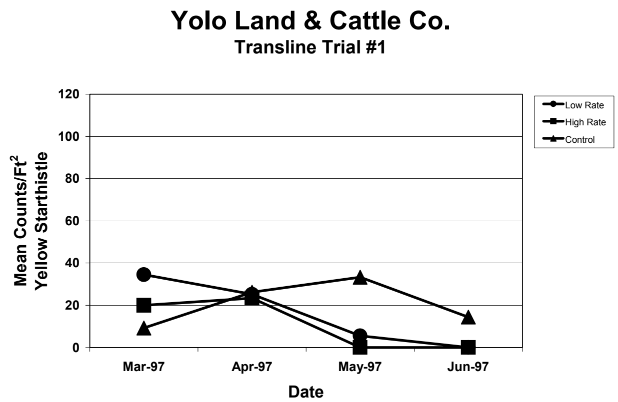


Figure 2a

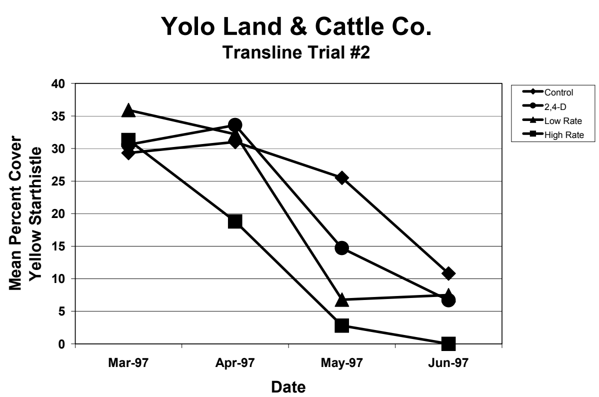


Figure 2b

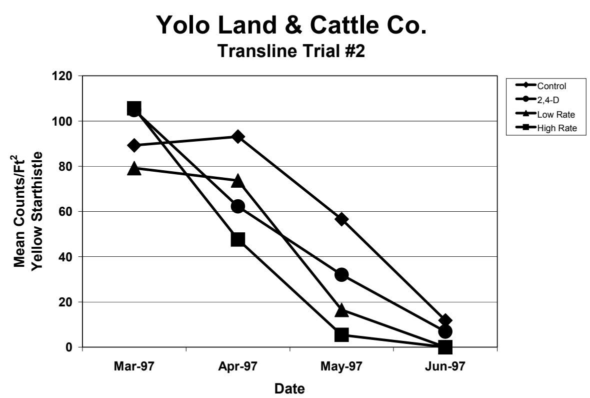


Figure 3a

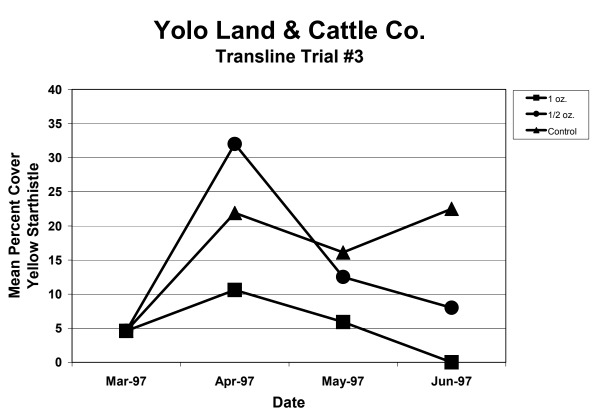
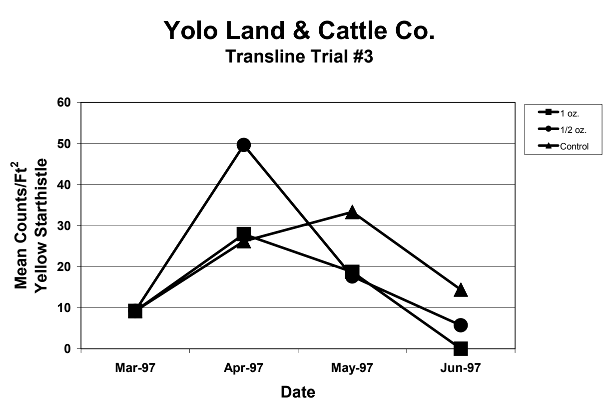


Figure 3b



Dinitroaniline Resistance in Barnyardgrass (Echinochloa crusgalli (L.) Beav.)

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Mahlon Hile – Professor, California State University, Fresno

When a weed species that has been susceptible to a herbicide develops populations that can now tolerate the herbicide, that species is said to have developed resistance to the herbicide. Over 30 weed species have been reported to have developed resistance to one or more of at least 11 chemical families of herbicides. Resistance to the triazine and acetolactate synthase inhibiting herbicides have been the most numerous.

The dinitroaniline herbicides have been used for over three decades in the growing of many crops. In the San Joaquin Valley of California, trifluralin is the dinitroaniline that has been used most extensively, primarily in the growing of cotton. Worldwide, resistance to the dinitroanilines has been reported only on four species of weeds: Palmer amaranth, goosegrass, green foxtail and johnsongrass.

Observations of poor control of barnyardgrass by trifluralin in cotton fields located in Tulare County of California was the first indication that this species might be developing resistance. Later discussions with others revealed a similar concern from a site in Kings County, California.

Barnyardgrass seed from plants suspected of being dinitroaniline resistant were collected from cotton fields in Tulare and Kings County where the control of barnyardgrass with trifluralin had recently not been satisfactory. Seeds of barnyardgrass were collected from plants growing nearby in areas where dinitroaniline herbicides had not been used and were presumably susceptible to dinitroanilines.

Of the four herbicides selected for this study, two were dinitroanilines – trifluralin and pendimethalin. The mode of action of this chemical family of herbicides is to interfere with cell division in root tips of germinating seedling by interfering with intermediate steps of mitotic cell division. Any potential differences in the details of the mode of action between these two herbicides have not been investigated/reported. The other two herbicides are also used soil incorporated preemergence to weeds. The mode of action of these two herbicides is distinctly different from the dinitroanilines (atrazine interferes with photosynthesis and napropamide stops mitotic cell division before it starts. Based on the crop rotation used on the field sites involved, it is unlikely that napropamide or atrazine had been used in the fields where the resistant barnyard grass occurred.

The response of the seeds from each of the four sites was evaluated when exposed to varying rates of four preplant incorporated herbicides. Trifluralin, pendimethalin, atrazine or napropamide was applied to the soil at 0, ½, 1, 2 and 4 times a frequently used recommended rate. The recommended (1x) rates used (kg active ingredient per ha) were trifluralin 0.56, pendimethalin 0.56, atrazine 2.22, and napropamide 1.68. All plants were grown in a greenhouse for 30 days. The percent reduction in total shoot dry weight per pot caused by the recommended (1x) rate of these four herbicides to barnyardgrass seedlings collected from four sites is shown below.

	Tulare County		Kings County	
Herbicide	**Susceptible**	**Resistant**	**Susceptible**	**Resistant**
trifluralin	57	10	59	29
pendimethalin	99	73	99	82
napropamide	98	98	98	98
atrazine	97	97	97	97

This summary table clearly shows that a biotype exists in both counties that is resistant to trifluralin and that the resistant biotype from Tulare County is more resistant than the resistant biotype from Kings County. At an equivalent rate of use, pendimethalin produced greater reduction in barnyardgrass seedling growth than trifluralin for all biotypes. The resistant biotype from both counties had less reduction in growth than the susceptible biotype with pendimethalin as compared to trifluralin.

For napropamide and atrazine, all biotypes were able to grow very little compared to the untreated control. Thus there is no indication of a cross-resistance being present between these two herbicides and the dinitroanilines trifluralin and pendimethalin.

To prevent a buildup of barnyardgrass that is resistant to trifluralin, cotton growers could use a selective postemergence grass herbicide before the barnyardgrass produces seed. They should also rotate to another crop where a soil applied herbicide with a different mode of action could be used to control the dinitroaniline resistant barnyardgrass.

Weed Management Systems in Transgenic Crops in the Western U.S.

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The first demonstration of Buctril (bromoxynil) resistant cotton in the Western U.S. took place near Phoenix, Arizona in 1993 and generated considerable excitement by demonstrating the potential of genetic engineering to provide new weed control technologies to farmers. In recent years, many genetically based examples of herbicide resistance have been found in weeds or have been introduced into crop plants using genetic engineering (Table 1). Agriculture stands on the threshold of an era of widespread availability of crop plants that have been genetically modified using molecular biological techniques to have herbicide and insect tolerance as well as other agronomically desirable yield and quality traits. For example, the Weed Science Society of America recently listed eight transgenic crop species resistant to several herbicides that have been or soon will be commercialized (Table 2). Many other herbicide resistant transgenic crops are currently under development.

With the widespread commercialization of transgenic herbicide resistant crops (HRC), it is relevant to consider the potential economic consequences of HRC. Will HRC reduce the cost of weed control or economic losses caused by weed interference with crops? Clearly, for many farmers the potential reduction in hand weeding costs and reduction in yield losses due to weed interference make the use HRC and associated herbicides economically attractive. However, total seed and weed control costs with HRC and associated herbicides can be more expensive than existing or older chemical control options so that, depending on weed populations in their fields, not all farmers will adopt new weed control technologies based on HRC. The development of HRC has had economic consequences beyond direct impacts on farmer's weed control strategies. The need for coherent crop seed production and marketing of HRC in conjunction with the associated herbicides has led to the consolidation of herbicide manufacturers and crop seed companies. For example, Monsanto now owns or controls most the companies selling cotton seed to American producers. Seed companies producing transgenic crop seed must manage the development of more varieties considering all of the possible combinations of regionally adapted varieties and potential insect and herbicide resistant traits. Will this increased complexity affect the improvement of basic agronomic traits in transgenic crop varieties? Competitive market place pressures from combined chemical/HRC seed companies has also resulted in consolidation and mergers between other chemical companies. The overall increased economic concentration due to the reduction in numbers of independent seed companies, chemical manufactures, and other companies in the portion of the farm economy from which farmers must purchase equipment and inputs may have long-term consequences on the cost of farming.

Do herbicide resistant crops change grower practices? HRC still require that growers use spray rigs or tractor mounted sprayers for ground applications, and airplanes for aerial herbicide applications. Growers must still worry about the calibration and maintenance of spray equipment and the details of herbicide applications such as the selection of nozzle type and size, pressure, spray volume and adjuvant selection. In contrast, transgenic bacillus thuringiensis (Bt) Corn or Bt Cotton produce an insect toxin and thus can eliminate the need for some insecticide applications. This obviously reduces application and insecticide costs and can have desirable secondary effects such as improved management and utilization of beneficial insects in IPM programs for these crops. HRC merely represent another mechanism for providing selective chemical tools to growers and as such supplement more tradition chemical screening and herbicide discovery efforts of the agrochemical industry. As an example, Staple herbicide was developed for selective weed control in cotton by Dupont using traditional methods at about the same time that Buctril and Roundup resistant cotton varieties were developed by Calgene and Monsanto, respectively, allowing the use of the associated herbicides in cotton.

Herbicide resistant crops and new selective herbicides provide many advantages to growers. They may provide new post-emergence weed control options that provide increased flexibility in designing weed management programs. For example, Roundup Ready (RR) Cotton, BXN Cotton, and Staple herbicide all allow cotton growers to control broadleaf weeds in seedling cotton during a time period when they were previously unable to spray post-emergence herbicides. New herbicide technologies often allow easier or better control of previously difficult to control weeds without the disadvantages associated with other herbicides. For example, sequential Roundup Ultra use in RR cotton often results in better control of purple and yellow nutsedge and less injury to cotton than sequential DSMA and MSMA applications. Similarly Roundup Ultra use in RR Corn provides a means to control Johnsongrass without the soil residual effects on rotational crops of Accent (nicosulfuron) or Beacon (primisulfuron).

Herbicide resistant crops and new selective herbicides may also increase the ability of farmers to use non-chemical or mechanical weed control methods. Weed competition with cotton, particularly early season competition, can severely reduce cotton lint yield. Many studies have investigated various levels of herbicide inputs and cultivation for weed control in cotton. In general, both herbicide use and cultivation reduce cotton yield losses caused by weed competition but acceptable control was not obtained with cultivation alone. Poor weed control in the seed row is the major shortcoming of mechanical weed control. Before effective cotton herbicides became available, growers relied on both meticulous cultivation and hand hoeing for weed control. Torsion weeders and spring-hoe weeders were employed on some cultivators to mechanically remove weed seedlings from within the seed row in larger cotton. These devices consist of pairs of spring steel rods which compress and crumble the soil around the base of cotton plants in such a way that small weed seedlings are uprooted. Although effective, the in-row weeders demand careful attention from tractor drivers and slow travel speeds to minimize crop damage. These disadvantages combined with a shrinking agricultural labor pool and the introduction of preemergence herbicides for cotton in the 1960's resulted in the virtual abandonment of mechanical in-row weeding techniques.

The development of precision guidance systems for farm implements has removed many of the impediments to using in-row weeding techniques. Electro-hydraulic guidance systems actively steer the tractor or implement using a sensing device to detect a furrow or crop row. The sensing device sends electrical signals which actuate a hydraulic steering system. Side-shift guidance systems move the implement laterally with respect to the tractor (and crop row) in response to a sensing system mounted on the implement. Side-shift guidance systems have problems moving cultivators laterally with respect to the crop row because cultivators with a lot of steel in the ground have a large amount of lateral stability as they are pulled through the soil. Most side-shift and articulated guidance systems are packaged in a quick-attach hitch configuration. Articulated guidance systems, like side-shift systems, also move the implement relative to the tractor, but rather than shifting laterally, the implement pivots about a king pin, which is a part of the hitch mechanism. As the implement pivots, resistance on the soil engaging tools increases, which in turn causes the implement to move sideways. Because of the convenience of the quick-hitch configuration and the superior steering capability of articulated guidance systems, articulated guidance systems are now gaining popularity for precision cultivation in Arizona cotton fields.

Topical applications of Staple herbicide or Roundup Ultra on RR cotton, or Buctril on BXN cotton followed by sequential post-directed applications now allow growers to chemically control weeds in the cotton seed row. These herbicides complement the use cultivation with in-row weeders by giving growers the means to control weeds in the cotton seed row early in the season when the cotton is not large enough (i.e., generally less than 8 to 10 inches tall) to allow the use of in-row weeders. Electro-hydraulic guidance systems facilitate the use of in-row weeders by keeping the cultivator precisely aligned on the seed row and also allow close cultivation without crop damage early in the season, thereby reducing the amount of herbicide used (i.e., by reducing the width of the spray band). In both research experiments and demonstrations in Arizona, the combination of the early season herbicide sprays and precision guided cultivation with in-row weeding tools made hand weeding of fields unnecessary by nearly eliminating annual morningglory from cotton fields. In-row weeders are effective in removing broadleaf weed seedlings in the crop row but are ineffective on purple and yellow nutsedge. However, close cultivation does reduce nutsedge competition with cotton. In addition to the substantial saving associated with the elimination of hand weeding costs, the reduced operator fatigue and greater tractor speeds attained with precision guidance also increase productivity and reduce cultivation costs.

There are some drawbacks or disadvantages associated with the development and use of HRC. In cases where the genetically engineered tolerance to a herbicide is not complete, careful use of the herbicide may be required. For example, RR cotton exhibits good vegetative tolerance to glyphosate but flower and boll production can be sometimes be affected by “off label” or inappropriate applications when compensation for fruit loss does not occur. For example, over-the-top applications of glyphosate made after the 4 true leaf stage of growth reduced seed cotton yield 60% at the 10 node stage of growth in an Arizona study. However, post-directed glyphosate applications made after the 4 true leaf stage do not cause yield losses. The requirement that a herbicide be used carefully is a relatively trivial disadvantage compared to the potential HRC to increase the occurrence of herbicide resistant weeds.

The greatest risk posed by the widespread adoption of herbicide resistant crops and associated herbicides is the increased risk of developing herbicide resistant weed populations. Herbicide resistance is the ability of a species to withstand substantially higher concentrations of a herbicide than the wild type of the same plant species or, in other words, the inherited ability to not be controlled by a herbicide. Resistance is commonly associated with biochemical and physiological changes due to a single gene that results in a modified site of herbicide action (i.e., a protein) or the detoxification of a herbicide (Table 1). Resistance can arise through a new mutation (genotype) not previously present in a weed population or a resistant genotype present at a very low frequency in the population may become the most common genotype in a particular population. In both situations, a new genotype conferring herbicide resistance becomes common and a species formerly easily controlled by a particular herbicide is no longer controlled. Weed populations can become resistant to more than one type or class of herbicides. Multiple-resistance is the phenomenon of resistance to herbicides from more than one chemical class after exposure of a population to difference herbicides. Cross-resistance is the phenomenon whereby, following exposure to a single herbicide or herbicide class, a weed population evolves resistance to herbicides from different chemical classes to which it has never been exposed.

The era of chemical weed control started after WWII with the spectacular success of 2,4-D in controlling broadleaf weeds in cereal crops. Weed control provided by herbicides is now an integral part of most modern agronomic systems delivering food and fiber. Given the widespread and persistent use of herbicides it was inevitable that there would be biological repercussions from the reliance on a single method of weed control. Herbicide resistance has been found to phenoxyacetic acids such as 2,4-D (1962), to triazines such as simazine and atrazine (1968), to dinitroanilines such as trifluralin (1973), to bipyridiliums such paraquat (1976), to acetyl coenzyme A carboxylase inhibitors such as the aryloxyphenoxpropanoates (e.g., fluazifop-p) and cyclohexanediones (e.g. sethoxydim and clethodim) in 1982, to substitued ureas such as diuron (1983), to organic arsenicals such as MSMA (1984), to acetolactase synthase inhibitors such as the sulfonylureas (e.g., chlorsulfuron) and the imidazolinones (e.g., imazapyr) in 1986, to carbamates in 1988, and to glyphosate (Roundup) in 1997.

Requirements for the development of resistance are that heritable (i.e., genetic) variation for the herbicide resistance trait exists and that natural selection acts upon the weed population. The degree of selection imposed by herbicide use depends on the efficacy of herbicide (i.e., effectiveness of weed control), the frequency of herbicide use, and the duration of the herbicide effect. The widespread use of HRC can greatly increase the frequency of use of a particular herbicide. In addition, if normal crop selectivity and HRC result in the use of the same chemistry or herbicide in several crops in a rotation, the frequency of use further increases and if a chemistry or herbicide has both postemergence and preemergence herbicide activity the duration of the herbicide effect increases. Both phenomenon alone and especially together (e.g., imidazolinone use in IMI-corn, bean, and alfalfa rotations) increase the risk of developing herbicide resistant weeds.

Management to avoid developing herbicide resistant weeds or to manage existing herbicide resistant weeds involves avoiding total reliance on a single herbicide or class of herbicide chemistry. Management strategies include manipulating herbicide rate where appropriate, alternating herbicides with different target sites, and using herbicide mixtures (i.e., using different mechanisms of action simultaneously). Integrated weed management (IWM) practices are also important in minimizing the use of chemicals. In contrast to chemical weed control, mechanical weed control is generally non-selective (i.e., does not discriminate between plant species or genotypes within a species) in that all species contacted by steel are killed. Other IWM practices useful in avoiding the development of herbicide resistant weeds include limiting seed dispersal of suspected small resistant populations (i.e., eradication) and rotating crops and associated cultural practices and herbicides. Most occurrences of herbicide resistant weeds have proven to be manageable using the practices described above. Thus, in the short-term, the advantages associated with HRC appear to out weight the risks of developing more herbicide resistant weeds in many crop production systems. The long-term benefits of HRC are uncertain and will depend on the wise use of chemical technologies within the context of integrated weed management practices.

Table 1. Gene based examples of herbicide resistance in crops and weeds.

Herbicide	Novel gene product	Mechanism
triazines (e.g., prometryn, atrazine)	chloroplast D1 protein	mutated target
substituted ureas (e.g., diuron)	chloroplast D1 protein	mutated target
sulfonylureas (e.g. chlorsulfuron)	acetolactase synthase	mutated target
imidazolinones (e.g., imazapyr)	acetolactase synthase	mutated target
pyrimidyl thiobenzoates (e.g., pyrithiobac)	acetolactase synthase	mutated target
aryloxyphenoxypropanoates (e.g., diclofop)	Acetyl coenzyme A carboxylase	mutated target
cyclohexanediones (e.g., sethoxydim)	Acetyl coenzyme A carboxylase	mutated target
glyphosate (e.g. Roundup, Touchdown)	EPSPS (5-enolpyruvylshikimate--3-phosphate synthase)	over expression
glyphosate (e.g. Roundup, Touchdown)		mutated target
glyphosate (e.g. Roundup, Touchdown)	glyphosate oxidoreductase	detoxification
bromoxynil (e.g., Buctril)	nitrilase	detoxification
2,4-D	monooxygenase	detoxification
glufosinate (e.g., Liberty)	N-acetyl transferase	detoxification

Table 2. Commercialized transgenic crops with herbicide resistance listed by the Weed Science Society of America in 1998[a].

Transgenic Crop	Herbicide Tolerance	Trademark/Company	Estimated Year & Place Commercialized
Canola (*Brassica napus*)	bromoxynil	BXN Canola - Rhone-Poulenc	Europe (1995)
		Liberty Link Canola - AgrEvo	Canada (1995) Europe (1995)
	glyphosate	Roundup Ready Rape - Monsanto	Canada (1997) Europe (1998)
Clover (*Trifolum repens*)	bromoxynil	CSIRO & New Wales Agriculture	Australia (2001)
Corn (*Zea mays*)	glufosinate	Liberty Link Corn - AgrEvo	USA (1997)
	glyphosate	Roundup Ready Corn, Monsanto & DeKALB Genetics	USA (1997) Canada (1998)
	imidazolinones	IMI Corn - American Cyanamid, Pioneer, Ciba Seeds, Asgrow, Northrup King	Australia (1998-99) USA (1997)
	sethoxydim	SR Corn - BASF/DeKalb Genetics	USA (1997) Brazil (1997)
Rice (Oryza sativa)	glufosinate	Liberty Link Rice - AgrEvo	USA (2000-01) Asia (2000-01)
Soybean (*Glycine max*)	glufosinate	Liberty Link Soybean - AgrEvo	USA (1998) Brazil (1998-99)
	glyphosate	Roundup Ready Soybean, Monsanto & Asgrow Seeds	USA (1997) Brazil (1997) Argentina (1997)
	sulfonylureas	STS Soybeans - DuPont	USA (1993)
Sugar Beets (*Beta vulgaris*)	glufosinate	Liberty Link Sugar Beet - AgrEvo	Europe (1999-00)
	glyphosate	Roundup Ready Sugar Beet, Monsanto	Europe (1997-98)
Tobacco (*Nicotiana tabacum*)	bromoxynil	BXN Tobacco - Rhone-Poulenc	Europe (1997-98)
Upland Cotton (*Gossypium hirsutum*)	bromoxynil	BXN Cotton - Rhone-Poulenc	USA (1997)
	glufosinate	Liberty Link Cotton - AgrEvo	USA (2000)
	glyphosate	Roundup Ready Cotton-Monsanto	USA (1997)
	sulfonylureas	19-51a Cotton - DuPont	USA (1997)

[a]Adapted from: Weed Science Society of America. 1998. Herbicide Handbook-Supplement to the 7th ed. Edited by Kriton K. Hatzios. 102 pages.

Weed Strategies at the J. G. Boswell Company

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Abstract

The J.G. Boswell Company ranches have implemented a successful weed control program on their farm ground in the San Joaquin Valley of California. After several decades of row crop farming, along with many challenges, the land continues to be very productive with weed competition at low levels. Through vigilant efforts, Johnson grass and morning glory to name a few, have been totally eradicated.

Introduction

Row crop production at J.G. Boswell Company consists of primarily annual crops. Rotation of various crops from year to year on specific fields allows for enhanced tillage practices, optimal fertility management and reduction of specific weed pests. Crop production is ongoing year round, hence, management of weed pests continues throughout the year. Primarily the annual crops consist of cotton, safflower, seed alfalfa, alfalfa hay, and cereal grain crops. Seed production is the biggest reason for implementation and maintenance of weed control programs in the company.

Discussion

Philosophy. The basic philosophy at J.G. Boswell Company is to not let weeds go to seed. We do this by keeping fields clean and managing weed pests before they become a problem.

Record Keeping. An important role in weed management depends on keeping accurate field records. Levels of infestation, costs of treatments, and mapping are key to maintaining a field history of weed pests.

Infrared photographs are kept to show a history of levels of infestation of dodder weed and/or any other noxious weeds in specific fields.

Scouting. The management structure and intensity lends itself to weed eradication. Our fields are laid out so accessibility is easy throughout the season. Most fields have open roads on all four sides with one or two drive rows within the field. This access provides constant inspection throughout the entire field. Additionally, the observations are easily made by a number of management levels. Agronomists, district managers, and field foreman will likely visit every field two to three times per week.

Another important tool used is helicopter surveillance. Pilots map out and stake noxious weeds during the summer and fall months. Later, hand crews will visit these spots and thoroughly eradicate weed pests. As mentioned earlier, infrared photography has played a role in past years but its use now is much more limited. New technology consists of G.I.S. (global information systems), whereby weed problems can be "logged" into a set of coordinates based on satellite positioning around the earth. Ultimately, ground based application methods could utilize the positions to make precise applications where necessary.

Prevention. Prevention of weed problems must start with equipment sanitation. Caution is used when cultural equipment is leaving a field in which weed pests may have been a problem. Harvesters, both grain combines and cotton pickers, must practice the same preventative measures. Occasionally, harvesters will harvest around weedy areas and cut those areas last, or in extreme cases, avoid the areas altogether. In such cases, disposal of weeds and seed is accomplished by burning.

Nightshade and any other noxious weeds are bagged and exported out of fields by weeders who then put them into enclosed trailers. When full, the trailer is taken to a remote area where the weeds will be removed and burned or buried.

Close mechanical cultivation is extremely important in weed management. Scrutiny on this point is a money saver and moneymaker. Early tillage on fields before weeds can produce seed obviously reduces the future "seed bank." It is also important from a weed resistance standpoint. If weeds develop a resistance to specific chemicals, then mechanical or hand tillage is critical for elimination of resistant species.

Advanced technology has improved our arsenal of tools against weeds. Electronic sprayers, the ***Patchen*** system for example, allow us to spray specific plants with pinpoint accuracy. Tillage tools like the ***Mulch Master*** have been used to successfully incorporate grain seed *and* kill small germinating weeds at planting time.

Chemical controls will probably have a fit for a long time to come, although the trend is towards less use at the J. G. Boswell company. Some examples of chemical use in the company are 1) Dinitroanalines – for pre-plant control of certain broadleaves and grasses. Dry granules for alfalfa crops. 2) Cyanazine – layby control of weeds in certain crops. Currently this product has lost its registration and is being phased out. 3) Diuron – waterways and roadside sterilization and weed control in alfalfa. 4) Oxyfluorfen – vegetable crops and fallow bed weed control. 5) Glyphosate – early weed control and defoliation aid. 6) Pyrithiobac sodium – specific control for nightshade. 7) Prometryn – pre emergence weed control; fallow bed. Key to chemical control measures is methods of incorporation. Tools that we have found to be effective are the Mulch Masters, rolling cultivators, and seed bed discs.

Summary

The weed control strategies employed at J. G. Boswell company have had long term benefits. In spite of the seemingly endless supply of weed seeds through wind dispersal, vehicle traffic, and floods, our company has not only controlled, but also essentially eliminated certain species of weeds. Through persistence and vigilance, combined with close management supervision, weed control can be manageable.

Afton Canyon Riparian Restoration Project
Fourth Year Status Report

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"Can you live without the willow tree? Well, no, you can't.
The willow tree is you. "
John Steinbeck (1902-1968)

Abstract: In 1996, the Bureau of Land Management completed its fourth year of work on the multiyear Afton Canyon Riparian Restoration Project. The objectives of this ambitious restoration project are to control exotic plants, particularly the phreatophyte saltcedar (primarily *Tamarix ramosissima, T. parviflora*), restore critical native plant community structural elements and minimize adverse effects to the riparian zone within the Afton Canyon Area of Critical Environmental Concem. The goals of this riparian, or streamside, project are to improve the proper functioning condition status of a small southwestern stream segment and to restore a specific site's key Potential Natural Community elements. Treatments have resulted in a fairly high degree of saltcedar control and native revegetation is progressing slowly. Project work appears to have improved this stream segment's proper functioning condition from a "nonfunctioning" to a "functioning at risk" status. Project activities and accomplishments to date are summarized and current trends/status are discussed in relation to planned objectives and goals.

Introduction

The Afton Canyon Riparian Restoration Project, initiated by the Barstow Resource Area Office of the Bureau of Land Management (BLM) with publication of the "Afton Canyon Area of Critical Environmental Concern (ACEC) Management Plan (BLM 1989), entered its exotic plant control and riparian restoration phases in 1992. The objectives of this multiyear project are to control exotic plants, restore critical native plant community elements and minimize adverse native plant impacts on approximately 700 acres of riparian habitat on the Mojave River, within the designated Afton Canyon ACEC, beginning with a 300 acre pilot. The associated goals of this restoration project are to improve the proper functioning condition rating (BLM 1993), or stream health, of a small southwestern river segment from a "non-functioning" to a "functioning at risk" condition and to restore this specific site's key Potential Natural Community (PNC) components (diverse vegetative composition and age classes, high plant vigor, appropriate vegetative root mass, bank cover and soil moisture maintenence characteristics, and adequate sources of large woody debris). This status report summarizes the BLM's first four years of restoration activities and accomplishments at Afton Canyon and discusses current trends/status in relation to project objectives and goals.

The exotic plant group dealt with herein is commonly referred to as saltcedar *(Tamarix ramosissima, T. parviflora, T. chinensis*), or tamarisk, and are a group of phreatophytic plant species introduced to North America from Eurasia in the 1800s for ornamental, shade and soil stabilization purposes. As many as 54 species of this group have been formally recognized, though not all are considered invasive. Collectively, those species considered invasive have come to occupy over a million acres of sensitive riparian and wetland habitats, ranging from Mexico to Canada. This exotic plant has established itself in nearly all southwestern riverine systems and many wetland or marsh areas critical for native plants and animals. Saltcedar's propensity for adversely affecting an area's hydrology and geomorphology, displacement of native plants and degradation of both wildlife access to water and plant/ground structure necessary to meet most native bird and mammal species' requirements for foraging, breeding and nesting, has been well documented (Blackburn *et al*, 1982; Cohan *et al*, 1978; Kerpez and Smith 1987). These identified impacts have elevated saltcedar control to the forefront of riparian restoration work in the American Southwest.

Characteristic of opportunistic invaders (Bossard 1992), saltcedar often becomes established in "edge" or border areas of riparian or wetland habitats, and frequently forms extensive growth stands when local, conducive circumstances present themselves. In the case of saltcedar in North America, such circumstances commonly present themselves in terms of native plant community or water system disturbance related to flooding or lack thereof, fire, herbivory or drought, with a few exceptions. SaItcedar infestations have been documented in a few isolated spring systems lacking any observable form of native plant community or water system disturbance, though these stands of growth are usually small in nature and rarely completely displace the native plant community.

In contrast, those riparian and wetland areas where the water table is between 1.5 and 6 m from the ground surface (Campbell and Dick-Peddie 1964) and are, or have been, subject to disturbance via altered water flow or fire regimes, woodcutting, livestock grazing or vehicle use impact, frequently form dense, monotypic stands of saltcedar (Egan *et al*, 1993; Horton 1977). The native plant community, in such instances, is often severely fragmented, degraded in vigor and/or completely displaced by the invading saltcedar. However, saltcedar control has been shown to be feasible at some sites, at least for the short term, through intensive restoration efforts (Barrows 1993, Bureau of Reclamation 1992, Lovich *et al*, 1994).

Exotic villain or adaptive victor, temporarily vanquished invader or thriving monoculture, saltcedar is a formidable survivor and is here to stay. The only identified, ecologically freindly recourse to widescale displacement of our native riparian communities appears to be control of this invasive plant in some fashion, providing protection for our remaining pockets of native riparian vegetation and restoring those sites most capable of supporting a competitive, healthy native plant community. The Afton Canyon Restoration Project is an example of a recent attempt to do just that-remove and control saltcedar at a manageable level at an appropriate site, concurrent with restoration of some of Afton Canyon's potential native plant community attributes.

Study Area

Afton Canyon, or the "Grand Canyon of the Mojave Desert," is located on the lower third segment of the Mojave River, in the heart of one of the world's hottest deserts (Figure 1). The canyon is currently one of only two river reaches that provide perennial surface water flow and is one of only a handful of sites on the Mojave River that support native riparian vegetation. The abundant natural resources provided by the canyon were extensively utilized by early wagon train, homesteading, ranching and railroad activities, as the primary overland route for travelers into Southern California from the east followed the Mojave River throuoh the canvon. Large stands of cottonwood (*Populus fremontii*), willow (*Salix nigra* var. *gooddingii, S. lasiolepis, S. laevigata, S. exigua*) and mesquite (*Prosopis pubescens, P. glandulosa*), as well as abundant pools of water, meadow grasses and marshland (suspected wetland emergents such as *Juncus spp., Scirpus spp., Carex spp., Typha spp*.), once carpeted the canyon floor, according to a journal entry of Father Francisco Garces, the first European to document travels on the "Mojave Trail. "

In addition to significant resource extraction impacts, Afton Canyon has been subject to profound human influences, both within and upstream of the canyon, in the last century. Primary among these were river staightening for railroad construction, flood control, water diversion, groundwater pumping, off-highway vehicle (OHV) free-play activities, the introduction of several exotic plant species such as saltcedar, and broadscale aerial herbicide application (1959-63) to control camel thorn (*Alhagi pseudalhagi*), a plant species toxic to cattle. The functiong condition of the canyon's riparian zone (discussed further under project components and accomplishments section), though likely degraded from pre-railroad conditions, is thought to have been in "properly functioning" condition until the late 1960s. Sometime following upstream dam construction (1968) and the flood of 68-69, this functioning condition rating of the Afton Canyon river segment is considered to have slipped to a "functioning at risk" condition, likely due in part to altered river flows, continued perennial cattle occupation of the canyon floor, increased OHV travel within the central riverine channel and upstream demands upon regional groundwater. SaItcedar is suspected to have exploded in density during the early 1970s, and recent USGS saltcedar core samples preliminarily indicate that many oldgrowth saltcedar trees at Afton became established in the mid to late 1960s. Afton Canyon's ecological condition is considered to have continued a downward trend to a condition of "non-functioning," by the late 1980s.

In a relatively short timeframe, saltcedar displaced an estimated 75 percent of the native vegetation within the canyon, with drastic ramifications upon the diversity and abundance of native plants, aquatic animals, mammals and particularly avian species. Few open surface water areas existed prior to initiation of project work and wetland emergent "green strip", width as well as length, were thought far less than the site's potential. Forb, grass and shrub community diversity/abundance were considered depauperate and only one cottonwood tree remained in the canyon as of 1992. Surviving mesquite and willows were similarly stressed in vigor or dying and few age classes were present. The effective floodplain had been reduced severely and large old growth saltcedar dominated terraces lined a primarily dry, saltgrass (*Distichlis spicata*)/young saltcedar dominated, meanderless river segment. Saltcedar's common impact upon both plant and animal species at this site was determined to be this invasive plant's tendency to alter habitat structure, whether vegetative, water or soil related.

The far western, upstream reach (approximately 2 miles length) of the Mojave River at Alton Canyon, supporting in the neighborhood of 300 acres of riparian habitat, was selected as the initial study area or pilot, for the long term restoration project at Afton. Following completion of this western stream segment, project work is planned to continue as funds/personnel permit, in a downstream direction for approximately five additional miles, supporting roughly 400 additional acres of riparian habitat.

Project Components and Accomplishments

The BLM's approach to saltcedar control and site restoration at Afton is designed to be an integrated and evolving approach, utilizing a variety of components/techniques to restore native plant community elements and control saltcedar, as well as other adverse, onsite influences (Chavez 1996; DeGouvenain and West, 1996; Egan *et al*, 1993; Egan 1996a; West 1996). Saltcedar treatment techniques and components to date have included:

1) protection of existing native vegetation to ensure future native plant seed stock;

2) the use of prescribed fire in dense saltcedar stands containing sufficient fuels, to remove saltcedar biomass and provide access for secondary herbicide application;

3) low volume herbicide application to saltcedar resprouts following fire, using primarily Pathfinder II (a triclopyr herbicide);

4) manual saltcedar stem cutting and herbicide application to cut stems using Pathfinder II;

5) selective burnt saltcedar stem thinning to improve revegetation microsite conditions;

6) revegetation of saltcedar removal areas emphasizing natural revegetation, native tree pole plantings and native shrub seedings; and

7) project monitoring using photoplot ground/canopy cover analysis (six permanent, 2 X 2 m plots) and cross-sectional riparian plant frequency/cover trend analysis (six permanent, 400 -800 m length, 50 x 50 cm nested frame, transects set perpendicular to and crossing streamcourse).

Project monitoring has relied heavily on the use of a qualitative evaluation process referred to as Proper Functioning Condition Assessment (PFC). This assessment is conducted by an interdisciplinary team of specialists and is designed to assess riparian area/wetland functioning condition by analyzing the interaction among geology, soil, water and vegetation. The central premise of this assessment process is that "riparian areas are functioning properly when adequate vegetation, landform, or large woody debris are present to:

A) dissipate stream energy associated with high waterflows, thereby reducing erosion and improving water quality;

B) filter sediment, capture bedload, and aid in floodplain development;

C) improve flood-water retention and ground-water recharge;

D) develop root masses that stabilize streambanks against cutting action;

E) develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and

F) support greater biodiversity."

Riparian and wetland areas are considered to be functioning properly when there is adequate structure present to provide the listed benefits applicable to a particular area (BLM 1993). It is essential that PFC assessment be based on an riparian area's capability and potential. Although Ecological Site Inventory (ESI) has not been conducted at Afton Canyon for the purposes of defining site capability/potential, evaluation of the study area was completed using historical references, current onsite data and Mojave River relict site information, alluding to Afton Canyon's site potential.

Project accomplishments following the first four years of work, including ACEC management actions completed immediately prior to project initiation, have included:

1) area route designation emphasizing riparian area protection and rerouting of Mojave Trail vehicle use out of central riverine channel;

2) construction of seven post and cable barriers to OHV travel along the central riverine channel;

3) installation of a three mile length cattle allotment/OHV use exclusion fence in the study area;

4) removal of approximately 300 acres of varying density saltcedar growth utilizing burn or manual cutting (chainsaw-brushsaw) technique followed by herbicide application to burnt plant resprout basal foliage or the cut surface of sawed stems, using low volume spray applications of Pathfinder and PathfinderII (Garlon 4, a triclopyr herbicide) from shoulder-sling and backpack, 2.5 gallon sprayers;

5) extensive monitoring of treated areas, currently indicating complete saltcedar control on approximately 200 acres (some acreage requiring up to as many as three repeated spray treatments for complete control), with 100 acres of treated land in varying stages of control (Tables 1 and 2);

Table 1. Afton canyon monitoring photoplots

Six 2 M^2 photoplots were randomly established within high density, young (Y), medium (M), and old (O) age class saltcedar (*Tamarix ramosissima*) stands. All plots with the exception of 1B were located within burn-herbicide treated areas. Saltcedar was removed from plot 1B using a cut stem-herbicide treatment. Standing dead was largely removed from plots 1A and 2B. Onsite ocular vegetative cover estimates were recorded prior to treatment (12/91), post-treatment (09-92), post-flood (03-93), first growth season following treatment (05/93), and fifth growth season following treatment (04/97). Dead saltcedar resprouts were recorded as litter and burnt/cut saltcedar stems as standing dead.

PLOT	COVER TYPE	AGE	(%) CANOPY COVER					(%) GROUND COVER				
			12/91	09/92	03/93	05/93	04/97	12/91	09/92	03/93	05/93	04/97
IA	*Tamarix ramosissima*	M	85.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0
	LITTER	-	-	-	-	-	-	80.0	03.0	01.0	01.0	10.0
	BARE SOIL	-	-	-	-	-	-	0.0	92.0	94.0	93.5	65.0
	GRASS/FORB*	-	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.05	20.0
	STAND DEAD	-	0.0	2.0	2.0	1.0	1.0	0.0	05.0	05.0	05.0	05.0
1 B	*Tamarix ramosissima*	Y	20.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0
	Salix spp.	O	40.0	40.0	45.0	50.0	40.0	05.0	05.0	05.0	05.0	05.0
	LITTER	-	-	-	-	-	10.0	35.0	35.0	06.0	07.0	10.0
	BARE SOIL	-	-	-	-	-	-	50.0	50.0	87.0	87.0	80.0
	GRASS/FORB*	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	01.0	05.0
	STAND DEAD	-	0.0	0.0	0.0	0.0	0.0	0.0	10.0	02.0	0.0	0.0
2A	*Tamarix ramosissima*	O	65.0	0.0	0.0	0.0	0.0	15.0	0.0	0.0	0.0	0.0
	LITTER	-	-	-	-	-	-	85.0	02 .0	02.0	04.0	15.0
	BARE SOIL	-	-	-	-	-	-	0.0	95.0	95.0	92.0	57.0
	GRASS/FORB*	-	0.0	0.0	0.0	0.0	40.0	0.0	0.0	0.0	01.0	25.0
	STAND DEAD	-	0.0	04.0	04.0	04.0	03.0	0.0	03.0	03.0	03.0	3.0
2B	*Tamarix ramosissima*	Y-M	90.0	0.0	0.0	0.0	0.0	85.0	0.0	0.0	0.0	0.0
	LITTER	-	-	-	-	-	-	08.0	47.0	02.0	02.0	15.0
	BARE SOIL	-	-	-	-	-	-	07.0	03.0	63.0	60.0	75.0
	GRASS/FORB*	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	03.0	0.0
	STAND DEAD	-	0.0	15.0	15.0	15.0	1.0	0.0	50.0	35.0	35.0	10.0
3	*Tamarix ramosissima*	0	95.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0
	LITTER	-	-	-	-	-	-	75.0	25.0	25.0	26.0	30.0
	BARE SOIL	-	-	-	-	-	-	0.0	60.0	60.0	59.0	55.0
	GRASS/FORB*	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	STAND DEAD	-	0.0	06.0	06.0	05.0	3.0	0.0	15.0	15.0	15.0	15.0
4	*Tamarix ramosissima*	0	75.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0
	LITTER	-	-	-	-	-	-	80.0	03.0	05.0	07.0	10.0
	BARE SOIL	-	-	-	-	-	-	0.0	90.0	88.0	86.0	83.0
	GRASS/FORB*	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	STAND DEAD	-	0.0	10.0	10.0	6.0	6.0	0.0	07.0	07.0	07.0	07.0

**Cryptantha circumscissa, Helictropium curassavicum, Polypogon monspeliensis, Schismus arabicus, Spartina gracillis, Kochia maritima, Distichlis spicata, and Pluchea sericea.*

Table 2. Afton Canyon Vegetative Frequency/Cover Transects

Six frequency/cover transects were established post-Saltcedar (*Tamarix ramosissima*) treatment (May 1993) in order to assess vegetative trend. Baseline data (1990), though not depicted below, was estimated concurrent with 1993 data collection. Transects were randomly positioned from east (Transect 1) to west (Transect 6), with Transects 2-4 located within first year treatment-affected areas. Frequency and cover data were collected using a 50 x 50 cm nested frame, with riparian perennials selected as key species (refer to text). Cover categories consisted of bare ground (BG), persistent litter (PL), nonpersistent litter (NPL) and live vegetation (LV).

TRANSECT	KEY SPECIES	(%) FREQUENCY	COVER TYPE	(%) COVER
1[a]	*Tamarix*		BG	80
	ramosissima	12	PL	05
(n = 113)	*Pluchea*		NPL	11
	sericea	05	LV	04
	Distichlis			
	spicata	03		
2	*Tamarix*		BG	60
	ramosissima	08	PL	15
(n = 178)	*Pluchea*		NPL	21
	sericea	07	LV	04
	Distichlis			
	spicata	08		
3[a]	*Tamarix*		BG	60
	ramosissima	10	PL	13
(a= 177)	*Distichlis*		NPL	25
	spicata	04	LV	02
4	*Tamarix*		BG	68
	ramosissima	03	PL	08
(n = 157)			NPL	20
			LV	04
5	*Undetectable*[b]		BG	87
			PL	03
(n = 115)			NPL	04
			LV	06
6[a]	*Tamarix*		BG	78
	ramosissima	22	PL	09
(n = 153)	*Chilopsis*		NPL	10
	linearis	04	LV	03

[a] Sample frame size adequate to detect change in Saltcedar trend only.
[b] No perennial vegetation detected.

6) selective burnt saltcedar thinning on 10 acres to increase vegetation recovery rates;

7) seed planting (25 kg) of native shrubs/grasses and pole planting (7000+) of cottonwood and willow trees, emphasizing reestablishment of native ground and canopy cover; and

8) an apparent increase in proper functioning condition within the study area from a "non-functioning," pre-project work condition (Figure 2) to a condition of "functioning at risk" with an upward trend (Figure 3), as of 04/97.

Status Report

Site work completed thus far has met with both success and failure, though the restoration project taken as a whole, is considered a major success. First year efforts yielded about a 80% removal of saltcedar on approximately 150 acres through burning, manual cutting and associated herbicide application (Egan *et al*, 1993). Manual cutting, small controlled burns and associated herbicide treatments on an additional 150 acres, as well as herbicide retreatment on the initial 150 acres, were completed by the beginning of the fifth growth season following treatment (1997), with complete control anticipated in the project pilot by 1998. Saltcedar removal/native restoration costs have been estimated in the $1500-3500/acre range, depending on saltcedar stand density, type of project crew used and the degree of native plant restoration. Following first year efforts, saltcedar ground and canopy coverage within all photoplots had been eliminated (Table 1), although such results were not uniform across the treatment area (Table 2). As of April 1997, no saltcedar reestablishment within photoplots, has occurred, grass/forb production has begun to increase and levels of bare ground have begun to decrease (Figure 4). Concurrently, native plant production, diversity and vigor have all increased within and downstream of the study area, as has the availability/accessibility of primary wildlife habitat components such as open water, snags, brush, shade and forage.

Study area trend analysis is encouraging in that the 1990-96 trend for average bare ground cover, following a rapid increase between 1990-93 concurrent with initial saltcedar treatment and a major flood event (1993-94), is gradually decreasing while the 1990-96 trend for average nonpersistent litter, persistent litter and live vegetation, following an initial decrease between 1990-93, are gradually increasing (Figure 5). Average saltcedar frequency and number of perennial plant species trends for the period 1990-96, depicted in Figure 6, partially explain the attribute changes over time shown in Figure 5. Average bare ground, initially rather high in 1990, became even higher with project saltcedar burning/cutting in 1993, particularly with the addition of a high sediment depositional flood following treatment, and then began gradually decreasing as native plants began to reestablish themselves; average non-persistent litter, persistent litter and live vegetation on the other hand, decreased following saltcedar treatment work in 1993 and have all gradually increased with continued project work.

Individual stream reach transect trend analysis (Tl-wet, T3-moist and T6-dry) depicted in the Saltcedar Frequency 1990-96 Trend of Figure 6 is also interesting in that it confirms previously ground-identified retreatment needs in the far western edge of the study area or "dry stream reach," an area receiving the least amount of retreatment to date. The amount of retreatment in this upstream reach area may also have had a bearing on the static to slight decline change depicted in the dry stream reach (T6) of Number of Perennial Plant Species 1990-96 Trend of Figure 6, though it is more likely that this apparent trend is a function of both water availability and lower levels of saltcedar retreatment, compared to the other, wetter stream reaches.

Both photoplot and trend analyses indicate that saltcedar has become a less dominant feature and that native plants have become more of a dominant feature, within the study area in the time span 1990-96. Wetland emergent "green strip" width and length have increased markedly and native plant diversity/productivity within and downstream of the study area have increased exponentially. In terms of overstory restoration, young cottonwood, willow and mesquite trees now number in the hundreds, though over 7000+ trees have been planted to date (suspected survival rate of 15-20%). As far as understory plants, a patchwork of forbs, shrubs and grasses have replaced a monoculture of saltgrass and bare ground. However, several sites within intensely burned areas remain unvegetated five growth seasons post project burns, possibly due to boron or salt accumulations.

A small amount of cottonwood/willow recruitment and reestablishment has occurred since project work was initiated, but most willow/cottonwood reestablishment has resulted from project pole plantings. Since project initiation, screwbean mesquite, desert willow (*Chilopsis linearis*), smoke tree (*Dalea spinosa*), baccharis (*Baccharis emoryi, B. glutinosa*), quailbush (*Atriplex lentiformis*), common reed (*Phragmites communis*), and grasses such as alkali sacaton (*Sporobolus airoides*), species largely absent from the study area prior to project work, have also reestablished themselves within the study area.

Wildlife species diversity, abundance and degree of use appear to have increased both within and downstream from the study area with the plant community changes noted above. Animals not regularly observed within the study area, particularly pisciverous, insectivorous, and accipitrine bird species, are now regularly encountered in both winter and breeding seasons. Aquatic invertebrates, amphibians and small mammals all appear to have increased in diversity and abundance, though no extensive surveys have been conducted to verify these apparent increases. A few areas where humans experienced difficulty crawling through old growth saltcedar stands prior to treatment, are now being used as desert bighorn sheep (Ovis *canadensis nelsonii*) foraging/water access areas.

During the first four years of project work at Afton Canyon, the effective floodplain has also increased in size, as well as in the number of braided channels that remain vegetated throughout the year with native wetland emergents (plant species necessary for maintenance of riparian soil moisture). Low to average winter water flows appear to be conveyed over a broader area in 1997, when compared to pretreatment profiles. Point bars are revegetating and the stream appears to be in greater balance with the water and sediment being supplied by the watershed in 1997 when compared to that occurring in 1990. The riparian zone appears to be widening and sinuosity, width/depth ratio and gradient appear to be in greater balance with the landscape setting, following project work conducted to date. Based on the 1990-96 changes noted in this document, pertaining to all major sections (hydrologic, vegetative and soils-erosion deposition) of the Proper Functioning Condition Standard Checklist, the proper functioning condition rating for the study area has increased from a "non-functioning" condition (Figure 2) to a "functioning at risk" condition, with an upward trend (Figure 3).

Figure 1. Saltcedar removal study area – Afton Canyon, California

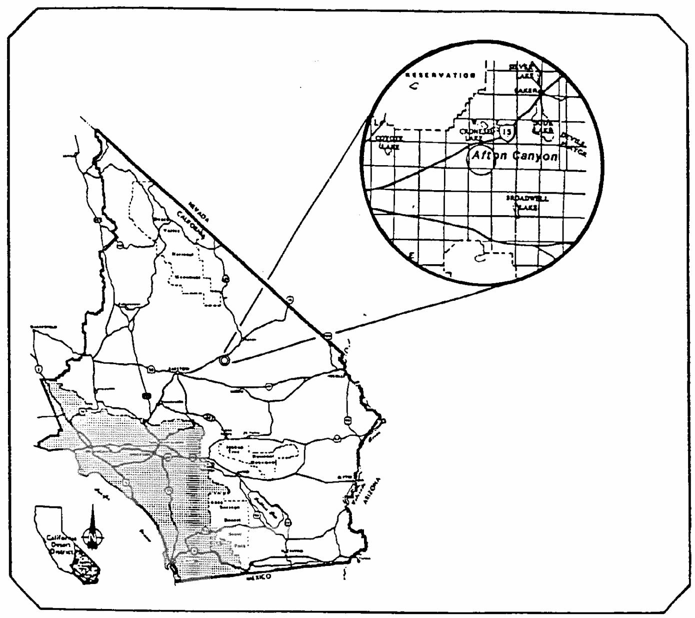


Figure 2. 1990 Proper Functioning Condition Assessment

Standard Checklist

Name of Riparian-Wetland Area: Afton Canyon-Mojave River

Date: 04/90 Area/Segment ID: West Canyon Miles: 2

ID Team Observers: Egan, T.B.; R.A. Chavez; and B.R. West

Yes	No	N/A	HYDROLOGIC
	X		1) Floodplain inundated in "relatively frequent" events (1-3 years)
	X		2) Active/stable beaver dams
	X		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
	X		4) Riparian zone is widening or has achieved potential extent
X			5) Upland watershed not contributing to riparian degradation

Yes	No	N/A	VEGETATIVE
	X		6) Diverse age-class distribution (recruitment for maintenance/recovery)
	X		7) Diverse composition of vegetation (for maintenance/recovery)
	X		8) Species present indicate maintenance of riparian soil moisture characteristics
	X		9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events
	X		10) Riparian plants exhibit high vigor
	X		11) Adequate vegetative cover present to protect banks and dissipate energy during high flows
	X		12) Plant communities in the riparian area are an adequate source of coarse and/or large woody debris

Yes	No	N/A	SOILS-EROSION DEPOSITION
	X		13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody debris) adequate to dissipate energy
	X		14) Point bars are revegetating
	X		15) Lateral stream movement is associated with natural sinuosity
X			16) System is vertically stable
	X		17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

(Revised 1995)

Remarks

Afton Canyon-Mojave River (cont) streambanks presently exists, and streambanks lack definition in a majority of the subject reach; 12) saltcedar is a poor source of large woody debris, as the plants seldom develop large trunks and those that do, generally remain in place on top of established terraces; 13) though a large floodplain physically exists on the reach, saltcedar has reduced the effective floodplain by forming large terraces that tend to focus flows in a linear fashion; 14) although saltcedar has established itself on some point bars, a majority of the subject steam reach lacks a defined stream channel and thus point bars; 15) lateral stream movement partially constrained by large saltcedar-accumulated sediment terraces; and 17) there appears to be excessive erosion/sedimentation in the reach.

Summary Determination

04/90 Functional Rating:

Proper Functioning Condition ____
Functional—At Risk ____
Nonfunctional X
Unknown ____

Trend for Functional—At Risk:

Upward ____
Downward ____
Not Apparent ____

Are factors contributing to unacceptable conditions outside BLM's control or management?

Yes X
No ____

If yes, what are those factors?

X Flow regulations ____ Mining activities X Upstream channel conditions
____ Channelization ____ Road encroachment ____ Oil field water discharge
____ Augmented flows ____ Other (specify) ____

Figure 2. (continued) 1990 Proper Functioning Condition Assessment

Remarks

Afton Canyon-Mojave River (cont)

1) Upstream water regulation (dam), diversion and groundwater overdraft impacts severe; 2) although within historic beaver range and located downstream from a current beaver use area, suitable beaver habitat lacking; 3) little to no defined stream channel within majority of reach, though the subject reach is considered capable of supporting such definition; 4) riparian zone is extremely narrow where it exists, far below perceived site capability; 6) only two age classes present primarily-new and very old growth; 7) dominant vegetation consists of only two species-the non-native shrub saltcedar and the rhizominous native saltgrass; 8) dominant vegetation not considered primary indicators of soil moisture maintenance; 9) little streambank vegetation currently exists and that vegetation

Summary Determination

occurring are not considered to have roots capable of withstanding high flow events (saltcedar tends to accumulate sediment and form terraces but

04/90 Functional Rating:

Proper Functioning Condition _____
Functional—At Risk _____
Nonfunctional __X__
Unknown _____

Trend for Functional—At Risk:

Upward _____
Downward _____
Not Apparent _____

Are factors contributing to unacceptable conditions outside BLM's control or management?

Yes __X__
No _____

If yes, what are those factors?

_X_ Flow regulations ___ Mining activities _X_ Upstream channel conditions
___ Channelization ___ Road encroachment ___ Oil field water discharge
___ Augmented flows ___ Other (specify) _____

generally does not have root masses capable of withstanding high flow events on streambanks, though saltcedar roots appear to assist in streambank stabilization in low to average flow events); 10) native plants exhibiting low vigor, saltcedar exhibiting high vigor; 11) little to no vegetation on

Figure 3. 1997 Proper Functioning Condition Assessment

Standard Checklist

Name of Riparian-Wetland Area: Afton Canyon-Mojave River

Date: 04/97 Area/Segment ID: West Canyon Miles: 2

ID Team Observers: Egan, T.B.; R.A. Chavez; and B.R. West

Yes	No	N/A	HYDROLOGIC
	X		1) Floodplain inundated in "relatively frequent" events (1-3 years)
	X		2) Active/stable beaver dams
X			3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
X			4) Riparian zone is widening or has achieved potential extent
X			5) Upland watershed not contributing to riparian degradation

Yes	No	N/A	VEGETATIVE
X			6) Diverse age-class distribution (recruitment for maintenance/recovery)
X			7) Diverse composition of vegetation (for maintenance/recovery)
X			8) Species present indicate maintenance of riparian soil moisture characteristics
X			9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events
X			10) Riparian plants exhibit high vigor
X			11) Adequate vegetative cover present to protect banks and dissipate energy during high flows
	X		12) Plant communities in the riparian area are an adequate source of coarse and/or large woody debris

Yes	No	N/A	SOILS-EROSION DEPOSITION
X			13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody debris) adequate to dissipate energy
X			14) Point bars are revegetating
X			15) Lateral stream movement is associated with natural sinuosity
X			16) System is vertically stable
X			17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

(Revised 1995)

Remarks

Afton Canyon-Mojave River (cont)

1) Upstream water regulation (dam), diversion and groundwater overdraft impacts severe; 2) although within historic beaver range and downstream from current beaver use area, suitable beaver habitat lacking; and 12) though native woody vegetation is gradually replacing saltcedar, this source of coarse and/or large woody debris is currently considered inadequate but improving. Overall, the subject stream reach has greatly improved since 04/90.

Summary Determination

04/97 Functional Rating:

Proper Functioning Condition _____
Functional—At Risk __X__
Nonfunctional _____
Unknown _____

Trend for Functional—At Risk:

Upward __X__
Downward _____
Not Apparent _____

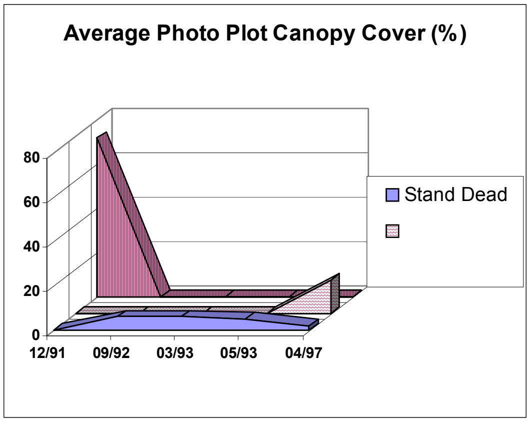
Are factors contributing to unacceptable conditions outside BLM's control or management?

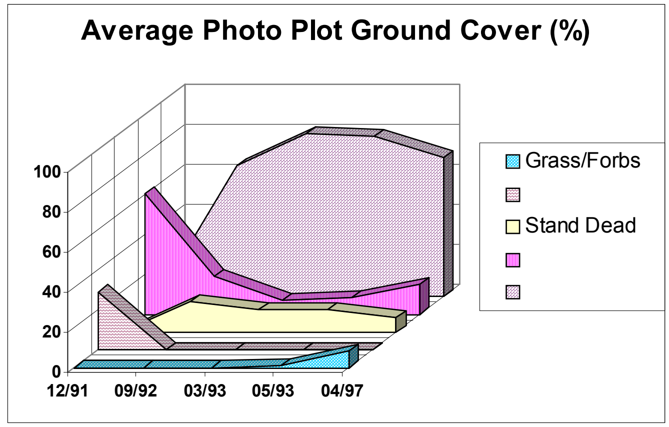
Yes __X__
No _____

If yes, what are those factors?

_X_ Flow regulations ___ Mining activities _X_ Upstream channel conditions
___ Channelization ___ Road encroachment ___ Oil field water discharge
___ Augmented flows ___ Other (specify) _____

Figure 4. Average 2 x 2M Photoplot (N=6) Canopy and Ground Cover (Ocular Estimation) for the period 1991-1997, in the initial treatment area of the Bureau of Land Management's Afton Canyon Riparian Restoration Project

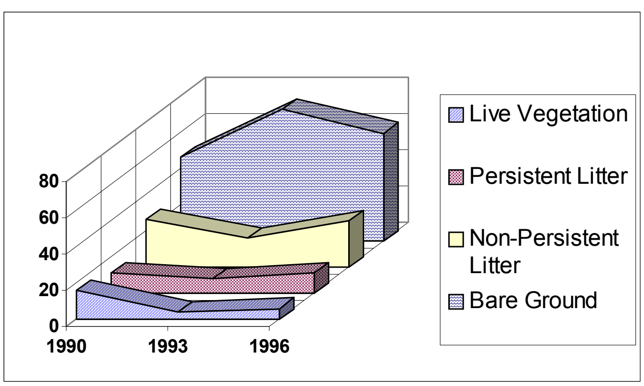




Average Photo Plot Canopy Cover						
DATE	T		GF		SD	
	X	SD	X	SD	X	SD
91	72	27.5	0	0	0	0
92	0	0	0	0	6	5
3/93	0	0	0	0	6	5
5/93	0	0	0	0	5	5
97	0	0	15	23	2	2

Average Photo Plot Ground Cover										
DATE	T		L		BS		GF		SD	
	X	SD	X	SD	X	SD	X	SD	X	SD
91	29	27.8	60	31	9	20	0	0	0	0
92	0	0	19	19	65	36	0	0	15	18
3/93	0	0	7	9	81	16	0	0	11	13
5/93	0	0	8	9	80	16	1	1.2	11	13
97	0	0	15	8	69	12	8	11.2	7	5

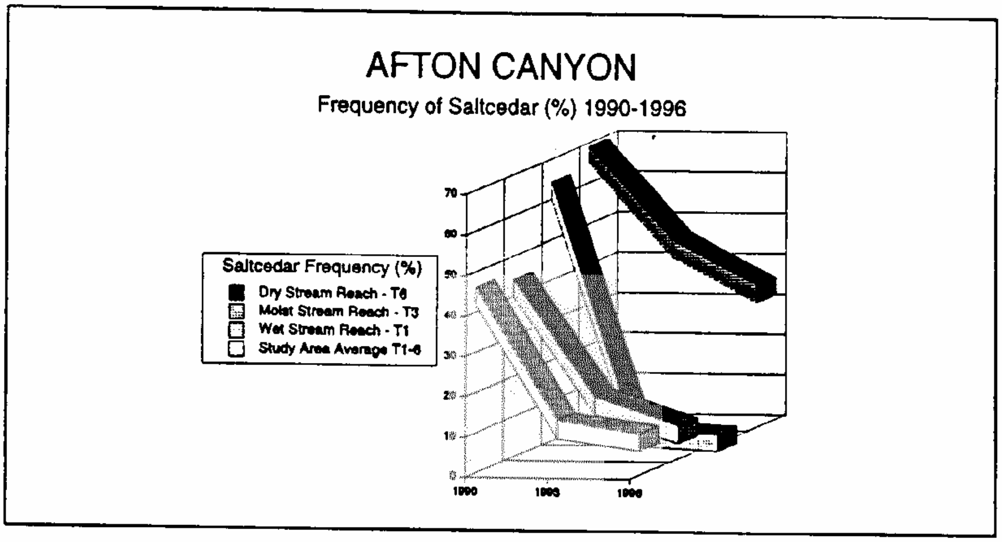
Figure 5. Average Cover (%) Trends of Bare Ground, Non-Persistent Litter, Persistent Litter, and Live Vegetation for the Period 1990-1996, within the Initial Treatment Area of the Bureau of Land Management's Afton Canyon Riparian Restoration Project. Study Area Averages Represent the Average of Cross Channel Transects T1-6.

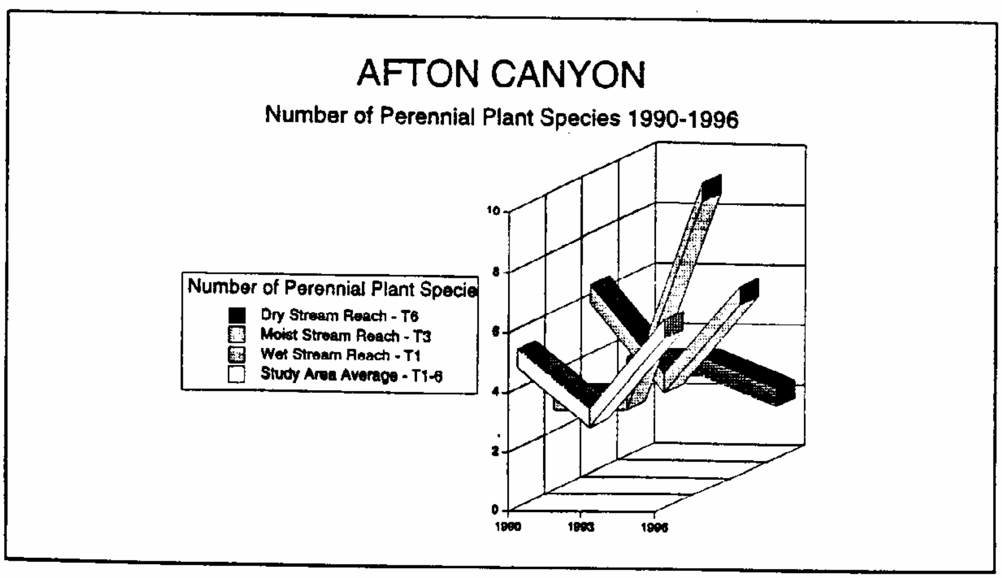


AFTON CANYON STUDY AREA - Average Cover (%) for the period 1990-1996

Legend	1990		1993		1996	
	X	SD	X	SD	X	SD
BG	46	12.4	72	11.1	59	10.3
NPL	26	8.9	16	9.3	25	4.0
PL	11	4.7	8	4.2	11	4.1
LV	16	8.3	4	1.3	6	5.4

FIGURE 6. SALTCEDAR FREQUENCY (%) AND NUMBER OF PERENNIAL PLANT SPECIES TRENDS FOR THE PERIOD 1990-1996, WITHIN THE INITIAL TREATMENT AREA OF THE BUREAU OF LAND MANAGEMENT'S AFTON CANYON RIPARIAN RESTORATION PROJECT. STUDY AREA AVERAGES REPRESENT THE AVERAGE OF CROSS-CHANNEL TRANSECTS T1-6 FOR SALTCEDAR FREQUENCY (1990: X=44, SD=17.6; 1993: X=11, SD=17.0; 1996: X=8, SD=12.7) AND NUMBER OF PERENNIAL PLANT SPECIES (1990: X=5, SD=1.9; 1993: X=3, SD=1.5; 1996: X=6, SD=4.1) USING FRAME 2 DATA OF A 50 X 50CM NESTED FRAME. WET, MOIST AND DRY STREAM REACHES REPRESENT INDIVIDUAL STUDY AREA TRANSECTS.





Discussion

Restoration work is often a tedious and sometimes rewarding, but time-consuming task, where practitioners are forced to learn by their mistakes or accept less than desired results. Our work in Afton Canyon has certainly necessitated the former, but in terms of the latter, our project objectives and goals have remained unchanged. We have a long ways to go, in terms of restoring Afton Canyon's riparian system, but are confident that restoration work within our initial study area will be completed by 1998. However, we have an additional 400 acres of planned treatment outside of the initial study area to complete and have yet to develop an effective strategy for dealing with upstream sources of saltcedar seed/vegetative propagules on private land. Furthermore, funding/avail able personnel for continued project work is always in question. To top these uncertainties off, we are unsure of what to expect from high water flow events in the near future, prior to suitable growth establishment of restored native vegetation.

Our current observations are that reestablishment of native vegetation ground and canopy cover drastically reduces saltcedar reinfestation rates, but that some degree of saltcedar reinfestation generally occurs along the central channel of saltcedar-affected riverine systems, even when native plants are restored. Terraces adjacent to central channels, on the other hand, appear to hold their own against saltcedar reinfestation for a longer time interval, if the initial saltcedar treatment is complete. Regardless, it appears that some degree of saltcedar site maintenance will be required on this riparian restoration project, and probably most others. Should ongoing tests for an effective saltcedar biological control agent prove fruitful, anticipated maintenence needs of saltcedar control/restoration projects could be greatly reduced. In any case, the Afton Canyon Riparian Restoration Project has demonstrated that cost-effective saltcedar control at specific sites is feasible and that such control can assist in improving the proper functioning condition of saltcedar affected streams.

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Adjuvants with Herbicides

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Adjuvants

- Surfactants
- Oils
- Salts – AMS, AMN + UREA, BUFFERS
- Antifoam
- Drift reduction

Surfactants

Spray retention – droplet size, spray volume, plant species, dynamic surface tension, HLB all interact in determining spray retention.

Redroot pigweed retained spray without surfactant and surfactant reduced retention with high spray volumes.

Common lambsquarters spray retention was increased by adjuvants: low HLB surfactant > high HLB surfactant > methylated vegetable oil > vegetable oil = petroleum oil.

Low spray solution dynamic surface tension generally relates positively to spray retention. Low surface tension is mainly important for retention of large spray droplets on hard to wet species.

Herbicide absorption – surfactant HLB, deposit characteristics, surfactant concentration all directly or indirectly determine herbicide absorption.

Absorption of water soluble herbicides generally is enhanced more by surfactants with high HLB, hydrophilic, than low HLB, lipophilic surfactants.

Nonspreading surfactants that leave a concentrated spray deposit also appears positive to enhancement of water soluble herbicides.

Oil soluble herbicides formulated as emulsifiable concentrates are not greatly influenced by surfactants. The formulant may provide the needed solvents for absorption or the parent oil characteristics of the herbicide alone may directly penetrate the plant epicuticular surface.

Oils

Absorption – oil adjuvants function by enhancement of herbicide absorption. Glyphosate (Roundup) and paraquat (Gramoxone) which are very water soluble are antagonized by oil adjuvants. However, other herbicides formulated as water soluble salts (bentazone, dicamba, 2,4-D) are often enhanced by oil adjuvant. The solubility of the parent herbicide acid may be more important than the formulated soluble salt. The final molecular form in the spray deposit may not be that of the formulated salt with different solubility.

Methylated vegetable oils are far better solvent of cuticular wax than either the parent vegetable oil or petroleum oils. The methylated vegetable oils appear most effective with herbicides having intermediate water solubility (nicosulfuron, sethoxydim, clethodim). The very lipophilic herbicides (diclofop, quizalofop, fluazifop) are similarly enhanced by methylated vegetable or petroleum oil. Quizalofop is antagonized by vegetable oil. The above interaction between oil types and herbicides indicates that certain herbicides require the solubilization from the methylated vegetable oil, but other more lipid soluble herbicides may penetrate the cuticular wax without an oil. The presence of an oil is still required to provide a micro environment for absorption. The antagonism of quizalofop by vegetable oil may be from too great of an affinity of quizalofop for the oil preventing absorption.

Salts

Overcome antagonistic salts in the spray solution

Glyphosate and weak acid type herbicides in spray carriers high in certain cations (Ca, Na) combine with these cations upon droplet drying to form less absorptive compounds. Ammonium and sulfate ions either directly or indirectly prevent the formation of the less absorptive forms. The ammonium ion by mass action may form an ammonium herbicide salt positive to absorption. The sulfate ion causes formation of the relatively insoluble calcium sulfate early in droplet drying preventing the calcium from subsequent combination with the herbicide.

Glyphosate salt model:

Compound solubility, gly IPA & Na = 50%; glyH4 = 30%; glyCa = 3%

Gly-IPA + Ca = Gly-Ca
Gly-IPA + Ca + NH4SO4 = CaSO4 + Gly-NH4 (CaSO4 <sol Gly-Ca)
Gly-IPA + Ca + NH4NO3 = Gly-Ca (CaNO3>sol Gly-Ca)
Gly-IPA + NH4SO4 = Gly-NH4
Gly-IPA + Na = Gly-Na + Gly-IPA
Gly-IPA + Na + NH4SO4 = Gly-NH4
Gly-IPA + Na + NH4NO3 = Gly-NH4

The above equations indicate the form of glyphosate that occurs in the dry spray deposit because of solubility of various ion combinations. The underlined compounds are those to first precipitate as concentration increases upon droplet drying. Note that ammonium nitrate overcomes sodium but not calcium ions in the spray carrier, but ammonium nitrate overcomes sodium antagonism. In the case of sodium the ammonium ion is the functional ion. However, when calcium is present the sulfate (phosphate also effective) ion is required to remove the calcium before it combines with glyphosate. The deposit form of glyphosate is important to absorption and efficacy as indicated below.

Glyphosate salt efficacy applied with X-77 and absorption with MON0818

Glyphosate salt	% fresh wt. reduction	Absorbed, % of applied
Sodium	18	21
Ammonium	33	44
Isopropylamine	39	44
Calcium	11	1
Acid	37	49
LSD 5%	5	5

Other weak acid herbicides formulated as salts would have a similar response to salts. However, the solubility of the parent compound could change the salt solubility interrelationships. Below are results of salt antagonism of several herbicides and response to ammonium sulfate.

Kochic (%FWR) with herbicides, formulations, and salts

	--------------Carrier salt--------------		
Herbicide	None	CaC12	CaC12 + AMS
2,4-D dea	45	0	45
2,4-D Na	0	0	38
Bentazon-Na	55	7	61
Dicamba-dma	67	17	70
Dicamba-Na	34	9	69
Acifluorfen	100	48	100
Glyphosate-IPA	100	4	24
LSD 5%	--		

In the above table ammonium sulfate did not overcome the calcium antagonism of glyphosate. All treatments were without a surfactant and result of other research indicated that surfactant was essential to overcoming calcium chloride antagonism of glyphosate for kochia. The salts in the deposit on the crystalline wax of the kochia leaf probably prevent good physical contact by glyphosate with the epicuticular surface. The presence of a surfactants provides a liquid route for glyphosate diffusion and absorption. Thus, the amount of salt and physical characteristics of the deposit could influence herbicide efficacy. Salts that upon drying give large crystals may deposit above the herbicide and surfactants and not interfere with absorption. On the other hand, salts that leave a powder type deposit could physically trap the herbicide, reducing absorption.

The effectiveness of various herbicide forms appears to depend upon environment. Sodium salt forms of some herbicides were effective under moist conditions (dew or high humidity), but not when dry. Thus, the beneficial response with some herbicides from the presence of ammonium salts in the spray solution depends on the prevailing conditions.

Direct responses to ammonium fertilizers

Ammonium fertilizers have enhanced efficacy of herbicides in the absence of antagonistic salts. Possible reasons for these enhancements are increased plant growth, overcoming antagonisitic salts within the plant, changing spray deposit characteristics and stimulation of the proton gradient by ammonia at the cell membrane level. Ammonium sulfate and some other fertilizer salts have enhanced phytotoxicity of glyphosate to sunflower and acefluorfen to velvetleaf in the absence of any antagonistic ions in the spray solution. The Table below indicates species response to glyphosate and salts.

Species percent FW reduction from glyphosate with salts

	---------------------Salts------------------------			
Species	None	CaC12	AMS	Ca+AMS
Wheat	62	0	69	74
Sunflower	55	1	100	93

The enhancement of glyphosate phytotoxicity to sunflower by ammonium sulfate in a spray solution without antagonistic salts is a direct benefit from the ammonium sulfate. Micrographs of the spray deposits indicated the presence of crystals resembling Ca SO4. Thus, it was speculated that the calcium from the plant may have been removed from complexing with glyphosate.

Nitrogen fertilizers applied with herbicides may be positive to plant growth needed for a toxic response. Research in the late 1960's had shown that 28% nitrogen fertilizer in a barban spray overcame the tolerance in wild oat that occurred with plant growing in soil with low fertility. Barban was an emulsifiable formulation that should not have been antagonized by spray carrier salts. The response may have been a growth response or an increased cellular membrane penetration as reported for imazethapyr (see Figure).

Indirect response to fertilizer salts

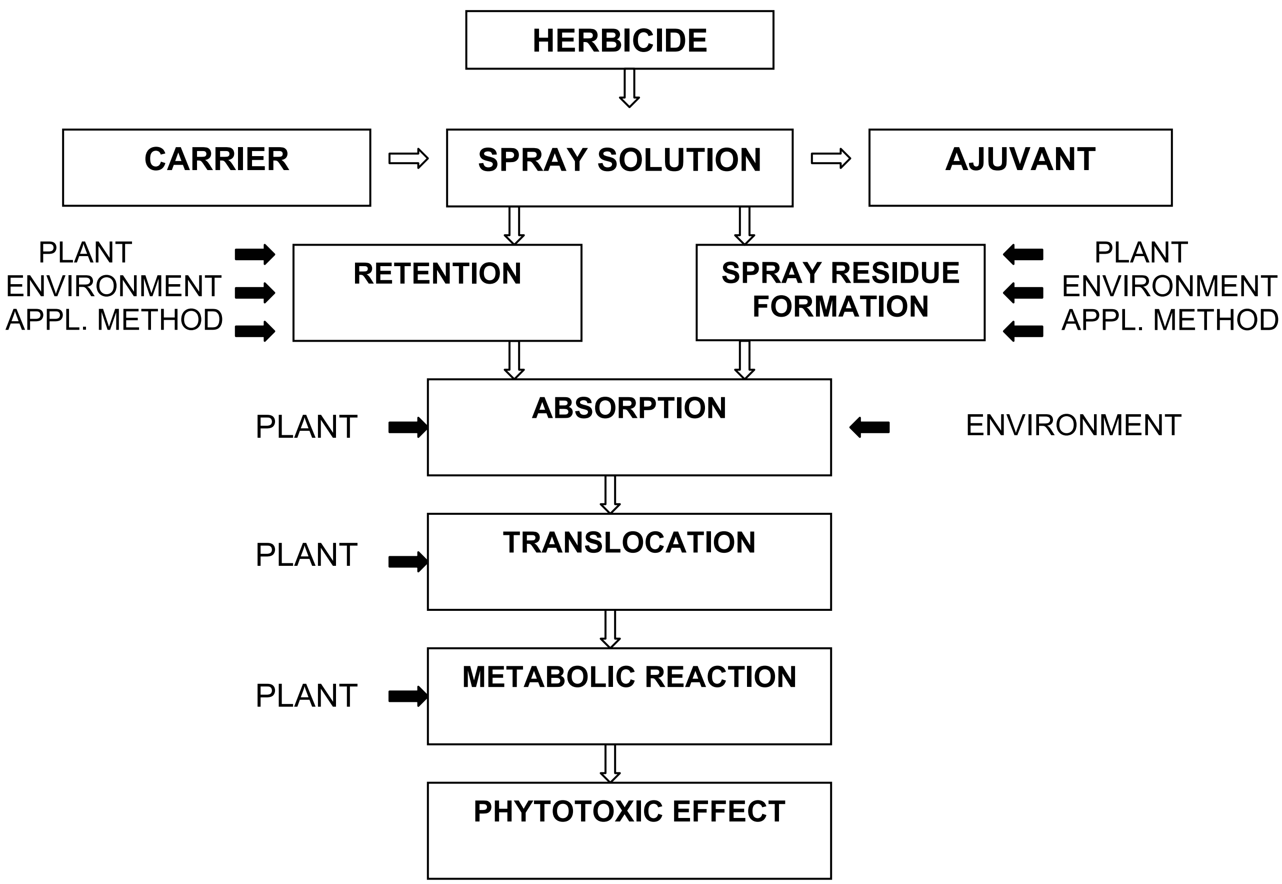
Nitrogen fertilizers in combination with oils in spray solution have overcome the antagonistic effects of the oil with glyphosate. The speculation is that the fertilizer salts create micro hydrophilic areas with the spray deposit containing a high concentration of the highly water soluble glyphosate giving increased absorption and efficacy.

Spray deposits are the final step in determining herbicide penetration into the leaf. Salts depending on their physical and chemical characteristics influence droplet spread; deposit physical appearance; and deposit hydrophilic and lipophilic characteristic. The optimum HLB of surfactants for some herbicides is lower when the spray contained fertilizers. This is believed from the fertilizer reducing spread of the low HLB surfactant important to absorption of water soluble herbicides. Fertilizer with high HLB surfactants reduced efficacy by causing a bulky deposit with poor contact to the epicuticular surface. Fertilizer and salt influence on herbicide efficacy differs with both the salt and surfactant which may be from within deposit herbicide – salt – solubility relationships.

Questions relative to nitrogen adjuvants

- Amount and efficacy, percentage vs area
- Surfactant fertilizer mixtures
- Type of nitrogen compound
  - AMS, AMN, UREA, AMCitrate, Amphosphates
  - Importance of nitrogen vs any salt
- Drift reduction compounds and fertilizers
- Function of nitrogen compounds, physiological or physical
- Pesticides responding to fertilizer salts.

Postemergence Herbicide Action



Barriers to Foliar Penetration and Uptake of Herbicides

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To be effective, herbicides must enter the plant. This process can occur very quickly or very slowly, depending on the herbicide, formulation, plant, and environmental conditions. For foliar applied (postemergence) herbicides, penetration and uptake can occur through cracks in the leaf surface, stomatal cavities, or by diffusion through the cuticle. Other surface features of the leaf such as trichomes (hairs and glands) can greatly influence herbicide uptake.

Trichomes

Plant leaves can have a variety of trichomes, including glands and simple and/or complex hairs (5). Trichomes on the leaf surface can reduce herbicide efficacy by intercepting spray droplets before they contact the epidermal surface (5). Complex branched trichomes can greatly reduce the number of spray droplets reaching the leaf surface, and even a low density of simple trichomes can reduce herbicide contact with the cuticle. The addition of a surfactant to the spray solutions allows drops to break into smaller droplets when they hit trichomes. This increases the amount of spray solution contacting the epidermal surface.

Cracks in leaf surface

Breaks in the cuticle layer caused by wind, rain, insects and other agents can increase the absorption of herbicides, particularly water soluble compounds. In some mature plants, such as English ivy, intentionally injuring the foliage and stems with a metal rake can create avenues for significant herbicide uptake. Under normal conditions, however, cracks and tears in the foliage are not major routes of herbicide entry.

Stomatal entry

Most weeds have stomata on both the upper and lower leaf surfaces (5). Although volatile herbicides easily penetrate stomata, stomatal penetration by an aqueous solution is not possible unless the surface tension of the spray solution is significantly reduced. Most surfactants are incapable of reducing surface tension enough to allow stomatal penetration. Prior to the development of the organosilicone surfactants, stomatal infiltration of herbicides into the leaf was considered to be of minor importance. In contrast to other wetting agents, the organosilicone surfactants can reduce surface tension to levels low enough to allow stomatal infiltration of aqueous spray solutions (10, 11, 12). When stomatal penetration occurs, it is greatest in the morning when stomates are more likely to be open.

Cuticle

The cuticle is a thin layer (0.1 to 10 μM thick) on the outer wall of leaf epidermal cells. Cuticles can also cover specialized structures like trichomes, pore walls of stomata, and guard and epidermal cells lining the substomatal chamber (3). The primary function of the cuticle is to protect and prevent uncontrolled water and gas loss from plant tissues leaf surfaces. The cuticle typically acts as the primary barrier to foliar applied herbicide penetration into leaf tissues. However, for foliar herbicides to be active they must be able to penetrate the cuticle and subsequently enter the cell.

The cuticle differs in structure and composition within and among species (3). As a result, herbicide permeability across the cuticle also differs greatly among plant species and stages of leaf development (9). For example, among ten plant species tested, the range of 2,4-D permeability across leaf cuticles differed by over 200-fold (7). Any environmental condition that directly effects the cuticle will have some effect on herbicide absorption.

The cuticle is composed of three distinct substances; waxes (epicuticular and embedded), cutin, and pectin.

Waxes

Waxes are very lipophilic and non-polar. They effectively prevent water from penetrating into the underlying cells. Cuticular waxes are composed of two types, epicuticular and embedded. The epicuticular wax is the most significant barrier to the penetration of water-soluble herbicides. In contrast, lipophilic oil soluble or ester herbicide formulations easily penetrate this waxy layer by simple diffusion. In general, epicuticular wax comprises only about 10% of the total mass of the cuticle (9).

Epicuticular wax

Epicuticular wax consists of a variety of long chain even numbered (C_{22}-C_{24}) primary alcohols, acetates, aldehydes, and fatty acids, and their hydroxy- and oxyderivatives, as well as odd-carbon-numbered (C_{17}-C_{35}) hydrocarbons, secondary alcohols, ketones, ketols, and β-diketols (3). Surface wax deposits can vary among species and these differences influence herbicide wettability and penetration into the foliage (5).

The very hydrophobic epicuticular wax can lack surface features (amorphous), or can be semicrystalline or crystalline in nature (5). The surface-fine structure of the epicuticular wax can be characteristic of a species (3, 4). Crystalline wax domains reduce retention of the spray solution on the cuticle surface compared to a smooth surface (6). Even surface wax roughness can greatly influence herbicide penetration (1). Since epicuticular crystalline wax domains are often inaccessible to solutes, they can slow herbicide penetration into the leaf tissue (8). Differences in epicuticular surface features can exist among plants of a species or on leaves of an individual plant. Leaves of different ages or from plants grown under various environmental conditions can have different surface wax patterns that influence the rate of herbicide uptake (9).

Surfactants are well known to increase the portion of the leaf surface covered by water-based spray solutions (5). Even in the presence of a surfactant, herbicides in aqueous solutions rarely spread out evenly over the leaf surface following foliar application (5). In fact, they tend to accumulate in the depressions above anticlinal walls (perpendicular to leaf surface) after individual spray drops dry on the leaf surface. Leaves with little epicuticular wax have spray deposits that spread out over larger areas of the surface. In contrast, leaf surfaces with greater epicuticular wax development have deposits that cover a lower proportion of the leaf. Since less herbicide is in contact with the leaf surface, absorption is generally reduced (5).

Foliar applied herbicides formulated as suspensions, such as wettable powders or flowables, have only a fraction of the particle surface in direct contact with the cuticular surface (5). This limits the absorption potential of the active ingredient. The addition of a surfactant or crop oil concentrate to the tank mix can increase absorption, provided the herbicide is soluble in the adjuvant. Many foliar applied suspensions accumulate high concentrations of herbicide around the margin of the dried droplet. The margins of these ring-like deposits have stacked layers of particles. This leads to reduced leaf contact and decreased rates of absorption (5).

Emulsifiable concentrate formulations can appear as discrete droplets on the leaf surface or can form crystallize deposits. Differences in the type of spray deposit on the leaf can influence herbicide absorption and performance. Herbicide absorption is usually greatest in emulsifiable concentrate formulations that do not crystallize on the leaf surface (5).

Embedded waxes

In addition to deposits of epicuticular wax on the leaf surface, most cuticles also have a layer of wax oriented perpendicular to the cuticle surface embedded within the cutin matrix (2, 3). These waxes can also provide a pathway for non-polar herbicides absorption. Polar (hydrophilic) herbicides are not required to transport through these waxes as they can more readily move through the adjacent cutin layer.

<u>Cutin</u>

The majority of the cuticle volume consists of cutin. Cutin is thought to primarily function in protection of cellular constituents by absorbing UV radiation. Cutin is hydrophilic, polar with a negative charge and is composed of highly cross-linked polymers of hydroxylated fatty acids (3). Cutin is lipophilic and will hydrate in the presence of water. The water imparts a hydrophilic component to the cuticle for diffusion of water-soluble herbicides. Because of the presence of embedded waxes within the cutin, lipophilic (non-polar) herbicides can also readily move through this layer once they have diffused across the epicuticular wax. Thus, the cutin is not considered a major barrier to lipophilic or particularly hydrophilic herbicide movement.

<u>Pectin</u>

Pectin strands are composed of polymers of galacturonic acid and are located at the cutin/cell wall interface or dispersed within the cutin layer. They are very hydrophilic and, like cutin, provide pathways for water-soluble herbicides when hydrated.

Herbicide penetration through the cuticle

The ability of a foliar applied herbicide to be absorbed through the epicuticular wax of the cuticle depends upon two factors; the partitioning of a chemical into the waxy layer (partition coefficient) and its mobility within the epicuticular wax (diffusion coefficient) (6, 9). Non-polar (lipophilic) herbicides, such as ester formulations, are highly permeable and mobile in waxes. These compounds can easily penetrate the epicuticular wax and move through the embedded wax. Most herbicides, however, are polar and are applied in an aqueous form. Poor performance of water-soluble herbicides is often attributed to limited penetration across the epicuticular wax layer (2, 9). The absorption of these herbicides could be improved through increased partitioning of the active ingredient into the cuticle, or enhanced mobility of active ingredient within the cuticle. Surfactants accelerate the rate of herbicide uptake by expanding the contact area on the leaf surface and by increasing the permeance of herbicides in the cuticle (6). The permeability of herbicides across cuticles differs among plant species and can be greatly influenced by environmental conditions, as well as adjuvants (9).

Herbicide movement through the cuticle is a diffusion-controlled process (2, 9). Lipophilic herbicides diffuse across the non-polar waxes much faster than water-soluble compounds. Surfactants are typically added to formulations containing water-soluble herbicides to maximize leaf coverage of the spray solution and to increase the diffusion coefficient of the herbicide. This will be discussed in greater detail in the next presentation.

For optimum herbicide penetration, there must be a balance between herbicide concentration and coverage on the leaf surface. Higher herbicide concentration in a low volume spray solution increases the driving force for diffusion. However, poor coverage reduces the surface area where penetration can occur. By comparison, very low surface tension of a high volume application can maximize the surface area covered, but may reduce the driving force for diffusion by lowering the herbicide concentration in the spray solution.

Cell walls

Once a herbicide has penetrated the cuticle it encounters the cell wall. Cell walls provide mechanical stability and protection to the plant cell. They primarily consist of cellulose, which is very porous. Although both polar and non-polar molecules can easily move through the cellulose, compounds with >700 mw (molecular weight) do not easily diffuse through the cell wall due to their size. For this reason, no commercially available herbicides have a molecular weight greater than 700.

Herbicide uptake across membranes

The final barrier for entry of herbicides into the cell is the plasma membrane (cell membrane). Cell membranes regulate the internal chemical environment of the cytoplasm. Herbicide movement across the plasma membrane can be through two processes, non-facilitated diffusion and carrier-mediated uptake.

Nonfacilitated Diffusion

Most herbicides move across the plasma membrane of plants by non-facilitated diffusion. This process is often called simple diffusion. Those that diffuse across the membrane can be divided into two groups based on their physiochemical characteristics. These include lipophilic neutral (lacking charge) molecules and lipophilic molecules with a functional group sensitive to pH. This latter group (weak acids) can dissociate into a less lipophilic ion.

Lipophilic Neutral Molecules

Lipophilic, neutral herbicide molecules are thought to passively diffuse very rapidly across the lipid bilayer of plant membranes down their concentration gradient. The plasma membrane is not a barrier to their absorption, and uptake of these compounds is independent of pH. Many herbicides, including the triazine compounds, penetrate plant cell membranes by simple diffusion.

Lipophilic Molecules with Functional Group Sensitive to pH

Lipophilic herbicides with a functional group sensitive to pH are referred to as weak acids. They typically have pK_a values between 2 and 5. At the pK_a value weak acid herbicides exist at a 1:1 ratio in both the neutral undissociated form and as the anion. The undissociated acid freely diffuses across the plasma membrane because cell membranes are more permeable to undissociated, neutral molecules compared to dissociated, charged molecules. Once in the alkaline compartments of the cell (cytoplasm), the neutral acid form releases the hydrogen ion (acid group) and the herbicide becomes negatively charged. This disassociation process creates a concentration gradient for further influx of the neutral acid form. This process results in accumulation of the anionic herbicide in the cytoplasm. The negatively charged molecule in the cytoplasm has a low permeability across the plasma membrane and cannot readily move out of the cell. Thus, weak acid herbicides accumulate in the cytoplasm by an ion trapping mechanism. These compounds nearly always translocate in the phloem via the symplastic pathway.

Carrier-Mediated Uptake

Some herbicides are moved across the plant membrane very slowly. A protein transport carrier may limit the rate of uptake. Evidence suggests that uptake of 2,4-D (also a weak acid), glyphosate, glufosinate, and paraquat is via a carrier-mediated system. The carrier in these cases is a protein that typically transports other cellular constituents. Once these herbicides have entered the cell they do not move back into the apoplast (cell wall) to any degree. Like the weak acid herbicides, they are translocated primarily within the symplastic pathway.

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Surfactants and Additives

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Adjuvants for postemergence herbicide applications

An adjuvant is any material added to a herbicide spray solution to enhance or modify the performance of the solution. Adjuvants can be divided into two general categories: spray modifiers and activators (Kirkwood, 1994). Spray modifiers are those adjuvants that change the wetting, spreading or sticking characteristics of the spray solution. This is primarily accomplished by a modification in the surface tension of the spray solution. Activator adjuvants primarily influence the absorption of the herbicide by a direct interaction with the plant cuticle. The most common types of adjuvants are surfactants (surface active agents). Surfactants can be defined as spray additives that facilitate or enhance the emulsifying, dispersing, spreading, sticking or wetting properties of liquids (spray modifiers). However, surfactants also directly influence the absorption of herbicides by changing the cuticle characteristics (activators). Surfactant types receiving significant attention in the past few years are organosilicones. Another commonly used adjuvant type is oil. In addition to oils being used as adjuvants they can also be used as contact herbicides and as carriers for synthetic herbicides. A third adjuvant type, salts commonly used as fertilizers, is rapidly gaining in popularity. A final adjuvant grouping are buffers which are used to adjust the acidity of the spray solution. The most commonly used buffers are for reducing the pH of water.

Surfactants

Most surfactant molecules are composed of a lipophilic long chain hydrocarbon (alkyl) group and a hydrophilic polar group. The polar group can be ionic [cationic (positive charge), anionic (negative charge) or zwitterionic (having both a positive and negative charge)] or nonionic. Because adjuvants contain both lipophilic (oil-like) and hydrophilic (water-like) properties, they can interact with lipophilic plant surfaces and lipophilic herbicides as well as hydrophilic herbicides and water. The most common surfactants for agricultural use are nonionic and anionic. Common anionic surfactants are alkyl sulfates and alkylbenzene sulfonates (see diagram). Most agricultural nonionic surfactants have chains of ethylene oxide (also called oxyethylene or ethoxylate) (-CH2CH2-O-) as the polar (hydrophilic) groups. The number of ethylene oxide units in the polar portion of the nonionic surfactant is often referred to as the "number of moles of ethylene oxide (EO)." Common nonionic surfactants are alcohol, alkyl sulfates and alkylphenol ethoxylates (see diagram). Propylene oxide [-(CH2)3-0-1 or butylene oxide [-(CH2)4-0-1 can be built into the ethylene oxide chain to reduce its hydrophilic nature which makes the surfactant more compatible with lipophilic herbicides (Butselaar and Gonggrijp, 1993). The more EO or PO units on the surfactant the more polar the surfactant. The polarity of the surfactant can be further modified by the constituent at the end of the EO or PO chain (often called the end-cap). For example, a methoxy end-cap (-O-CH3) is less polar than a hydroxy end-cap (-OH).

Amine surfactants (e.g., tallow amines) are available for use as nonionic adjuvants and formulation components (e.g., Roundup) and as cationic quaternary amine adjuvants (often called "quats"). Another type of nonionic surfactant uses one or more glucose molecules as the hydrophilic polar group (Hoyle and Holloway, 1996). These are often called alkyl polysaccharides or alkyl polyglycosides. The "saccharide" name comes from containing sugar (glucose) and the "glycoside" comes from the covalent bonding of two sugars via a glycosidic bond (a hydroxyl group on one sugar bonded with a carbon on another sugar). Although more expensive than conventional nonionic surfactants, they are more biodegradable and more compatible (mixable) with ammonium based fertilizer solutions used as surfactants. Often these surfactants are sold as mixtures with ammonium sulfate.

Surfactants are often assigned a "hydrophilic-lipophilic balance"(HLB) value. For nonionic surfactants this value is approximated by the weight percent of the total weight of the surfactant that is hydrophilic. For ionic surfactants the HLB is less straight forward and is usually determined experimentally. In one popular system (from ICI), HLB has been given a numerical range from 1 to 20. HLB values can be estimated by observing dispersibility in water (no dispersion = 1 to 3, poor dispersion = 3 to 6, unstable milky dispersion = 6 to 8, stable milky dispersion = 8 to 10, translucent to clear dispersion = 10 to 13, and clear solution = 13+). Lipophilic (lipid soluble) surfactants are assigned HLB numbers of 8 and below. Surfactants with HLB numbers between 9 and 11 are intermediate, and those with HLB numbers above 11 are hydrophilic in nature (water soluble). Surfactants used as wetting agents have HLB values of 7 to 9. A Surfactant with optimal HLB for a particular herbicide can be predicted based the water solubility of the herbicide --> low HLB surfactants for water insoluble herbicides and high HLB surfactants for water soluble herbicides. For example, de Ruiter, Uffing and Meinen (1996) and Nalewaja, Devilliers and Matysiak (1996) showed that high HLB surfactants were more effective at increasing glyphosate (water soluble) efficacy than low HLB surfactants. Tan and Crabtree (1992) reported that for polyethylene-glycol based surfactants, absorption of adjuvant into plant cuticles was inversely related to HLB numbers (i.e lower HLBs absorbed better). This is not surprising because low HLB surfactants are more lipophilic thus more able to diffuse into the lipophilic cuticle than high HLB surfactants that are less lipophilic.

At very low concentrations surfactants are soluble in water; however, as the surfactant concentration is raised to those commonly used in weed control, the lipophilic groups associate with one another to form "micelles". The surfactant concentration where micelle formation occurs is called the "critical micelle concentration" (CMC). These micelles can emulsify lipophilic substances, including herbicides, oils and perhaps cuticular components. The emulsifying agents used in EC formulations are usually blends of surfactants.

An important aspect of surfactants used as adjuvants is to reduce the surface tension of a spray solution in order to allow a more intimate contact between spray droplet and plant surface. Many surfactant effects occur at concentrations well above the CMC; therefore, the mechanism of action of surfactants must be more than just reducing the surface tension of the spray solution (Tan and Crabtree, 1992). For example, Wirth, Storp, and Jacobsen (1991) have shown that rebound of spray droplets from plant surfaces was reduced only when surfactant concentrations were well above the CMC.

Any substance that will bring the herbicide into a more intimate contact with the leaf surface and keep it in a soluble form has the potential of aiding absorption. Surfactants achieve this by:

1. Causing a more uniform spreading of the spray solution and a uniform wetting of the plant.
2. Helping spray droplets stick to the plant, resulting in less runoff.
3. Assuring that droplets do not remain suspended on hairs, scales or other surface projections.
4. Partially solubilizing the lipoidal plant cuticle substances (controversial).
5. Preventing crystallization of the active ingredient on the leaf surface by being a solvent.
6. Slowing the drying of, and increasing the water retention in, spray droplets once on the leaf surface.

After passing through the cuticle, surfactants may also increase movement of herbicides (e.g. glyphosate) through the plasma membrane (Wade, et al.,1993 and de Ruiter and Meinen, 1996).

An important action of adjuvants is their penetration into the plant cuticle. The amount of a nonionic surfactant that absorbs into and across the cuticle is dependent on the EO content. For octylphenol nonionic surfactants, Coret, et al. (1993) showed movement into the cuticle was highest for those with low EO contents (more lipophilic). The mechanism of action of nonionic surfactants once inside the cuticle is not fully understood, but progress is being made. Most evidence shows surfactants used in herbicide applications do not simply "solubilize" the cuticle (Riederer and Schonheff, 1990). The mechanism may well be different for high EO (hydrophilic) and low EO (lipophilic) nonionic surfactants. Increased water permeability of the cuticle can be measured after application of many high EO surfactants (Riederer and Schbnherr, 1990). In detailed studies Coret and Chamel (1993, 1995) have shown that at a given relative humidity, surfactants with high EO contents can increase the hydration state of the cuticle. For example, for the relative humidities tested (20 to 80%) a nonylphenol surfactant with 17 EO's greatly increased the water absorption into isolated tomato fruit cuticles when compared to no surfactant. However, when the EO content of the nonylphenol was 4, there was no increased water absorption when compared to no surfactant. An increased hydration state of the cuticle induced by high EU surfactants may well increase the diffusion of water soluble herbicides across the cuticle. The questions then arises as to how surfactants increase the absorption of oil soluble herbicides. Coret and Chamel (1994, 1995) used differential scanning calorimetry to show wax melting begins at a lower temperature after absorption of some surfactants (nonylphenol; 4 EO). They suggested the increased absorption of oil soluble herbicides (chlorotoluron was their model) may be due to an increase in wax fluidity which would increase the rate of diffusion across the cuticle. Schreiber (1995) and Schreiber, Riederer and Schom (1996) proposed that surfactants induce a unspecific and reversible "plasticizing" interaction between surfactant and cuticular wax which enhances solubility of the herbicide in the wax. Because the effect was reversible, the surfactant did not alter the molecular wax structure (solubilizing the wax or changing its crystalline nature). Substances other than surfactants can influence cuticle fluidity. Schonherr (1993a) showed alcohols with 7 to 10 carbon atoms increase the movement of herbicides across the cuticle by increasing its fluidity.

Thus, the prediction would be absorption of hydrophilic herbicides are aided most by surfactants with high EO content and lipophilic herbicides are aided most by surfactants with low EO contents (see the review by Kirkwood, 1993). This has been confirmed by experimental evidence (e.g., Riechers, et al., 1995; Sharma, Kirkwood and Whateley, 1996). Surfactants with an EO content of 11 to 20 were more effective than surfactants with 6 EO in increasing glyphosate (water soluble) activity on oats (van Toor et al., 1994). Coret and Chamel (1994) found that chlorotoluron (water insoluble) movement across isolated box-tree cuticles was greater for surfactants with low EO content (3 to 6) than for surfactants with high EO content (16 to 20). These authors also found that the concentration of surfactant in the cuticle was higher for low EO surfactants when compared to high EO surfactants. Picking the best surfactant also depends on the lipophilic portion of the surfactant. For example, at a given EO content, Coret and Chamel (1993) found glyphosate transfer across an isolated cuticle was greatest when the lipophilic portion of the surfactant (termed the hydrophobe) was a primary aliphatic amine and least when an aliphatic alcohol.

Some surfactants have a detergent action. The maximum detergent action occurs when the surfactant has a hydrophobe carbon chain length of from 12 to 14 and a total EO content of greater than 60% of the weight of the surfactant. Current evidence, however, suggests the detergent action of surfactants do not play much of a role, if any, in enhancement of herbicide absorption (Stock and Holloway, 1993). Riederer and Schbnherr (1990) found no detectable amounts of aliphatic wax constituents were lost when the cuticles of orange and pear were treated with excessive amounts of nonionic and ionic surfactants and subsequently washed with water. It is also unlikely surfactants solubilize wax constituents in the cuticle. As Riederer and Schonheff (1990) point out, wax solubilization would be expected to be slow because much of the cuticular wax is in an ordered crystalline state and contain very long hydrophobic alkyl chains.

The addition of a surfactant can enhance foliar herbicide penetration in all types of plants. Therefore, a surfactant may reduce the tolerance of the herbicide to a crop if that tolerance is dependent upon selective foliar penetration (e.g., see Grayson, Webb and Pack, 1993).

Stomatal penetration (infiltration) of spray droplets from a water based solution is a complex process and does not occur in field applications of herbicides without surfactants. Stomatal infiltration is not possible unless the surface tension of the spray solution is significantly reduced by the use of surfactants in the formulation or spray tank. Most surfactants are not able to reduce the surface tension adequately to allow stomatal infiltration. However, the organosilicone surfactants (described below) reduce surface tension to the point where stomatal infiltration occurs. Even after stomatal infiltration, the herbicide must still penetrate a thin cuticle that exists on the cell surfaces of the cavity below the stomata.

The overall action of surfactants in enhancing herbicide absorption is complex and no doubt due to several factors. This fact was well stated by Stock and Holloway (1993):"Different surfactants do different things to different agrichemicals on different target species."

Organosilicone surfactants

During the past few years there has been a significant increase in the interest of using organosilicone adjuvants for herbicide applications. Excellent overviews of organosilicone surfactants have been published by Stevens (1993) and Knoche (1994).

Organosilicone surfactants are often composed of a trisiloxane-backbone (lipophilic or hydrophobe portion) with an ethylene oxide chain (hydrophilic portion) attached to one of the silicon atoms. The hydrophilicity can be reduced by using a mix of EO and PO or modifying the EO end-cap. Silicone backbones other than trisiloxane are being investigated. The hydrophobicity of the silicone backbone is not associated with the presence of silicon, but rather with the flexibility of the siloxane chain enabling exposure of methyl groups at the interfaces between the surfactant and it environment. Methyl groups are more hydrophobic than the methylene (CH2) groups which make up the bulk of the hydrophobe in conventional surfactants. The most commonly used organosilicone surfactant is Silwet L-77, which has a relatively low polarity due to the EO content being only 8. A newer product, Silwet 806, contains both EO and ranomly distributed PO and is said to be cost competitive with emulsifiable oils for application of graminicide herbicides (Policello, Stevens, and Murphy, 1996).

Organosilicone surfactants yield a reduction of surface tension of water based spray solutions greater than other surfactants. Organosilicone surfactants cause substantially greater spreading of the spray drop than would be predicted by the reduction in surface tension. This increased spreading is proposed by Ananthapadmanabhan, Goddard and Chander (1990) to be due to the compact size of the lipophilic portion of the trisiloxane moiety allowing it to transfer readily from the liquid/air interface of the advancing solution to a leaf surface. This action has often been termed "molecular zippering." Organosilicone surfactants with less compact hydrophobes exhibit reduced spreading. The ultimate limit to spreading may well be the depletion of the surfactant in the solution by adsorption at the expanding cuticle/liquid interface. Spreading is often less on leaves having increased surface area due to the presence of microcrystalline wax (e.g. grass species). The intense spreading of organosilicone surfactant solutions can lead to reduced spray retention on some plants if the application volume is high (due to run-off). However, the increased spreading characteristic allows better adherence of spray drops to those leaves that are highly water repellent. The increased spreading of a spray drop increases its evaporative surface which can lead to rapid drop drying (and reduced absorption); however, organosilicone surfactants have significant humectant properties which slow drying. Organosilicone surfactants are not only effective at increasing the overall absorption of herbicides, but are effective at decreasing the time needed for rainfastness (Roggenbuck, et al., 1993 and Sun, Foy and Witt, 1996).

One mechanism for organosilicone surfactant effectiveness is they induce direct stomatal infiltration (flooding) of the spray solution (Field and Bishop, 1988, and Buick, Robson and Field, 1992). For stomatal infiltration to occur surface tension of the spray solution needs to be less than the critical surface tension for stomatal infiltration. For example, in one study the critical surface tension of field bean (*Vicia faba* L.) for stomatal infiltration was determined to be 19.5 to 22.9 mNm^{-1} (Buick, Buchan and Field, 1993). The surface tension of a surfactant solution containing Silwet L-77 organosilicone surfactant (2.5 to 5.0 nil/L; CMC about 0. 1

nil/L) averaged 22 mNm^{-1}, which was low enough to permit stomatal infiltration. Stomatal infiltration is most closely controlled by surfactant concentration (Green, et al., 1996). However, many reports also show that organosilicone surfactants influence absorption of herbicides through the cuticle after stomatal infiltration is complete.

One problem with these surfactants is they are unstable when the pH of the spray solution is not within the range of 6 to 8 (Murphy, Policello and Ruckle, 1991). Hydrolysis of siliconoxygen bonds occur under acidic as well as basic conditions. This effect can be reduced by buffering the spray solution to a neutral pH. An organosilicone surfactant containing only one silicon atom (thus no silicon-oxygen bonds) is claimed to be as effective as trisiloxanes (Klein, Wilkowski and Selby, 1996). The best surfactants of this type have a trimethyl silane group attached to a short hydrocarbon chain (six was reported to be optimal) which is attached to an EO chain (see diagram). The surface tension of aqueous solutions containing this surfactant were low enough (23 mN/m at 0.1%) to allow stomatal infiltration.

Another disadvantage of trisiloxane surfactants is their high degree of spreading is lost when mixed with other non-organosilicone adjuvants (Murphy, Policello and Ruckle, 1991). The incompatibility is attributed to competition between the compact hydrophobe of the organosilicone and the bulky hydrophobe of the conventional surfactants for the interface between the spreading drop and the leaf Oamming the zipper). However, surfactants have now been identified that can be effectively mixed with the organosilicones. The extreme surface activity of these surfactants can cause excess foaming. This is managed by including a commercial antifoaming agent in the spray solution. Because of the extreme surface active characteristics of these surfactants, eye and skin contact must be avoided. A final problem is, to date, the cost of these adjuvants is significantly above conventional surfactants. This cost is associated with the need to distill the trisiloxane from bulk silicone fluid.

Organosilicone surfactants are not effective for all herbicides. For example, including organosilicone surfactants with glyphosate (Roundup) sprays can cause antagonism [see Knoche (1994) for review]. The cause is not known, but may be associated with the rapid drying of spray droplets due to extensive spreading. Gaskin and Stevens (1993a) proposed another explanation for the antagonism. They reported rapid glyphosate absorption in grass species immediately after application with organosilicone surfactants (stomatal infiltration), but glyphosate absorption slowed significantly 1 hr after application when compared to glyphosate absorption without organosilicone surfactants. This result confirms organosilicone surfactants have a cuticular absorption affect in addition to their inducing stomatal infiltration. These authors did not find any interaction between the organosilicone surfactant and the tallow amine ethoxylate surfactant present in Roundup. They suggested the antagonism occurred within the cuticle due to the rapid penetration of the organosilicone surfactant somehow impeding the pathway for further glyphosate absorption. In a related study, Gaskin and Stevens (1993b) reported the antagonism of glyphosate absorption was decreased by increasing the polarity (e.g., increasing the EO content) of the organosilicone surfactant.

Oils as Carriers and Adjuvants

Oils used in agriculture are of two primary types: refined mineral oil (petroleum based) and seed oils (sometimes called vegetable oils). Mineral oils are specific "cuts" from the distillation of petroleum. These oils require an extensive refining procedure prior to use as agricultural adjuvants. This involves solvent extraction to remove aromatics, dewaxing, and a final fractionation to recover a narrow boiling range oil. Nonphytotoxic mineral oils used as adjuvants usually have a high proportion of paraffin oils (long straight or branched chain hydrocarbons with chain lengths usually from 18 to 30 carbons). Seed oils are extracted from plants by pressing or solvent extraction. The hydrocarbon chain length of seed oils are even numbered with 16 or 18 carbons dominating. Seed oils need further purification to remove gums, mucilages, and phospholipids (e.g., precipitated with phosphoric acid then neutralized with sodium hydroxide) as well as color (e.g., heating in the presence of Fuller's earth) and short-chain aldehydes, ketones, acids and hydrocarbons (e.g., injecting steam into heated oil). Citric acid can be added to chelate metals which can cause oxidation and rancidity.

There are two main types of seed oils used in agriculture: "triglycerides" and "methylated oils." Triglyceride oils have a glycerol backbone with fatty acids esterified to each of the three carbon atoms in the glycerol. The fatty acids attached to each carbon of the glycerol are often different and overall, triglyercide oils have a higher viscosity than methylated oils. Seed oils are primarily triglycerides when isolated. Triglyceride oils need to be liquid at application temperatures, thus the attached fatty acids are often oleic (18: 1) or linoleic (18:2). While these oils can be used directly in agricultural applications they often perform better as adjuvants when in the methylated oil form (Nalewaja, 1994, Urvoy, Pollacsek and Gauvrit, 1992 and Nalewaja, Praczyk and Matysiak, 1995). In this case the fatty acids are removed from the glycerol backbone during processing and then esterified with methyl alcohol (methyl esters of fatty acids, which are termed methylated oils). This can be accomplished by hydrolyzing the triglyceride to yield free fatty acids, then esterifying them with methyl alcohol or by inducing a trans-esterification in which the triglyceride is reacted with methanol in the presence of sodium methoxide. Other esters have been prepared and tested (ethyl, butyl), but show little or no advantage over the methyl esters (Nalewaja, 1994). For a review of oil chemistry see Hamilton (1993). The composition of triglyceride oils varies depending on the seed source and consequently the composition of methylated oils will also vary depending on the source. The fatty acid composition does influence efficacy; however, the optimum composition varies for different herbicides and must be determined experimentally (Nalewaja, 1994).

There are two ways oils can be used in weed control: as a carrier for synthetic herbicides and as an adjuvant for spray solutions. Nonphytotoxic oils have been used as carriers for oil soluble herbicides applied postemergence; however, the application volumes originally used are no longer practical. Research on delivery systems such as the air-assist spray nozzle (McWhorter, Fulgham and Barrentine, 1988) and positive displacement pump (Hanks and McWhorter, 199 1) has rekindled the interest of using oils as carriers for oil soluble herbicides at ultra low volumes (1/4 to I gallon per acre) (Bohannan and Jordan, 1995). There are several advantages of using oils as carriers in low volume postemergence applications of oil soluble herbicides rather than water: low surface tension results in good wetting and spreading on treated leaves (McWhorter, Ouzts and Hanks, 1993), quicker and more thorough absorption of the herbicide yields higher activity, rapid rainfastness, the herbicide is less affected by cuticle composition, and there is less loss of the carrier during and after application.

Emulsifiable oils can be used as adjuvants (the usual volume is about 1 quart per acre). These adjuvants contain a nonphytotoxic oil (80 to 98%) and a surfactant (2 to 20%), and are often called crop oil concentrates (COC) when containing 15 to 20% surfactant and crop oils (CO) when containing 2 to 5% surfactant (note - this nomenclature is not universally accepted). The oil is usually a highly refined paraffin based oil or a methylated seed oil. There is significant interest in using seed oils as emulsifiable oils. Methylated esters obtained from seed oils usually perform better than the parent triglyceride oils and are often comparable to petroleum oils (Nalewaja, 1994). In one study, the absorption of diclofop-methyl was increased 11.8 fold when a methyl oleate oil was included in the formulation (Urvoy and Gauvrit, 1991). There was a 72% absorption of the oil itself during a 27 hour period. Emulsifiable oils usually enhance oil soluble herbicide absorption more than the corresponding surfactant alone. The purpose of the surfactant in the mixture is to emulsify the oil in the water based spray solution and lower the surface tension of the spray solution, but they can also can interact with the cuticle and assist herbicide absorption. In one study (de Ruiter, Uffing, and Meinen, 1997) the emulsifier was as effective as the oil + emulsifier (surfactant) at increasing efficacy of three out of four herbicides tested. The exact mode of action of these oils is unknown, but they enhance spreading of the droplet on the sprayed plant surface and increase the absorption of the herbicide into the plant (Gauvrit and Cabanne, 1993). Santier and Chamel (1996) proposed that after oils partition into the cuticle they increase the fluidity of cuticular components which increases the diffusion of oil soluble herbicides through the cuticle. Whether oils act as solvents of cuticular components (waxes) is controversial. For example, Manthey and Nalewaja (1992) reported methylated sunflower oil completely dissolved wax isolated from green foxtail, whereas Gauvrit and Cabanne (1993) reported methylated rapeseed oil did not dissolve wax extracted from several different plant species.

Salts of Fertilizers as Adjuvants

There is an increasing interest in using fertilizers as adjuvants in water based spray solutions. Many publications (see "Fertilizer Solutions" reference section for examples) show that adding ammonium sulfate, ammonium nitrate or urea plus ammonium nitrate (28% UAN) to postemergence herbicide spray solutions increases efficacy. Other salts have also been shown to increase herbicide performance. For example, sodium bisulfate increased the activity of imazamethabenz in wild oat (Liu, et al., 1995).

Although the exact mechanism of action is unknown, there are several reports of increased herbicide absorption when these fertilizers are used as adjuvants. In one study (Fielding and Stoller, 1990) the absorption of thifensulfuron into velvetleaf was increased from 4% without adjuvant to 45% with the addition of 28% UAN (9 L/ha; about 1 gal/acre). With regard to mode of action, one report (MacIsaac, Paul and Devine, 1991) suggested ammonium sulfate reduces the precipitation (crystallization) of herbicides (glyphosate) on the plant surface. Another mechanism may be the formation of ammonium salts of weak acid herbicides on the leaf surface (Wanamarta, Kells and Penner, 1993). Generally, an ammonium salt of herbicides more freely diffuses across the cuticle than the corresponding inorganic salt (e.g. sodium or potassium salt).

Ammonium sulfate used as an adjuvant has also been successful at overcoming decreased herbicidal activity due to antagonism with another component in the spray solution. Calcium, sodium, potassium, and magnesium salts in water used as a spray carrier have been reported to antagonize the efficacy of herbicides such as 2,4-D, bentazon, dicamba, acifluorfen, imazethapyr, glyphosate, nicosulfuron and clethodim (Nalewaja and Matysiak, 1993a, 1993b, McMullan, 1994 and Nalewaja, Praczyk and Matysiak, 1995). These authors showed the application of ammonium sulfate to the spray solution, in many instances, overcame the antagonism. Citric acid was found to overcome the antagonism of calcium on glyphosate activity by formation of calcium citrate which prevented the formation of the calcium salt of glyphosate (Thelen, Jackson and Penner, 1995b). Nalewaja, Devilliers and Matysiak (1996) showed that the uptake of glyphosate salts in wheat was isopropylamine > ammonium > sodium > calcium. In a spray solutions containing calcium and sodium ions, adding ammonium sulfate will reduce the effect of these ions on glyphosate absorption during drop drying by forming calcium sulfate (lower solubiliy than calcium glyphosate) and ammonium glyphosate prior to the formation of sodium glyphoste. In some cases antagonism between herbicides [e.g. bentazon plus sethoxydim (Wanamarta, Kells and Penner, 1993) and primisulfuron plus atrazine, dicamba or bentazon (Hart, Kells and Penner, 1992)] can be reduced by adding ammonium sulfate to the spray solution.

Humectants

The majority of herbicide is absorbed into the plant when it is in true solution on the leaf surface. Once the herbicide solution becomes dry and crystalline on the leaf surface, absorption decreases. Therefore humectants, in theory, should be ideal adjuvants. Although humectants have been evaluated as adjuvants, they are not extensively used in commercial applications of herbicides. In one study, Sundaram et al., (1996) showed glyerol addition to glyphosate spray solution containing Silwet L-77 organosilicone surfactant increased rainfastness as well as control of aspen trees.

Buffers

Buffers are adjuvants that modify and then maintain the pH (acid or base nature) of spray solutions. Buffers are defined as "systems capable of resisting changes in pH." They consist of molecules having a conjugate acid-base pair which can act as an proton donor and proton accepter. Some herbicides are not stable in aqueous solutions unless they are maintained at near a neutral pH (near 7). When the pH of the spray solution is away from neutral, the herbicides can be subject to base or acid hydrolysis.

In agricultural applications buffers are primarily added to spray solutions when the water used is either acidic or basic. These buffers bring the pH of the water back to near neutral and then maintain it near neutral. Buffers are most frequently used to reduce the pH of water from basic to neutral or slightly acidic. The most common commercial buffers to reduce the pH of a spray solution contain phosphoric acid (Buffercide®) or phosphoric acid plus surfactant (Bufferplus®). Another common agricultural buffer (Buffer X®) contained free fatty acids to reduce the pH of the spray solution and a surfactant. If the pH of the spray solution is too low, sodium carbonate (soda ash) is the most common additive.

Reference on Adjuvants

General Overviews

In 1992 a book titled "Adjuvants for Agrichemicals" (edited by C.L. Foy) was published by CRC Press, Boca Raton, FL. This book is based on papers presented at the Second International Symposium on Adjuvants for Agrichemicals. Included in this book (pages 3-15) is a biographical survey written by P.N.P. Chow and C.A. Grant containing 1490 references divided into nine subject categories.

Twelve papers on adjuvants from The Third International Symposium on Adjuvants for Agrichemicals were published in Pesticide Science during 1993 (Volume 37 Number 2). An additional 18 papers were published in Volume 38 Number 2/3.

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Clarity Herbicide

Kay Mercer, BASF

BASF's CLARITY Herbicide is a new salt of dicamba. The registration was received in California in early August, 1998, but the federal label has existed for several years. There are many similar characteristics between Clarity and other dicamba herbicides such as labeled rates, crops, and many physical properties. One difference is that CLARITY is a diglycoamine salt of dicamba and is considered to be a new active ingredient. CLARITY is a much larger compound than other dicamba herbicides and has a significantly reduced vapor pressure. Reduced volatility means CLARITY will not lift off after it has been applied. This makes CLARITY safer to use around adjacent sensitive crops. Therefore, temperature restrictions for application timing have been removed from the label. Crop rotational restrictions have also been removed from the label. CLARITY is listed on the California Restricted Use Pesticide list; and therefore, must be included on application permits and must have a Notice of Intent (N.O.I.) filed with the county agricultural commissioner's office prior to use. CLARITY is labeled preand post-emergence for use on corn (8-16 oz/acre) and small grains (2-4 oz/acre). Applications to weeds should be made before corn reaches eight inches in height. CLARITY is also labeled for sorghum, pasture, hay, rangeland, general farmstead (non-cropland), fallow, sugarcane, asparagus, turf and lawn, and grass seed crop uses. Please read the label for guidance as to application timing, rates relative to soil type, and other precautions. Note that care must be taken during CLARITY applications because adjacent sensitive crops are still subject to injury if physical drift occurs during application. Consult the label for application precautions and tank cleaning procedures.

New Product Registrations from Elf Atochem North America, Inc. Aquathol® Super K And Desicate®II

Roy S. Whitson, Ph.D. Field Development Representative

Elf Atochem will introduce a new formulation of Aquathol® aquatic herbicide in 1999 as Aquathol® Super K Granular Aquatic Herbicide. The Super K formulation is a granular formulation using super absorbent polymers as the carrier. The use pattern is identical to the current Aquathol® Granular Aquatic Herbicide formulation, but the Aquathol Super K is 6 times more concentrated (63% active vs 10.1% active). Thus, Aquathol® Super K will require 6 times less material per application, and fewer empty containers per application. Aquathol® Super K received EPA registration at the end of 1998, and should be registered for use in California during the first quarter of 1999.

In 1998, Desicate®II was registered for use in California. Like Des-I-Cate® which it replaces, Desicate®II is registered for use as a potato vine desiccant, and harvest aid for seed alfalfa and clover. Desicate®II is a more concentrated formulation of Des-I-Cate® with 2 lbs/gallon of endothall versus 0.52 lbs/gallon in the previous formulation. This more concentrated formulation means lower use rates (quarts per acre, instead of gallons per acre), and fewer containers for disposal. Applications of Desicate®ll should include ammonium sulfate and a surfactant (preferably silicone based) for maximum efficacy. Please read and follow label directions thoroughly prior to use.

New Registration: Confront* for Post-Emergence Broadleaf Weed Control in Turf

Bruce Kidd, Dow AgroSciences, Murrieta, CA

In December 1998, Dow AgroSciences announced the posting for California registration of CONFRONT, a new, nonphenoxy, post-emergence herbicide for annual and perennial broadleaf weed control in turf. Full registration is anticipated in January, 1999.

CONFRONT is a combination product featuring 33% triclopyr amine plus 12.1% clopyralid amine, formulated as 3 lb/gallon concentrate, and packaged in 1-gallon jugs and 30-gallon drums. CONFRONT is labeled for all common species of turf grown in California, and is especially recommended for cool season species such as tall fescue, perennial rye, and Kentucky bluegrass. Bentgrass may be treated with CONFRONT at the low rate only, and if some injury can be tolerated. Warm-season grasses such as Bermudagrass and Kikuyugrass have shown sensitivity to CONFRONT when treated in the Fall, during high temperatures, or when height of cut is below

At low use rates of 1-2 pints/A, CONFRONT has shown exceptional control of annual and perennial clovers, plaintain, chickweed, dandelion, and creeping yellow woodsorrel (Oxalis corniculata). CONFRONT works slowly, translocating to all parts of the plant for complete control. Low volume applications at 5-20 GPA or standard broadcast applications delivering 2-200 GPA are recommended, as are spot applications mixing 0.5 oz CONFRONT in 1 gallon of water per 1,000 square feet. optimum timing for applying CONFRONT is in mid-Spring or Fall, after most broadleaf weeds have emerged, but while weeds are still small and leaf cuticles have not yet hardened. CONFRONT may be tank-mixed with pre-emergence products like GALLERY* for a complete broadleaf weed control program.

CONFRONT may be used on newly seeded turf after the turf is established and has been mowed two or three times. Reseeding may be done three weeks following a CONFRONT application. CONFRONT should not be applied to exposed tree roots or suckers as injury may result. Grass clippings of turf treated with CONFRONT should not be used for mulch or compost during the season of application. Spray drift onto non-target broadleaf plants must be avoided.

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* Trademark of Dow AgroSciences

New Registration: Snapshot* 2.5tg Pre-Emergence Herbicide for Nursery Ornamentals and Landscapes

Bruce Kidd, Dow AgroSciences, Murrieta, CA

In December, 1998, California registration emergence herbicide for nurseries, landscapes and Dow AgroSciences announced the of SNAPSHOT 2.STG, a new prebroad-spectrum weed control in non-crop areas.

SNAPSHOT 2.5TG is a combination product featuring 2% TREFLAN* (trifluralin) plus 0.5% GALLERY* (isoxaben), formulated as a clay granule and packaged in 50-lb bags. SNAPSHOT 2.5TG is labeled for control of 125 weeds and grasses in 440 container or field grown ornamentals, 35 nonbearing fruit and nut trees, and in non-crop areas.

Applied to the soil prior to weed germination, SNAPSHOT 2.5TG has shown outstanding weed control for up to 4 months at the 100 lb/A rate and 8 months or longer at the 200 lb/A rate. Labeled weeds include Sowthistle, Groundsel, Russian thistle, Spurge, Oxalis, Mare's Tail, Bittercress and many others. Due to its exceptional length of control, SNAPSHOT 2.5TG may be applied less frequently than some other products. The signal word on SNAPSHOT is CAUTION.

SNAPSHOT 2.5TG may be broadcast over bare soil or over-the top of labeled species. SNAPSHOT 2.5TG will not burn plants even if granules stick to wet foliage on hot, sunny days. overhead irrigation, rainfall or light raking is recommended to incorporate the herbicide into the soil and promote activation. Light raking at any time will not break the barrier and may even improve control by making the barrier more uniform. SNAPSHOT 2.STG is non-staining and odorless.

SNAPSHOT 2.STG should not be applied to bedding plants, pots less than 4" wide, nursery seedbeds, unrooted cuttings or liners, or to plants in poor health.

After nearly eight years of use in other states, SNAPSHOT 2.5TG has proven to be a reliable, economical and easy-touse product that provides the broadest-spectrum weed control for the most months over the most ornamentals species of any pre-emergence product on the market.

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* Trademark of Dow AgroSciences

POSTERS

Changes to Preemergent Herbicide Use Maintains Weed Control and Reduces Off Site Movement Risk in Citrus

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Introduction

In the San Joaquin Valley of California, weeds are currently managed with preemergent herbicides in fall and winter seasons to control germinating weeds. At least half of the annual preemergent herbicide is applied during the fall in order to maintain bare soil through the winter because vegetation cover during the winter is thought to lower tree canopy temperature. Clean citrus orchard middles often are compacted and have low water infiltration rates. Low infiltration rates and a smooth soil surface result in a greater potential for surface runoff. Losses of herbicides from soil to surface runoff water result in a decrease in the effectiveness of the soil herbicide and increase the risk of lower water quality. Effectively managing weed problems in citrus orchards while maintaining environmental and human health is an objective of our work.

Materials and Methods

Two sites were established, one near Clovis in Fresno county and the other near Ivanhoe in Tulare county. The Clovis site was in a mature grove of Navelencia oranges on a soil with 44% sand and 31% clay content. The Ivanhoe site was in an 8 years old grove of Valencia oranges. Studies were conducted from 1996 to 1998. Treatments established in each grove are listed in Table 1&2. The experimental design was a randomized complete block with 4 replications in 1996 - 1997 study and 6 replications in 1997 – 1998 study. Herbicides were applied to the soil surface over the entire orchard floor.

Total weeds by species were counted in April 1997 and May 1998 by sampling the entire area of 4 trees for each plot at both sites. Total weed numbers of each plot was logarithmically transformed before performing analysis of variance. Statistical analyses were performed using general linear model (GLM) procedure in the Statistical Analysis System (SAS, 1985). All statistical tests were performed at $\alpha = 0.05$ level of significance.

Table 1. Treatments selected for study at Clovis citrus. Treatment 1 is defined as grower standard

Trt #	Herbicide	Rate (lb ai /ac) 96 – 97	97 – 98	Season of Application	Additive	Non-chemical
1	Simazine, diuron	2.0 2.0		Fall Winter	none	none
2	Simazine, diuron	1.0 1.25		Fall Winter	Silicon Surfactant	none
3	Glyphosate, Simazine, and diuron	1.0	2.0	Fall Winter	none	none
4	Glyphosate, Simazine, diuron	1.0 1.0	1.0 1.0	Fall Winter	Silicon Surfactant	
5	Simazine, diuron	2.0 2.0		Fall Winter	PAM	
6	Untreated				none	none

Table 2. Treatments selected for study at Ivanhoe citrus. Treatment 1 is defined as grower standard.

Trt #		Rate (lb ai /ac) 96 – 97 97 – 98	Season of Application	Additive	Non-chemical
1	Simazine, diuron	2.0 2.0	Fall Winter	none	none
2	Simazine, diuron	1.0 1.25	Fall Winter	Silicon Surfactant	none
3	Glyphosate, Simazine, diuron	1.0 2.0	Fall Winter	none	none
4	Glyphosate, Simazine, diuron	1.0 1.0 1.0 1.0	Fall Winter	Silicon Surfactant	
5	Simazine, diuron	2.0	Fall Winter	PAM	
6	Simazine, diuron	2.0 2.0	Fall Winter	none	Mech. Incorp.
7	Untreated			none	none

Results And Discussion

In 1996 – 1997, weed species and density data recorded in early April illustrated the effective control achieved with all treatments at the Clovis site (Fig. 1). Plots with herbicide treatments had significantly fewer weeds than the untreated control. Weed species included: common groundsel, redstem filaree, burr medic, horseweed, annual sowthistle, and purple cudweed. Data at Ivanhoe site showed that postemergent herbicide use in the fall, followed by preemergent herbicide in late winter (treatments 3 and 4 in Table 2) were not significantly different from the untreated control (Fig. 2). All herbicide treatments besides treatment 3 (1.0 lb glyphosate in fall and 2.0 lb/ac simazine + 2.0 diuron in winter) had the same total weed density as the grower standard treatment (treatment 1). Weed species at Ivanhoe included: spotted spurge, common groundsel, horseweed, annual sowthistle and purple cudweed. Spotted spurge and common groundsel consisted of almost 100% total weeds found in the treated plots.

The result obtained in 1997 - 1998 showed that no significant difference in weed density was found between herbicide treatments at the Clovis site (Fig. 1). Plots at the Ivanhoe site had similar results (Fig. 2). All herbicide treatments significantly differed from untreated plots. Weed species at Ivanhoe site included spotted spurge, common groundsel, annual sowthistle, horseweed and hairy fleabane. Spotted spurge and common groundsel consisted of about 98% total weeds found in the treated plots. Spotted spurge and common groundsel were dominant in younger orchards treated with simazine and diuron application.

Two years' results showed that reduced rates (1.0 lb herbicide ac^{-1} or 1.25 lb herbicide ac^{-1}) were as effective as the standard rate at 2.0 lb herbicide ac^{-1} at both sites. Data from both sites also showed that weed density in 1997 – 1998 was larger than in 1996 – 1997, especially for the younger grove at Ivanhoe site. Increased weed density most likely resulted from high rainfall in 1997-1998. For example, significant rainfall-runoff events occurred after winter application of herbicide in 1998. However, in 1996- 1997 period, no rain occurred after herbicide application in winter 1997. Rainfall – runoff events could result in herbicide loss and reduce its efficiency on weed control. The Clovis site had much lower weed populations in untreated controls and herbicide treated plots compared to the younger grove at Ivanhoe. A combination of a depleted seed bank from continuous use of herbicides and shading may have contributed to lower weed populations at Clovis site. Movement of herbicides to groundwater is an ongoing problem. Lower application rates reduces the amount of herbicide available for off-site movement while maintaining weed control equivalent to standard farmer application. A fall application of postemergent herbicide followed by preemergent in late winter avoids most of the heavy winter rainfall and reduce the risk of off-site herbicide movement. Modifying how preemergent herbicides are used to control weeds is becoming increasingly important to protect both our environment and our ability to continue use of these important weed control tools.

Figure 1. Total weed density of each treatment at Clovis site. Treatment numbers along the x-axis refer to the treatments listed in table 1. Means with the same letter are not significantly different to an LSD test at the 0.05 level.

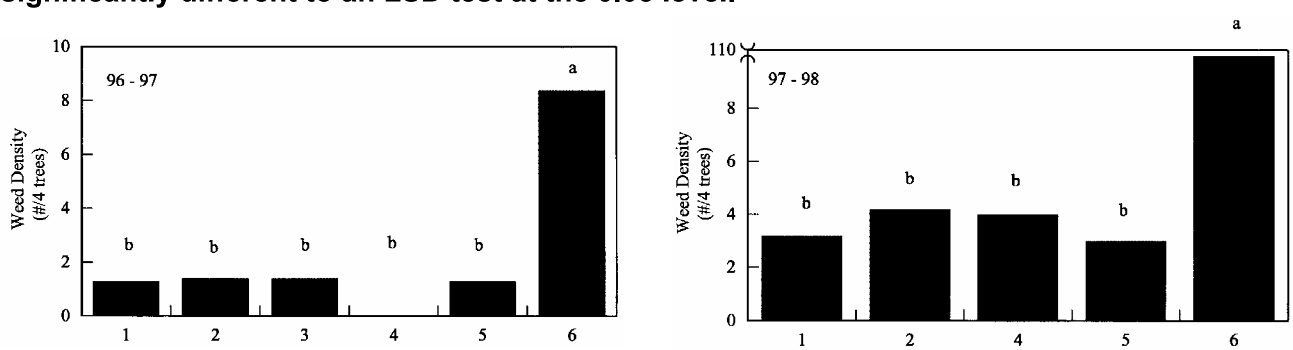
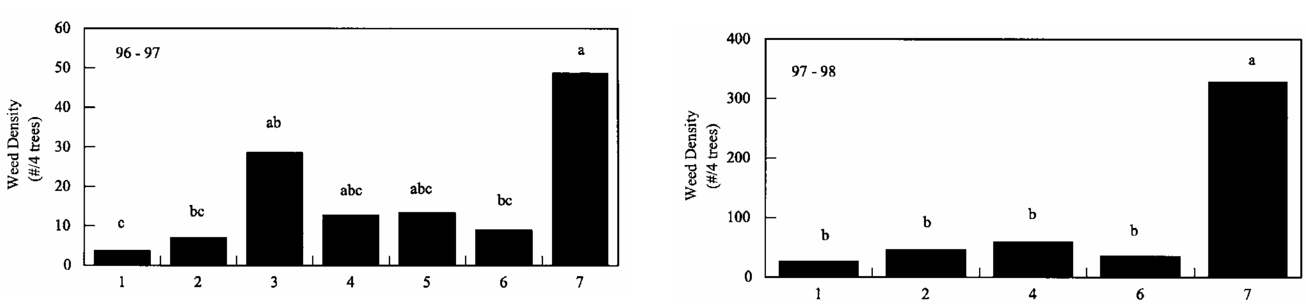


Figure 2. Total weed density of each treatment at Ivanhoe site. Treatment numbers along the x-axis refer to the treatments listed in table 2. Means with the same letter are not significantly different to an LSD test at the 0.05 level.



A Comparison of Balan, Kerb and Prefar on Thinning and Hand Weeding Time in Lettuce

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Abstract

Two studies were conducted in the Salinas Valley, CA to compare the cost of weed control in lettuce using Balan, Kerb and Prefar as base herbicides. Kerb was found to be the most effective herbicide for areas where cool-season weeds are predominate. In areas dominated by warm-season weeds, Balan or Prefar were the most effective herbicides.

Introduction

Current weed management systems used in California lettuce production include an effective combination of mechanical tillage, herbicides, cultivation and hand weeding. The cost of herbicide application, cultivation, and hand weeding represents a significant portion of the total cultural production cost per acre of lettuce (1). The provisions of the Food Quality Act (FQPA) of 1996 require the US Environmental Protection Agency (EPA) to reassess all pesticide tolerances by the year 2006 (2). During the first phase of the tolerance reassessment, the EPA plans to review the tolerances of pesticides classified as carcinogens including Kerb (pronamide) and organophosphorous compounds such as Prefar (bensulide). The potential loss of Kerb and Prefar would leave Balan (benefin) as the only soil-applied herbicide for lettuce. These studies compare Balan, Kerb, and Prefar in lettuce production.

Materials and Methods

- Two studies were conducted in the Salinas Valley, CA during 1998, one at the Hartnell farm and a second at the Spence farm.
- Hartnell was planted with Salinas MT head lettuce (June 1, 1998) and Spence was planted with Medallion romaine lettuce (July 22, 1998).
- Each study contained 7 treatments (Table) arranged in a randomized complete block design with 4 replicates.
- Plots were 4 beds wide (40 inch beds) by 75 ft long. Two rows were planted per bed.
- A hoeing crew was timed while thinning and hand weeding.
- Data collected included thinning times (29 DAP at Hartnell and Spence), hand weeding times (44 DAP at Hartnell and 51 DAP at Spence), weed densities (18 DAP at Hartnell and 29 DAP at Spence) and biomasses (74 DAP at Hartnell and 76 DAP at Spence).
- Mean separation of the data was done using Fisher’s project LSD (α=0.05).

- Cultural practices were typical for the Salinas Valley.

Results

- Where cool-season weeds predominate such as chickweed, henbit, burning nettle and shepherds-purse, hand weeding is the most efficient with Kerb as the base herbicide (Figures 1 and 2).
- Where pigweed predominates, Balan or Prefar are acceptable base herbicides (Figures 3 and 4).

Table. Balan, Kerb and Prefar base herbicide treatments for weed control in lettuce.

Treatment	Rate[a]	Timing[b]	Spray width[c]
Balan 60W	1.0	PPI	22
Balan 60W	1.2	PPI	22
Kerb 50W	1.0	PRE	5
Kerb 50W	1.5	PRE	5
Prefar 4E	5.0	PRE	5
Prefar 4E	6.0	PRE	5
Check	--	--	--

[a] lbs. ai/acre [b] PPI – Pre plant incorporated, PRE – pre plant [c] inches

Literature Cited

1. Schulbach, K. 1992. Sample costs to produce lettuce in Monterey County – 1992. Monterey County Cooperative Extension.

2. Goldman, L.R. 1997. Raw and processed food schedule for pesticide tolerance reassessment notice. Federal Register 67: 42019 – 42030.

Acknowledgements

California Lettuce Research Board

Figure 1. Weed density: Hartnell

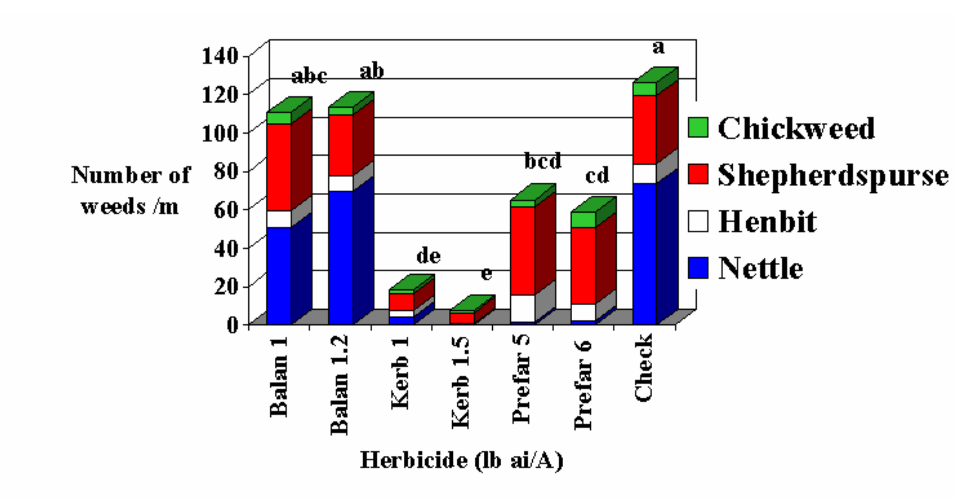


Figure 2. Hand weeding times: Hartnell

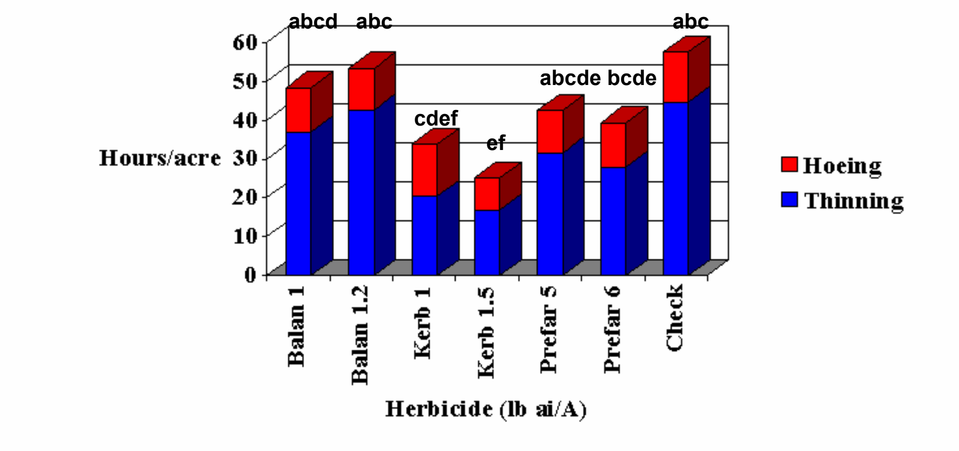


Figure 3. Weed density: Spence

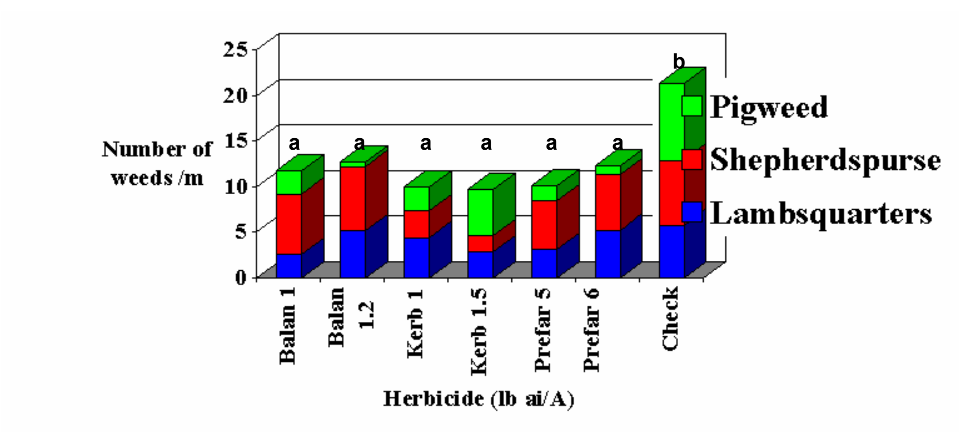
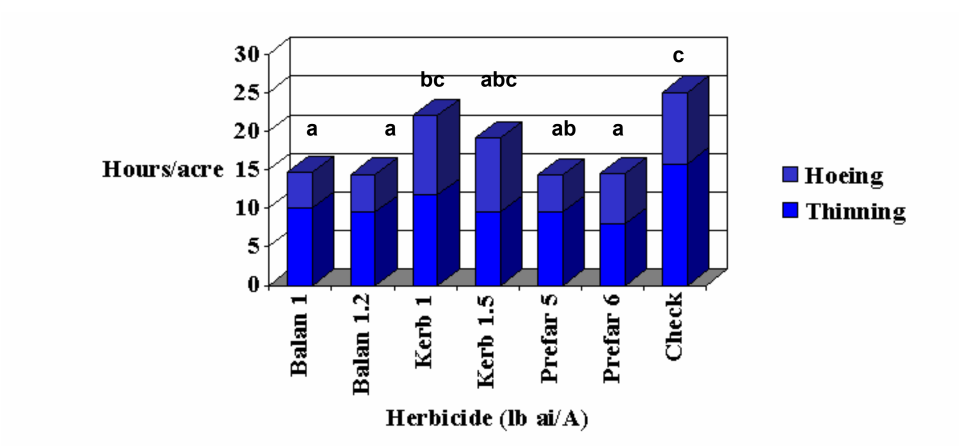


Figure 4. Hand weeding times: Spence



Control of Herbicide Resistant Watergrass in Northern California Rice with Regiment™ Herbicide

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Abstract

Regiment™ 80 WP (bispyribac-sodium) is a post-emergence herbicide that has excellent efficacy against certain grasses, sedges and broadleaf weeds with selectivity for rice. It inhibits the plant enzyme acetolactate synthase (ALS), thus blocking branched-chain amino acid biosynthesis.

Regiment™ 80 WP has a wide application window for control of barnyardgrass and watergrass. The herbicide can be applied to watergrass and barnyardgrass from the 1 leaf to 2-3 tiller stages of growth. Use rates range from 10 to 18 grams ai./Acre. Optimum use rates are 10 to 12 grams ai/A with the grass being at the 3 to 5 leaf stage. Higher use rates may be required for herbicide resistant watergrass. A non-ionic silicone based surfactant is required at rates of 0.125 to 0.25% v/v.

Over the last 3 to 5 years, growers in the Princeton area (Glenn County, CA) have had difficulty in controlling late season watergrass in their rice fields. Grass control failures have been observed with maximum rates of thiobencarb, molinate and fenoxaprop-ethyl applied alone and sequentially.

In 1998, Dr. Albert Fischer, UC-Davis, confirmed in greenhouse tests that resistance to thiobencarb, molinate and fenoxaprop-ethyl had developed in late-season watergrass biotypes. His findings also indicated that resistance to all three herbicides was not equal but varied from field to field.

Findings from greenhouse testing also indicated that certain watergrass biotypes exhibited resistance to bispyribac-sodium. To confirm greenhouse results, three field trials were established in the Princeton area. All three fields, Argo, Glasgow and Zoller had histories of herbicide failures and confirmed resistance in greenhouse testing by Dr. Fischer.

ARGO TRIAL: This trial was established by Chemtec, Inc. to determine the application timing and rates for control of herbicide resistant watergrass. The trial was located north and west of Princeton by 2 miles. Regiment™ 80 WP at 10, 18 and 24 grams ai/A was applied to 4 - 5 leaf and 1 - 2 tiller watergrass. All treatments included Kinetic® @ 0.125%v/v. The standard in the trial was Super Wham® at 6 qt./A.

GLASGOW TRIAL: This trial was located 2 miles south of the ARGO trial. The trial was also a cooperative test with Chemtec, Inc. Regiment™ 80 WP at 10, 18 and 24 grams ai/A

was applied to 2 - 3 tiller watergrass. All treatments included Kinetic® @ 0.125%v/v. The standard in the trial was Super Wham® at 6 qt./A.

ZOLLER TRIAL: This trial was located NW of the GLASGOW trial by 1 mile. John Taylor Fertilizers Co., Inc. conducted the trial. Regiment™ 80 WP at 10, 18 and 24 grams ai/A was applied to 4 - 5 leaf and 1 - 2 tiller watergrass. All treatments included Kinetic® @ 0.125%v/v. The standard in the trial was Super Wham® at 4 qt./A.

RESULTS: Consistent grass control was observed in all three trials. Best application timing was during tillering. The earlier application timing of 4 - 5 leaf watergrass consistently exhibited less control than the later timing.

Best grass control was observed at rates of 18 and 24 grams ai/A which ranged from 85 to 99 % control across all three trials. The 10 grams ai/A rate did not provide adequate control regardless of application timing.

The standard Super Wham® provided good control of watergrass in two of the three trials. Timing did not appear to be important for good control. It appears that the 6 qt./A rate was more efficacious than the 4 qt./A rate, which did not give adequate control in the ZOLLER trial.

Phytotoxoicity was minimal in all three trials.

CONCLUSION: Regiment™ 80 WP at 18 and 24 grams ai/A with Kinetic® @ 0.125 % v/v provided excellent control of herbicide resistant watergrass at the late application timing. Control was equal to Super Wham® at 6 qt./A and better than the 4 qt./A rate.

Regiment™ 80 WP appears to provide an additional tool for control of herbicide resistant watergrass in Northern California Rice.

Cowpea Cover Crop Mulch for Weed Control in Desert Pepper Production

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Introduction

With the decreasing availability of herbicides labeled for use in vegetable production, sustainable options need to be developed that can reduce herbicide input while maintaining acceptable weed control. One option available to growers is the use of a cover crop mulch for weed control. Cowpea (Vigna unguiculata) is a natural fit for a desert vegetable production systems. Cowpea is adapted to growth in the hot, dry climates found in the summer in the Coachella valley. Some varieties of cowpea produce abundant biomass that could be used as mulch in the following crop.

Objectives

1. Determine the influence of a cowpea cover crop mulch on season-long weed control in bell pepper production.

2. Investigate the influence of a cowpea cover crop mulch on pepper plant growth and pepper production.

Materials and Methods

A two year trial was conducted at the Coachella Valley Agricultural Research Station in Thermal, CA.

Treatments included: conventional bare ground (BG) with hand weeding, BG with no weed control, Cowpea mulch (CP) with hand weeding, CP with no weed control. Treatments were arranged in a randomized, complete block design with four replications. Cowpea (var, Iron Clay) was planted on July 7, 1997, and July 10, 1998. Bell pepper (var. Keystone) plants were transplanted into 76 cm beds on one foot spacing on Sept. 2, 1997, and Sept. 22, 1998. Peppers were harvested on Dec. 18, 1997, and Dec. 15, 1998. Data collected included cowpea biomass at the beginning and end of the season and weed emergence and pepper plant height on two week intervals.

Results and Discussion

At pepper transplanting, the cowpea biomass was 610 and 713 g m-1 bed. The cowpea mulch reduced weed pressure throughout both seasons (Table 1). At harvest, the number of weeds emerged was reduced by approximately 80 and 90% compared to non-weeded bare ground controls for 1997 and 1998, respectively. Pepper plant growth was not inhibited by the cowpea mulch with plants generally taller in the mulch plots (Table 2). At harvest, the mulch plots supported, in general, more pepper plant dry weight and significantly less weed dry weight than the bare ground plots (Table 3). Total pepper weight and number of peppers produced in the mulch plots was greater than in the bare ground plots (Table 3). In conclusion, cowpea mulch provided season-long weed control without herbicides and increased pepper production

Table 1. Weed emergence in cowpea mulch and bare ground non-weeded plots. Data represents number of weeds per meter of bed.

	3 WAT[1]		5 WAT		7 WAT		Harvest	
Treatment	1997	1998	1997	1998	1997	1998	1997	1998
Cowpea	13.8 a[2]	7.5 x	25.5 a	8.0 x	15.5 a	7.5 x	48.0 a	9.5 x
Bare Ground	299.0 b	142.0 y	211.2 b	120.5 y	200.0 b	84.8 y	244.0 b	110.5 y

[1]WAT, weeks after transplanting. [2]Means separated within columns with LSD at $p < 0.05$.

compared to conventional production systems.

Table 2. Growth of pepper plants over the season. Data represents plant height (cm).

	3 WAT[1]		5 WAT		7 WAT		Harvest	
Treatment	1997	1998	1997	1998	1997	1998	1997	1998
CP, Weeded	nt[2]	20.8 x[3]	28.4 a	25.6 x	30.8 a	26.5 x	32.4 a	28.3 x
CP, non-Weeded	nt	20.8 x	27.0 a	24.4 xy	29.5 a	26.9 x	30.1 a	28.0 x
BG, Weeded	nt	18.0 x	20.6 b	20.9 y	21.9 b	22.5 y	24.2 b	24.0 x
BG, non-Weeded	nt	19.6 x	19.5 b	20.8 y	21.1 b	24.3 xy	26.1 b	25.1 x

[1]WAT, weeks after transplanting. [2]nt, not tested. [3]Means separated within columns with LSD at $p<0.05$.

Table 3. Weed and pepper plant dry weight at harvest. Total pepper weight and peppers per plant for the 1998 season.

	Weed Dry Wt. at Harvest ($g\ m^{-1}$ bed)		Pepper Plant Dry Weight at Harvest ($g\ plant^{-1}$)		Pepper Production ($g\ plant^{-1}$)	Pepper Production ($fruit\ plant^{-1}$)
Treatment	1997	1998	1997	1998	1998	1998
CP, Weeded	nt[1]	nt	14.7 a	7.1 x	147.9 a	2.6 ab
CP, non-Weeded	12.2 a[2]	7.0 x	16.3 a	6.5 x	120.9 a	2.7 a
BG, Weeded	nt	nt	9.9 ab	4.6 y	81.3 b	2.1 ab
BG, non-Weeded	37.1 b	72.1 y	5.4 b	4.1 y	69.7 b	1.7 b

[1]nt, not tested. [2]Means separated within columns with LSD at $p<0.05$.

Effects of Ammonium Sulfate on Control of Weeds with Touchdown® 5

Scott Lingren[1], John Washington[1], Steve Dietz[2]

Abstract

The effects of ammonium sulfate (AMS) on the efficacy of Touchdown® 5, sulfosate, against selected weeds in prunes and in a non-crop situation were evaluated in Central California. Touchdown® 5 provided better weed control at 1.1 kg (AI) / ha than at 0.56 kg (AI) / ha. The addition of ammonium sulfate significantly improved control of most weed species evaluated, with the exceptions of horseweed, wild barley, and yellow nutsedge. A significant interaction between adjuvant (with or without AMS) and herbicide rate indicated that AMS had a greater influence on control of some weed species with lower rather than higher rates of Touchdown® 5.

Introduction

Touchdown® 5, sulfosate, is a trimesium salt of N-(phosphonomethyl)glycine, or PMG. This non-selective, systemic herbicide may be used to control a variety of annual and perennial weeds in both agricultural and industrial situations. Figures 1 and 2 illustrate the effects of Touchdown® 5 on weeds in corn stubble. Similar to the isopropylamine salt of PMG, glyphosate, the efficacy of sulfosate may be influenced by the presence of hard-water cations such as Ca^{+2} or Na^{+2} in the spray solution (Buhler and Burnside 1983, Nalewaja and Matysiak 1993, Thelen et al. 1995, Jordan et al. 1997). The basis for this influence is the formation of calcium or sodium salts of PMG that are not taken up by plants as readily as isopropylamine or ammonium salts of PMG (Thelen et al. 1995, Nalewaja et al. 1996).

This effect may be combated either by manipulation of carrier volume or by the addition of cationic surfactants (Buhler and Burnside 1983, Nalewaja and Matysiak 1993, Thelen et al. 1995, Jordan et al. 1997). Buhler and Burnside (1983) demonstrated that glyphosate phytotoxicity to selected annual grass weeds increased with decreasing carrier (water) volume. The authors hypothesized that fewer antagonistic cations were available in the spray solution at lower carrier volumes compared with greater carrier volumes. The addition of a cationic surfactant also was found to increase the phytotoxicity of glyphosate to selected annual grass weeds (Buhler and Burnside 1983). Interestingly, the effects of cationic surfactant was most pronounced at greater carrier volumes. Cationic surfactants, such as ammonium sulfate, act by competing with hard-water cations for binding with PMG. In the case of ammonium sulfate, the ammonium anion binds with PMG, creating a salt that is more readily absorbed by plants than calcium salts (Thelen et al. 1995, Nalewaja et al. 1996). Additionally, Ca^{+2} ions are precipitated from solution through the formation of $CaSO_4$ (Thelen et al. 1995). Because most studies

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concerning the effects of ammonium sulfate have focused on glyphosate, the objective of this study was to evaluate the effects of ammonium sulfate on the efficacy of sulfosate.

Materials and Methods

Two studies were conducted in Central California during 1998. Both studies were randomized complete block designs with factorial treatment arrangements and 4 replications. Touchdown® 5 was evaluated at 0.56 and 1.1 kg (AI) / ha with and without ammonium sulfate (AMS, 2% w/w). In the first study, plots (2.0 m x 15.2 m) were established in 2 year old French variety prunes near Farmersville, CA. Weeds evaluated in the study included annual sowthistle, *Sonchus oleraceus* L., common lambsquarters, *Chenopodium album* L., little mallow, *Malva parviflora* L., horseweed, *Conyza canadensis* (L.) Cronquist, and wild barley, *Hordeum murinum* ssp. *leporinum* L. Treatments were applied on 21 April 98 when weeds were 0.08 to 0.25 m in height using a CO_2 back pack sprayer calibrated to deliver 93 l / ha at 138 kPa. Plots were visually evaluated for percent weed control at 7, 14, and 28 days after application (DAA).

The second study was conducted near Dinuba, CA, on bare ground. Treatments and experimental design were the same in both studies. Plots were 2.1 m x 12.2 m in dimension. The weeds evaluated in this study were southwestern cupgrass, *Eriochloa gracilis* (Fourn.) Hitchc., redstem filaree, *Erodium cicutarium* (L.) L'Hér., and yellow nutsedge, *Cyperus esculentus* L. Treatments were applied on 30 June 1998 when weeds were 0.05 to 0.15 m in height. A CO_2 back pack sprayer calibrated to deliver 93 l / ha at 276 kPa was used to make applications. Plots were visually evaluated for percent weed control at 7, 14, and 21 DAA. Data for both studies were subjected to analysis of variance, and factor (Touchdown® 5 rate, presence or absence of AMS) means were separated using Fisher's protected LSD.

Results and Discussion

Tables 1 and 2 show the effects of different Touchdown® 5 rates on weed control in Farmersville and Dinuba, respectively. The 1.1 kg (AI) / ha rate of Touchdown® 5 provided good to excellent control of all weeds evaluated. Good control also was obtained with the 0.56 kg (AI) / ha rate of Touchdown® 5 for annual sowthistle, common lambsquarters, horseweed, wild barley, and redstem filaree. The higher rate of Touchdown® 5 [1.1 kg (AI) / ha] produced higher percentages of weed control than the lower rate [0.56 kg (AI) / ha] for all weeds evaluated except where control approached 100%. However, these differences were not significant for several weeds evaluated at the Farmersville, CA site, including annual sowthistle at 7 and 28 DAA, horseweed at 7 and 28 DAA, and for wild barley at 7 DAA (Table 1). All weed control differences between Touchdown® 5 rates at the Dinuba, CA site were significant. This disparity in significance probably is because weeds at the Dinuba site were hardened-off from high summer temperatures and required higher Touchdown® 5 rates to achieve control than those at the Farmersville site.

Tables 3 and 4 show the effects of AMS on Touchdown® 5 efficacy at the Farmersville and Dinuba sites, respectively. The addition of AMS significantly improved weed control with Touchdown® 5 for annual sowthistle, common lambsquarters, little mallow, southwestern cupgrass, and redstem filaree. The effects of AMS appeared to be most pronounced at 7 to 14

DAA, with only little mallow and redstem filaree showing significant AMS effects at more than 21 DAA. Control of horseweed, wild barley, and yellow nutsedge with Touchdown® 5 did not appear to be influenced by the addition of AMS. Wild barley control with Touchdown® 5 approached 100% at 7 DAA with and without AMS. It would, therefore, be difficult to detect significant differences among adjuvant treatments for wild barley. Such an explanation, however, is not valid for horseweed and yellow nutsedge. Other authors have demonstrated species-specific control responses to AMS plus glyphosate (Buhler and Burnside, 1983, Nalewaja and Matysiak 1992, Jordan et al. 1997). However, these authors offered no explanation for the observed species-specific responses to AMS. Some plant species, such as the Malvaceae, exude calcium and magnesium as bicarbonate salts. These salts further interfere with glyphosate and sulfosate, leading to species-specific responses to AMS (Ceris Jones, Zeneca Ag Products, personal communication). Additionally, hirsute plant species, such as horseweed, may impede herbicide penetration.

Water analysis from the two sites suggested that ions such as Ca^{+2} and Na^{+2} were present at sufficient levels to interfere with Touchdown® 5 activity. Water used for applications at the Farmersville site contained 43.9 mg / L Na^{+2} and 82 mg / L Ca^{+2} (A&L Western Agricultural Laboratories, Modesto, CA). Applications at the Dinuba site were made using water that contained 39.1 mg / L Na^{+2} and 112 mg / L Ca^{+2} (Valley Tech Agricultural Laboratory Services, Tulare, CA). Nalewaja and Matysiak (1993) demonstrated that when no ions were present in the spray solution, glyphosate decreased wheat, *Triticum aestivum* L., fresh weight by 81%. However, when 100 mg/L of Ca^{+2} was added to the spray solution, glyphosate decreased wheat fresh weight by only 67%. Additionally, when 100 mg / L each of Ca^{+2} and Na^{+2} were added to the spray solution, glyphosate reduced wheat fresh weight by only 60% (Nalewaja and Matysiak 1993).

Factorial analysis of data from the Farmersville site revealed a significant interaction between adjuvant and rate for common lambsquarters at 7 DAA (df = 1, 6; F = 5.56; p = 0.05),and for little mallow at 14 DAA (df = 1, 6; F = 14.29; p = 0.009). Significant interaction between adjuvant and rate for data from the Dinuba site were detected for southwestern cupgrass at 7 (df = 1, 6; F = 11.57; p = 0.008) , 14 (df = 1, 6; F = 22.22; p = 0.001) , and 21 DAA (df = 1, 6; F = 5.69; p = 0.04), and for redstem filaree at 7 (df = 1, 6; F = 19.11; p = 0.002), 14 (df = 1, 6; F = 60.28; $p < 0.001$), and 21 DAA (df = 1, 6; F = 15.51; p = 0.003). In each of the above cases, AMS increased weed control by a greater amount at lower Touchdown® 5 rates than at higher Touchdown® 5 rates. This finding is significant because it demonstrates the increased utility of AMS at lower versus higher Touchdown® 5 rates.

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Table 1. Mean percent weed control with Touchdown® 5 at different rates averaged over all adjuvant treatments (with and without ammonium sulfate), Farmersville, CA, 1998.

		Percent Control[a]		
Weed Species	Rate	7 DAA[b]	14 DAA	28 DAA
annual sowthistle	0.56 kg (AI) / ha	30.8 a	50.8 b	92.7 a
	1.1 kg (AI) / ha	42.5 a	78.3 a	100.0 a
common lambsquarters	0.56 kg (AI) / ha	43.3 b	90.8 b	96.7 a
	1.1 kg (AI) / ha	66.7 a	100.0 a	96.7 a
little mallow	0.56 kg (AI) / ha	30.0 b	30.8 b	38.3 b
	1.1 kg (AI) / ha	46.7 a	59.2 a	84.7 a
horseweed	0.56 kg (AI) / ha	29.2 a	60.8 b	95.8 a
	1.1 kg (AI) / ha	46.7 a	82.5 a	98.7 a
wild barley	0.56 kg (AI) / ha	92.5 a	100.0 a	100.0 a
	1.1 kg (AI) / ha	100.0 a	100.0 a	100.0 a

[a]Means followed by a different letter in a column for each weed species are significantly different (Fisher's Protected LSD, $p = 0.05$).
[b]Application made April 21, 1998.

Table 2. Mean percent weed control with Touchdown® 5 at different rates averaged over all ajuvant treatments (with and without ammonium sulfate), Ivanhoe, CA, 1998.

		Percent Control[a]		
Weed Species	Rate	7 DAA[b]	14 DAA	21 DAA
southwestern cupgrass	0.56 kg (AI) / ha	25.0 b	28.8 b	42.5 b
	1.1 kg (AI) / ha	62.5 a	84.4 a	90.4 a
redstem filaree	0.56 kg (AI) / ha	37.5 b	61.3 b	78.8 b
	1.1 kg (AI) / ha	73.8 a	99.1 a	100.0 a
yellow nutsedge	0.56 kg (AI) / ha	5.0 b	10.8 b	16.3 b
	1.1 kg (AI) / ha	12.5 a	23.8 a	52.5 a

[a]Means followed by a different letter in a column for each weed species are significantly different (Fisher's Protected LSD, $p = 0.05$).
[b]Application made June 30, 1998.

Table 3. Mean percent weed control with Touchdown® 5 alone and plus ammonium sulfate (2.0% w/w) averaged over all Touchdown® 5 rates [0.56 and 1.1 kg (AI) / ha], Farmersville, CA, 1998.

		Percent Control[a]		
Weed Species	Adjuvant	7 DAA[b]	14 DAA	28 DAA
annual sowthistle	None	26.7 b	49.2 b	93.0 a
	Ammonium Sulfate	46.7 a	80.0 a	99.7 a
common lambsquarters	None	38.3 b	94.2 a	98.3 a
	Ammonium Sulfate	71.7 a	96.7 a	98.0 a
little mallow	None	30.8 b	38.3 b	45.8 b
	Ammonium Sulfate	45.8 a	51.7 a	77.2 a
horseweed	None	36.7 a	65.8 a	97.7 a
	Ammonium Sulfate	39.2 a	77.5 a	96.8 a
wild barley	None	92.5 a	100.0 a	100.0 a
	Ammonium Sulfate	100.0 a	100.0 a	100.0 a

[a]Means followed by a different letter in a column for each weed species are significantly different (Fisher's Protected LSD, $p = 0.05$).
[b]Application made April 21, 1998.

Table 4. Mean percent weed control with Touchdown® 5 alone and plus ammonium sulfate (2.0% w/w) averaged over all Touchdown® 5 rates [0.56 and 1.1 kg (AI) / ha], Ivanhoe, CA, 1998.

		Percent Control[a]		
Weed Species	Adjuvant	7 DAA[b]	14 DAA	21 DAA
southwestern cupgrass	None	40.0 b	53.8 b	62.9 a
	Ammonium Sulfate	47.5 a	59.4 a	70.0 a
redstem filaree	None	47.5 b	72.3 b	83.8 b
	Ammonium Sulfate	63.8 a	88.1 a	95.0 a
yellow nutsedge	None	8.8 a	16.2 a	31.3 a
	Ammonium Sulfate	8.8 a	17.5 a	37.5 a

[a]Means followed by a different letter in a column for each weed species are significantly different (Fisher's Protected LSD, $p = 0.05$).
[b]Application made June 30, 1998.

The Germination Profile of Selected Salinas Valley Weeds

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Abstract

In most temperate climates warm-season and cool-season weeds generally exhibit seasonal patterns of germination**.** However, in the Salinas Valley, there is a considerable overlap in the periods when cool-season and warm-season weeds germinate. Weed emergence was observed over a 10 month period at three sites in Monterey County. Winter annuals observed were annual bluegrass (*Poa annua*), annual sowthistle (*Sonchus oleraceus*), burning nettle (*Urtica urens*), common chickweed (*Stellaria media*), common groundsel (*Senecio vulgaris*), persian speedwell (*Veronica* persica), and shepherdspurse (*Capsella bursa-pastoris*). Summer annuals included common purslane (*Portulaca oleracea),* hairy nightshade (*Solanum sarrachoides),* and pigweed (*Amaranthu*s spp.). Annual sowthistle, common groundsel, common purslane, and shepherdspurse germinated over most of the 10 month period. Hairy nightshade and pigweed germinated only during April to October. Annual bluegrass, burning nettle, and common chickweed germinated from April to December. Germination of persian speedwell fluctuated over the 9 month period with germination peaks occurring in April and July to November.

Introduction

Preemergence herbicides are by their nature preventative treatments applied to increase the likelihood that a crop can be produced successfully without losses due to weeds. The difficulty in using preemergence herbicides in an integrated weed management system is that one must apply these herbicides before the weeds germinate. We are working to develop models to predict weed germination on the Central Coast of California by observing the germination pattern of weeds over time.

Materials and Methods

1. Three studies were established in Salinas (2) and Chualar (1) to monitor weed germination over time.

2. The plot size was 75' long and 26.7' wide with 4 replicates.

3. Weed density counts were taken every 2 to 4 weeks from March to December 1998.

Results and Discussion

1. Surprisingly, common purslane germinated throughout the 10 month period, with the possible exception of December (Table).

2. Annual sowthistle, and common groundsel, and shepherdspurse germinated throughout the 10 month period.

3. Hairy nightshade and pigweed germination was observed from April until October.

4. Annual bluegrass, common chickweed, and burning nettle germinated from April to December.

5. Persian speedwell germination occurred throughout the period except for an interval in May and June when no germination was observed.

Acknowledgements

California Department of Pesticide Regulation

Table. Germination calendar of Salinas Valley weeds over a 10 month period in 1998.[a]

Weed	M	A	M	J	J	A	S	O	N	D
Winter annuals										
Annual bluegrass		+	+	+	+	+	+	+	+	+
Annual sowthistle	+	+	+	+	+	+	+	+	+	+
Burning nettle		+	+	+	+	+	+	+	+	+
Common chickweed		+	+	+	+	+	+	+	+	+
Common groundsel	+	+	+	+	+	+	+	+	+	+
Persian speedwell		+	-	-	+	+	+	+	+	+
Shepherdspurse	+	+	+	+	+	+	+	+	+	+
Summer annuals										
Common purslane	+	+	+	+	+	+	+	+	+	(-)[b]
Hairy nightshade		+	+	+	+	+	+	+	-	-
Pigweed spp.		+	+	+	+	+	+	+	-	-

[a] + (germination observed); - (germination not observed)
[b]Have not verified December germination

The Influence of Uprooting Time on Seed Production in Common Purslane

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Introduction

Common purslane has re-emerged as a major weed problem in the Salinas Valley during the 1990s. Previous to the mid-1970s purslane was a major problem weed and caused major crop losses[1]. Because of the efficient herbicides used on agronomic crops, such as sugar beets and dry beans, yield losses due to purslane declined from 1975 to 1985. During the 1980s agronomic crop production decreased as lettuce and cole crop acreage increased. Decreased crop rotation led to limited choices in herbicides such as Kerb and Dacthal, all of which may have contributed to purslane problems. Furthermore, the standard configuration for lettuce herbicides in the Salinas Valley is twin 5" herbicide bands centered over the rows. Thus, furrow bottoms and bed tops are left unsprayed, and purslane plants in the row centers or furrow bottoms are managed through mechanical cultivation or hand-weeding. We have observed that many uprooted purslane plants survive.

What then is the seed production potential of an uprooted common purslane plant? When must a purslane plant be uprooted to prevent seed production? The objective of this study was to determine how many viable seeds a purslane plant produces after uprooting at 1 to 6 weeks after emergence. If plants are not uprooted before the 3-week stage, how can seed production be minimized? A second study was conducted to determine if propane flaming, Round-up or crushing can be used to significantly reduce the number of viable seeds produced by established purslane plants.

Materials And Methods

Field plots. Purslane seeds were planted between two rows of lettuce seed on 40" beds. The plots were 13 ft. by 25 ft., and included four replicates per treatment and four subsamples per plot. The lettuce was thinned, cultivated once, and the plot was irrigated regularly. The plants were uprooted at 1, 2, 3, 4, 5, and 6 weeks after emergence, and were placed in open paper bags to dry in a greenhouse for three weeks. Seeds were hand-threshed from each plant and maintained separately.

Viability tests. The purslane seeds were counted and sorted by color into groups of tan, brown, and black seeds per the method of Egley (Egley 1974). The seeds were punctured with a scalpel and imbibed approximately 24 hours in a 1% tetrazolium solution to determine viability

[1] Personal communication, Harry Agamalian, Farm Advisor Emeritus Monterey County

(Ellis, et al. 1983). The number of black seeds was so great on the plants uprooted 5 and 6 weeks after emergence that the decision was made to take viability estimates on samples of black seed to estimate the fraction of viable black seeds. Tan and brown seeds from five and six-week-old plants continued to be imbibed in tetrazolium.

Treatments used to reduce seed output. The experimental units consisted of four uprooted purslane plants. The plants were each treated by one of the following treatments: (1) flaming plants with a propane torch, (2) spraying plants with 2% v/v Round-Up, (3) driving over the plants once with a tractor, and (4) an untreated control. The plants were placed into paper bags 24 hours later and dried in a greenhouse for three weeks after treatment. After hand threshing, the seeds were weighed and the weights were used to estimate the number if seed produced per plant.

Results

No viable seeds were produced in plants uprooted 1 and 2 weeks after emergence, though some viable seeds were produced in week 3 (Table 1). The number of seeds produced increased rapidly in 4- to 6-week-old plants. No tan seeds were viable. The relationship between the time of pulling and seed production was described by the linear function $s=810.6w+(-468.0)w^2+78.1w^3$ (Fig. 1), where s = number of seed and w = weeks from emergence to uprooting. The 6.2% viability rate of the brown seeds and the 93.6% viability rate of the black seeds are comparable to Egley's data (Egley 1974).

In the flaming study, the four propane-flamed plants yielded a total of 1359 seeds with an average of 339.8 seeds per plant. The plants sprayed with Round-Up produced 3737 seeds, an average of 934.3 seeds per plant. Plants that were crushed with a tractor produced a total of 15,173 seeds with an average of 3793.3 seeds per plant. The untreated plants yielded 20,298 seeds with an average of 5074.5 seeds per plant.

Discussion

These data indicate that common purslane uprooted 3 weeks after emergence or later are capable of producing viable seed and replenishing the seed bank. The best approach to purslane management appears to be to apply the herbicide prior to purslane emergence. The next best alternative is to remove the purslane within three weeks of emergence.

The most effective way to reduce the number of seeds in an established purslane plant is by flaming. This method kills the plant instantly, scorches the seeds, and minimizes further seed production. Spraying the plant with Round-Up significantly reduces the amount of seed by killing the plant quickly after treatment. Treatment of purslane plants with flaming or 2% v/v Round-Up significantly reduced the number of seeds per treatment relative to driving over the plants with a tractor or the control plants. The crushed plants did not show a reduction in the number of seed and most seeds appeared to be viable (fig. 2).

In future replications of this experiment, it would be wise to use plot flags instead of plant stakes. The purslane and crop plants can cover small plant stakes as they grow, making it difficult to find the marked plants. It is also recommended that the plants around the marked weeds be thinned to a uniform distance so that shading and variable competition does not occur. In the flaming study, plants should be marked on the date of germination to ensure that each plant is the same age on the date of treatment. The number of plants in this study should also be increased to include approximately 16 plants per treatment. The seed used in this study was purchased from a weed seed dealer in the Fresno area. It may be more valuable to use native Salinas Valley purslane seed in future studies.

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Ellis, R.H., Hong, T.D. & Roberts, E.H., 1985, Handbooks for Genebanks. Rome: International Board for Plant Genetic Resources, pp. 125-134.

Table 1. Relationship between the time of uprooting and the mean number of viable seeds, separated by color, as per Egley (1974).

Weeks[2]	Mean number viable seed of each stage		
	Tan	Brown	Black
1	0	0	0
2	0	0	0
3	0	0.81	1.06
4	0	5.19	164.75
5	0	8.75	1857.40
6	0	2.5	4162.7

[2] Weeks from emergence to uprooting.

Figure 1. Relationship between time of pulling and seed production

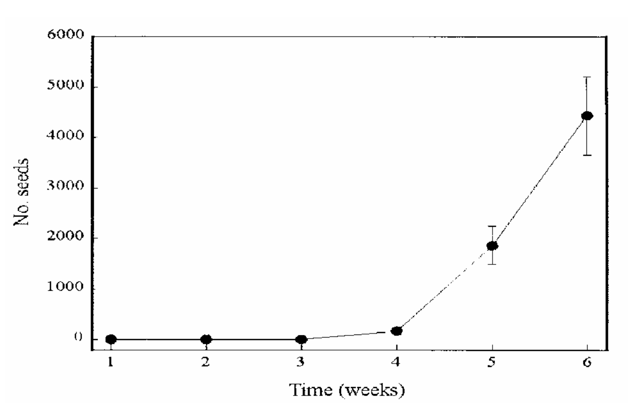
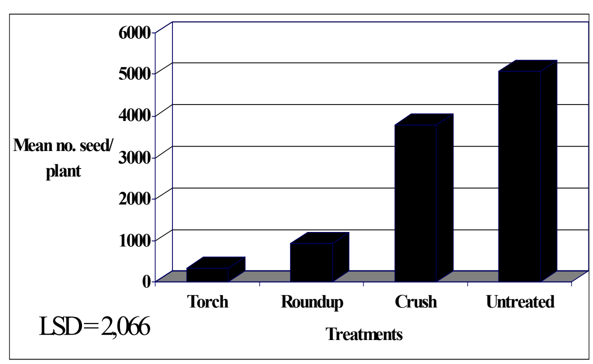


Figure 2. Relationship between treatments and number of viable seeds



New Business Isn't Always Good Business

Poems by David Haskell

The Day Sacramento Was Brought to Its Knees

I remember the day Sacramento was brought to its knees.
The day State Employees learned to say "Please".

The River People saved their bottles for a week,
then broke them in the middle of 12th street.
Gleaning gallo green covered the concrete,
and the early morning commuters made a hasty retreat.

And those five-dollars a day shopping-cart men,
wearing blue collared, "we're gonna win" union grins.
Stood on the freeway exits with their protest signs,
and the Teamsters honored their "wildcat" picket lines.

On the day Sacramento was brought to its knees.
The nine to five citizens discovered common courtesy.

Ten bagladies panhandled nuts from an almond recall,
and lured the Park Squirrels down to Capital Mall.
Where a riot of rodentious rage erupted in the street,
and there was tire slashing with angry rodent teeth.

And the downtown Winos with "Night Train" roaring in their veins,
surrounded the Capital building with a drunken human chain.
The Capital steps at sunrise were a frightening sight.
Hundreds of bums snoring in the early morning light.

Half-moon and the Drooler shared a common vision,
and joined the freeway traffic, to preach to everyone.
Making foreign speeches, speaking in tongues,
the K-Street prophets for all religions.

On the day Sacramento was held for ransom,
donations were given to every transient, wino and bum.

City folks say the unrest started before election day,
when Ronald Reagan stopped over for an hour stay,
And the street people prospered for a single day,
gathering all the paper, cans and political hay.

New Business Isn't Always Good Business

Now the pesticide salesman, he has a "tough row to hoe".
To reckon a farmers financial worth,
when even his wife may not know.

The color of his machinery,
could be a handy clue.
If there's rust dnipping off it,
his pockets might be filled with it too.

And those tires with that deep rubber,
attached to that shiny yellow and green.
Might only mean his cousin's a tractor dealer,
who can't say "NO" to someone whose family.

And that 80 acres of sandy loam,
he fondly calls the Home Ranch. Well,
Mama moved out 10 years ago.
He might have lost it in a refinance.

If that new account reaches five figures,
And the last payment is 60 days past due.
And the branch manager starts to wonder,
about what he is gonna due with you.

Well, a man's clothes can be indication,
of what's really going on inside.
And the belt is what I focus on,
the best barometer of a working man's pride.

If that leather stays up, high and tight,
and the tongue doesn't start to hang out.
Well, I have learned from past experience.
The money will come, without a doubt!

But my brow begins to furrow,
if gravity gets a hold of those pants.
And the tongue starts to hangin,
Like a dog's chasing a summer romance.

A diet of coffee and donuts,
can only carry a man so far.
And when the days start to grow shorter,
he can't out run the calendar.

So if a moon always starts rising,
before he finally grabs a hold of his pants.
Then it's "Cash Only on Delivery",
with prior approval from Finance.

You better stop thinkin about your commission,
with an account that's C.O.D.
And start planning for your future meeting,
with the president of the company.

So when you're out crunching new gravel.
Sometimes it's better to hit the brake.
Because there's a risk in doing business,
with only a smile and a handshake.

Cut Them All Down

Let the bankers, the wood cutters come,
and fight over the crumbs.
Taxes are the only thing these trees can grow.

Because I tired of pruning from dangerous heights.
And cutting fire blight, to save the trees from the bacterial ooze.

Knowing a fatal accident could wait,
behind every tired mistake,
when you are working in the orchard alone.

And my body still carries the residue,
from every pesticide brew, I
sprayed to keep the codling moths away.

I can't sign another canner's contract,
knowing the fact,
they still haven't paid me from last year.

And my ears can't stand to hear,
another, "Maybe next year",
from their un-sympathetic fieldman.

My son doesn't care,
anything about pears.
He likes living in a cyber world.

So let the weeds come and grow,
and I won't have to mow,
with equipment I borrowed last year.

And put these tired trees,
out of misery.
Make room for the pavement to grow.

Because I don't want to see,
a single tree.
I'm ready for the rocking chair.

Amerco's Shovel

I meet Amerco at the airport.
We were smoking squirrels on public land.
All day we worked next to the bean fields.
A young buck and this old ranch hand.

Amerco was an irrigator.
And the shovel was the tool of his trade.
Milled by the earth's resistance,
from a spade into a two-leafed blade.

The shovel was his constant companion.
They held each other on the long hot days.
And together they watched the mystery of gravity,
leading water on it's search for the Bay.

The unsure water moved with baby steps,
stepping around clods that stood in the way.
And they watched it with a mother's patience,
to keep it from going astray.

But the ranch foreman gave me his shovel.
A rude and disrespectful man.
And Amerco struggled with a new one,
that was rough and heavy in his hands.

His worried eyes watched my boots,
jam his companion into the ground.
But a life spent following orders.
He protested without making a sound.

The handle felt like braided hair,
almost weightless in my hands.
And it sliced the earth like chocolate cake,
reacting to my slightest demands.

All day he pouted for his shovel.
His face carried a deep furrowed frown.
He was jealous it would respond to my hands,
like a whore from the bad side of town.

When I lit the final smoke bomb,
and shoved it down the last squirrel hole.
I relinquished the precious shovel,
and returned that vacant part of his soul.

Life had given him this shovel to carry.
And his hands held on to it still,
with a love of tools that marks us,
that unique human expression of skill.

Guillermo

Now Guillermo was a cowboy,
And of this there was no doubt.
But with a new bride by his side,
he could no longer knockabout.

So he left his home in the high country,
where a man has room to roam.
And traded it all for a vinyl chair,
with a three-lined telephone.

Now his paycheck has four figures,
with a pre-paid dental plan.
and baby skin filled in the cuts,
the wires left in his hands.

He drinks coffee everyday till ten.
Answers nature's call at noon.
And when the secretaries all turn their heads,
Uses the trash can for his private spittoon.

He has a mustache black as charcoal,
with a perfect Indian nose.
And legs like strips of bacon,
stretched tight in his Levi clothes.

He had the fastest draw in the hallway,
fingers blazin in sex-gun style.
And he broke the meanest secretary,
with his ten-gallon cowboy smile.

But his boots were always shiny,
as he paced the office hall.
Gone completely "barn sour",
trapped in his office stall.

He could no longer smell the west wind,
nor watch those tumbleweeds blow.
Staring at the power lines,
outside of his office window.

Now a cowboy needs fresh air to live,
and a mountain range within his reach.
So why did you take that warden's job,
guarding grunion spawning on the beach.

L.A. is a poacher's town.
So we wish you the best of luck.
But after three years of pushing paper,
Are you still, "One Son of a Buck"?

I don't need no stinking saddle!
I don't need no stinking horse!
All I need is a stinking badge.
And my 357, of course!

Simulated Drift of Transline (Clopyralid) on Tomatoes, Cotton, Safflower and Sunflower

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A field study was established in 1998 on the Vegetable Crops Farm at Davis California to evaluate the effects of simulated drift of clopyralid on processing tomatoes, cotton, sunflower, and safflower. Clopyralid was applied at 1X, 0.1X, 0.01X, and 0.001X the maximum use rate in California (0.25 lb/a). Crops were treated at the two leaf stage or at flowering. Clopyralid applications were made on June 3 and July 2, to tomato, safflower and sunflower, which were at the second true leaf stage and flowering, respectively (Table 1). Cotton treatments were made on July 2 and July 30, to the second true leaf stage and to the flowering stage, respectively.

At four weeks after the seedling treatment, tomatoes were stunted by the full label rate (0.25 lb/a) treatment. Tomatoes treated with 0.025 lb/a of clopyralid were stunted, but yield was not significantly affected by the 0.025 lb/a or lower rates (Table 2). Treatment timing did not statistically influence yield. However, the type of injury was different depending on the treatment timing. When 0.25 lb/a was applied to 2-leaf tomatoes, they were severely stunted with a low fruit yield, due to small plant size. When the same treatment was applied to flowering tomatoes, some flower abortion occurred. These plants recovered and flowering and fruit set occurred, but these plants were set back, resulting in lower red fruit yields and a much higher green fruit yield (Table 2).

Safflower yields were reduced by 95%, 87%, and 55% by clopyralid treatment at 0.25, 0.025 and 0.0025 lb/a rates, respectively (Table 3). Application timing did not influence safflower yield. The 0.25 lb/a clopyralid treatment killed most of the safflower, with the 0.025 lb/a rate also causing death or severe stunting. The 0.00025 lb/a clopyralid rate caused etiolation of safflower when applied to seedlings, but yields were not different from the untreated control.

Sunflower plants were completely killed by 0.25 lb/a rate of clopyralid when applied to seedlings and only a few plants survived this rate when applied at flowering (Table 4). The 0.025 lb/a rate of clopyralid also killed many sunflower plants when applied to seedlings, but was less injurious when applied at flowering. The number of sunflower seed heads at harvest was reduced more by seedling clopyralid treatments than when clopyralid was applied to flowering plants. Sunflower seed yield was reduced by 97% when clopyralid was applied at the 0.025 lb/a rate to seedlings, but only by 40% when this rate was applied to flowering plants.

The number of cotton plants was reduced by 13% by the 0.25 lb/a rate of clopyralid (Table 5). Other clopyralid rates did not affect plant population. The biggest loss in cotton plants came when clopyralid was applied to seedling cotton plants. The number of cotton bolls formed was reduced when either the 0.25 or 0.025 lb/a rate of clopyralid was applied, regardless of the time of application. Clopyralid did not influence maturity of cotton as the effect of reduced number of bolls was observed for both those that were fully open and those not quite fully open (closed) (Table 5). The reduction in number of cotton bolls formed resulted in yield reductions of over 90% when cotton was treated at the 0.25 lb/a rate of clopyralid and by over

60% when treated at 0.025 lb/a. There was a slight trend toward lower yields when cotton was treated at the flowering stage, even at the 0.0025 lb/a clopyralid rate.

Although full labeled rates of clopyralid were injurious to crops, in this study, it is unlikely that this rate would drift onto these crops. More likely drift rates would be between 0.025 lb/a and 0.0025 lb/a. At potential drift rates of clopyralid, safflower and sunflower would likely show some injury. Tomatoes could be injured by clopyralid at 0.025 lb/a, if the applications were made close to flowering. In most areas of California, tomato flowering would commonly occur after mid-May and thus drift problems could be avoided by treating before this time. The late planting of cotton in California makes drift from clopyralid onto cotton at the flowering stage unlikely, as most clopyralid applications would target yellow starthistle and thus be applied much earlier in the year.

Table 1. Treatment information for the Transline (clopyralid) simulated drift study.

Location: Vegetable Crops Farm, UC Davis
Plot size - 22 X 10ft (Tomatoes - 2 beds); 22 X 5ft. (Safflower, Sunflower, and Cotton - 2 beds)
4 Replications
1st Treatment Date: June 3, 1998 (1st Cotton treatment July 2, 1998)
Weather: 70ºF – no wind
Treatment timing: 1st application - Second set of true leaves; 2nd application - Flowering
Spray Volume: 33 gal/a + 0.25% nonionic surfactant - CO_2 backpack sprayer
2nd Treatment Date: July 2, 1998 (2nd cotton treatment – July 30,1998)
Weather: 86°F, wind 1 to 2 mph
Spray Volume: 20 gal/a + 0.25% nonionic surfactant - CO_2 backpack sprayer

Table 2. Tomato yield (tons/a) in response to Clopyralid treatment

	------------------Yield-----------------		
Treatment	**Reds**	**Greens**	**Rots**
2 true leaf			
Clopyralid 0.25 lb/a	14.2	1.95	0.69
Clopyralid 0.025 lb/a	35.0	0.40	4.01
Clopyralid 0.0025 lb/a	37.5	1.02	6.15
Clopyralid 0.00025 lb/a	36.7	0.82	4.87
Untreated	28.8	0.71	4.76
Flowering			
Clopyralid 0.25 lb/a	5.8	10.53	1.46
Clopyralid 0.025 lb/a	22.2	2.67	4.05
Clopyralid 0.0025 lb/a	25.1	0.98	3.88
Clopyralid 0.00025 lb/a	26.8	0.71	4.09
Untreated	32.0	0.91	4.96
Significance			
Timing	NS	*	NS
Rate	***	***	***
Timing X Rate	NS	***	NS

Table 3. Safflower yield (tons/a) in response to Clopyralid treatment

Treatment	Yield (tons/a)
2 true leaf	
Clopyralid 0.25 lb/a	0.00
Clopyralid 0.025 lb/a	0.05
Clopyralid 0.0025 lb/a	0.46
Clopyralid 0.00025 lb/a	1.14
Untreated	1.06
Flowering	
Clopyralid 0.25 lb/a	0.11
Clopyralid 0.025 lb/a	0.23
Clopyralid 0.0025 lb/a	0.51
Clopyralid 0.00025 lb/a	0.89
Untreated	1.06
Significance	
Timing	NS
Rate	***
Timing X Rate	NS

Table 4. Sunflower harvest data in response to Clopyralid treatment

Treatment	Flower heads (#/30 ft.)	Seed Yield (tons/a)	Seed wt/head (g/head)
2 true leaf			
Clopyralid 0.25 lb/a	0.0	0.00	0.0
Clopyralid 0.025 lb/a	8.0	0.07	7.2
Clopyralid 0.0025 lb/a	27.5	1.83	104.8
Clopyralid 0.00025 lb/a	33.5	2.14	103.3
Untreated	40.2	2.65	102.7
Flowering			
Clopyralid 0.25 lb/a	1.0	0.01	2.2
Clopyralid 0.025 lb/a	28.5	1.32	70.6
Clopyralid 0.0025 lb/a	35.8	2.12	91.4
Clopyralid 0.00025 lb/a	28.2	2.17	120.1
Untreated	35.2	2.19	97.6
Significance			
Timing	NS	NS	NS
Rate	***	***	***
Timing X Rate	***	*	***

Table 5. Cotton harvest data in response to Clopyralid treatment

Treatment	Plants	Number of Bolls: Open	Number of Bolls: Closed	Number of Bolls: Total
	(#/30ft.)			
2 true leaf				
Clopyralid 0.25 lb/a	73.8	5.8	17.2	23.0
Clopyralid 0.025 lb/a	88.2	99.0	102.0	201.0
Clopyralid 0.0025 lb/a	93.5	227.5	131.0	358.5
Clopyralid 0.00025 lb/a	93.0	230.5	110.2	340.8
Untreated	93.8	253.5	128.8	382.2
Flowering				
Clopyralid 0.25 lb/a	90.8	58.5	15.8	74.2
Clopyralid 0.025 lb/a	92.2	68.8	65.8	134.5
Clopyralid 0.0025 lb/a	96.8	196.8	104.8	301.5
Clopyralid 0.00025 lb/a	87.5	229.5	105.8	335.2
Untreated	94.2	281.8	97.0	378.8
Significance				
Timing	NS	NS	NS	NS
Rate	*	***	***	***
Timing X Rate	NS	NS	NS	NS

Table 6. Cotton yield data in response to Clopyralid treatment

Treatment	Yield (lbs/a)	Yield (% of untreated)
2 true leaf		
Clopyralid 0.25 lb/a	138.2	4.2
Clopyralid 0.025 lb/a	1263.2	44.0
Clopyralid 0.0025 lb/a	2794.8	94.0
Clopyralid 0.00025 lb/a	2606.6	91.0
Untreated	2926.1	100.0
Flowering		
Clopyralid 0.25 lb/a	435.6	15.0
Clopyralid 0.025 lb/a	943.8	31.8
Clopyralid 0.0025 lb/a	2199.5	71.5
Clopyralid 0.00025 lb/a	2482.9	83.5
Untreated	3049.2	100.0
Significance		
Timing	NS	NS
Rate	***	***
Timing X Rate	NS	NS

Tomato Varieties Show Promise of Dodder Control

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Cuscuta spp. (dodder) infests thousands of acres of processing tomatoes in California. Other hosts include, alfalfa, safflower, onions, carrots, sugar beets and annual and perennial weeds. In California, dodder begins emerging from the soil during February and March (just in time for tomato emergence), but may continue emerging for several months. Because dodder is a rootless plant, it requires attaching to a green host plant within a couple of days of emerging from the soil or it will die. As a parasitic weed, it attaches to the host plant (generally the plant stem) and enters the plant using haustoria to gain water and nutrients from within the plant cells. Feeding off the host plant, it grows rapidly, enveloping tomato plants with its wiry orange strands. Tomatoes may be killed or severely retarded in growth under heavy infestations, leaving an entire tomato field blanketed with orange dodder plants. Dodder seed is known to survive in the soil for more than 10 years, making eradication difficult once it becomes established.

There are no registered herbicides that provide selective control of dodder in direct-seeded tomatoes. Recently, Shadeout® was registered in tomatoes in California but does not provide adequate control of dodder. Growers typically rogue infested fields twice early in the season to reduce its presence or apply postemergence herbicides (like glyphosate) as spot treatments to kill the host plant and the attached dodder. In either case, achieving control results in a loss of tomato plants and potential yield. Using transplanted tomatoes can be an effective method for protecting yields. While dodder can still attach to transplant tomatoes, the tomatoes will already be established ahead of the dodder attack. Delaying planting until after most of the dodder has emerged (about March 15) can be an effective method of avoiding the problem.

Studies conducted in 1994 by Sahm et al. in Germany demonstrated that tomato varieties infested with *Cuscuta reflexa* resulted in reduced dodder growth. Similar observations have been made in California by Lanini, King and others when H9492 was planted in dodder-infested fields.

Two studies were conducted in 1998 to evaluate dodder control using potential dodder-resistant tomato varieties. One study was conducted in western Fresno County and one at UC, Davis. The Fresno site had a history of dodder infection and dodder seed was planted at the Davis site. At the Fresno site, Heinz® 9492 and H9553 (a close relative of H9492) processing tomato varieties were compared against H8892 (grower standard). The three varieties were planted in multiple double-seeded rows, the length of the field. At the Davis site, H9492 was compared to a Harris Moran variety in 30'-long plots. All varieties tested in the studies are commercially available in California. Dodder attachment, growth, and seed production were evaluated in the studies.

Planting H9492 and H9553 resulted in significant dodder control at the Fresno site. While early counts showed no difference in the total number of dodder plants emerged or dodder attachment between the varieties tested, H9492 and H9553 did result in significantly less dodder growth than in H8892. Dodder attached to H9492 or H9553 grew a maximum of 0.5 feet from the site of attachment, compared to H8892, which supported dodder plants 18 feet or more in length. Additionally, while there was some early dodder growth associated with the two tested varieties, the dodder attached to those plants subsequently died. Dodder cover and seed production was high in H8892, but nonexistent in H9492 or H9553.

Dodder emergence was poor at the Davis site, making it difficult to evaluate the plots. Mid-season ratings showed a 25% incidence of dodder on H9492 compared to 65% for the Harris Moran variety.

Although the unseasonably cool and wet season resulted in a "light" dodder year in 1998, results from this study showed a dramatic reduction in the amount of dodder growth and seed production when H9492 and H9553 were planted in western Fresno County. While the study did show a significant reduction in dodder growth and seed production, it is important to note that managing other weeds within the field was important for success. To be effective, growers will have to provide effective control of weed hosts within the field. Planting one of these resistant varieties in a field where other weed control is not adequately achieved could mean dodder survival.

The ability for growers to direct-seed dodder-resistant tomato varieties in previously infested fields is indeed interesting. If used in rotation with other non-host crops (like cotton) and sound weed control practices, these varieties should help reduce the impact dodder has on tomato production. With the increasing demand for biotechnology, it may be just a matter of time before these resistant characteristics are transferred to other commercial varieties or commodities.