Using Foramsulfuron for Spring Transition in Overseeded Turf

Chris Olsen
Bayer Environmental Sciences

Abstract

Utilizing the new herbicides available to aid spring transition can bring dramatic improvement to bermudagrass turf over a one to two year period. Continued use allows the golf course superintendent to maintain a high quality bermudagrass base. However, if chemical transition agents, such as foramsulfuron, are initiated on a poor bermudagrass base there will be an interval of compromised turf quality. This happens due to the speed of perennial ryegrass kill versus the time required for growth and fill-in of the bermudagrass. Examples will be shown of both the short-term turf quality loss as well as long-term benefit of chemical transition in California.

"Spotlight" A New Tool for Broadleaf Control in Turf

Randy L. Smith[1] and Sowmya Mitra[2]
Product Technology Specialist Dow AgroSciences and Associate Professor, California State Polytechnic University, Pomona

Abstract

Fluroxypyr was evaluated in combination with triclopyr, mecoprop-P (MCPP), 2,4-D, and dicamba for broadleaf weed control in turf. Numerous field trials were conducted across the country in 2002-2003 utilizing common protocols. Treatment combinations were applied as a liquid spray and on a granule carrier. Performance comparisons were made with liquid and granule combinations of triclopyr/clopyralid and MCPP/2,4-D/dicamba. Broadleaf weed control evaluations were made approximately 4 and 8 weeks after treatment. Results from these field trials demonstrate liquid spray combinations of fluroxypyr with triclopyr or MCPP provide greater than 90% control of narrowleaf plantain, white clover, and ground ivy. The same combinations provided greater than 80% control of dandelion. Granule combination of fluroxypyr and triclopyr resulted in approximately 80% control of white clover. These results are similar to those expressed by the comparison standards. A synergistic response was observed with the combination treatment of fluroxypr and 2,4-D amine in controlling white clover, dandelion and broadleaf plantain.

Introduction

Management of broadleaf weeds in turfgrass can be challenging because of the weed complex that occurs. Such a complex often requires a mixture of herbicides to achieve acceptable weed control. This is particularly challenging in residential turf because regulatory issues can reduce the herbicide options available to the homeowner and lawn care professional. Clopyralid, the highly effective herbicide used against difficult-to-control weeds such as white clover and other legume species, recently has fallen victim to regulatory issues and is no longer available for use on residential turf. Without clopyralid, herbicide options available to control difficult weeds in residential turf are limited. Fluroxypyr has been developed as an effective alternative for clopyralid in turfgrass. The data presented demonstrate the effectiveness of fluroxypyr on common broadleaf weeds.

Materials and Methods

Data developed from over 25 small plot replicated studies. A single postemergence (POST) spring application was made to actively growing weeds. Liquid applications were applied in a water volume of 20 to 40 GPA. Granule applications were applied via hand-shaker method. Weed control evaluations were made 4 and 8 weeks after treatment.

Weeds evaluated in studies;

- white clover (*Trifolium repens*)
- common dandelion (*Taraxacum officinaleci*)
- ground-ivy (*Glechoma hederacea*)
- broadleaf plantain (*Plantago major*)
- narrowleaf (buckhorn) plantain (*Plantago lanceolata*)

Field trials conducted at Cal Poly Pomona during the summer of 2005. Treatments were laid out in a randomized block design with four replicates. Data for control of broadleaf plantain, dandelion and white clover was fitted to Colby's synergistic and antagonistic response model for pesticide combinations (Colby, 1967).

In the liquid formulation trials the following treatments were evaluated;

Treatment Code	Herbicide Components	Application Rates lbs a.e./acre
FT	Fluroxypyr + Triclopyr	0.25 + 0.75
FM	Fluroxypyr + MCPP	0.25 + 1.1
FDD	Fluroxypyr + 2,4-D + Dicamba	0.25 + 1.0 + 0.12
FDT	Fluroxypyr + 2,4-D + Triclopyr	0.25 + 1.0 + 0.11
CT	Clopyralid + Triclopyr	0.18 + 0.58

In the granular formulation trials the following treatments were evaluated;

Treatment Code	Herbicide Components	Application Rates lbs a.e./acre
FT-G	Fluroxypyr + Triclopyr	0.25 + 0.75
FM-G	Fluroxypyr + MCPP	0.25 + 1.5
FDT-G	Fluroxypyr + 2,4-D + Triclopyr	0.25 + 1.0 + 0.37
CT-G	Clopyralid + Triclopyr	0.18 + 0.58

Results and Discussion

Fluroxypyr application at 0.5 lb a.e./acre controlled over 90% of the white clover 4 weeks after treatment (WAT). There was no significant difference in level of white clover control between the fluroxypyr (0.5 lb a.e./acre) and the triclopyr (0.42 lb a.e./acre) and clopyralid (0.14 lb a.e./acre) combination treatment at 8 WAT. The liquid formulations of fluroxypyr and triclopyr combination resulted in optimum control of narrowleaf plantain, dandelion, white clover and ground ivy at 4 WAT. There was no difference in percent control of white clover, narrowleaf plantain and dandelion between the fluroxypyr and triclopyr combination treatment and the clopyralid and triclopyr combination treatment at 8 WAT. The liquid herbicide applications of clopyralid and fluroxypyr provided better overall broadleaf weed control than the granule applications (Fig. 1).

Data for control of broadleaf plantain, dandelion and white clover was fitted to Colby's synergistic and antagonistic response model for pesticide combinations (Coby, 1967). The weed control data for the fluroxypyr treatment at 1 pt/acre, 2, 4-D amine treatment at 2 pt/acre and their combination treatment were fitted to Colby's model. The model calculated expected responses if the mixture was additive and then the data from the observed responses were compared to expected values. If the difference between the observed and expected response was zero then the response was additive. If the value was positive then the response was synergistic and when the value was negative then the response was antagonistic.

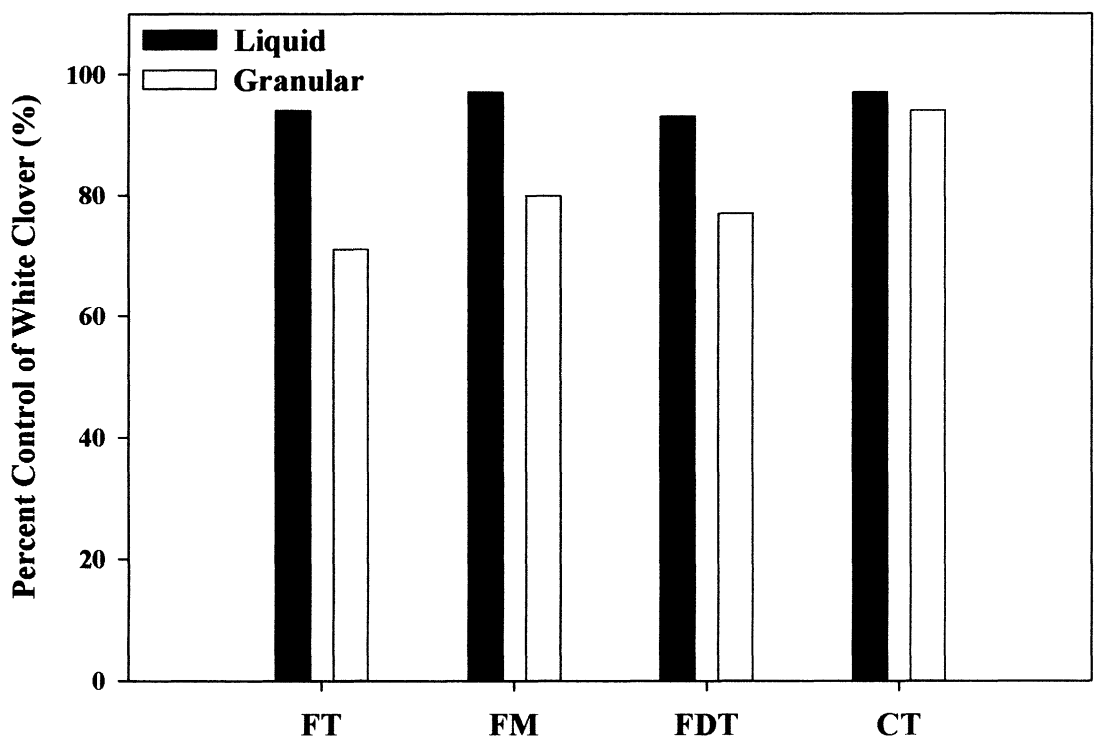


Figure 1. Effect of liquid and granular formulations on white clover control at 8 weeks after treatment (WAT). The FT, FM, FDT, and CT denotes fluroxypyr + triclopyr, fluroxypyr + MCPP, fluroxypyr + 2,4-D amine + triclopyr, and clopyralid + triclopyr respectively.

Conclusion

The data clearly show that fluroxypyr is an effective alternative to clopyralid for broadleaf weed control in turfgrass. Results from the liquid and granule herbicide trials demonstrate the effectiveness of fluroxypyr-containing mixtures for control of key broadleaf weeds in turfgrass. Comparisons with clopyralid-containing mixtures show that fluroxypyr in mixtures provides comparable control of weeds such as white clover, common dandelion, ground ivy, and plantain species. As would be expected, the liquid herbicide applications of clopyralid and fluroxypyr provided better overall broadleaf weed control than the granule applications. A synergistic response was observed with the combination treatment of fluroxypr and 2,4-D amine in controlling white clover, dandelion and broadleaf plantain as observed at 2, 4, 6 and 8 weeks after treatment (WAT).

Table 1. Data for weed control was fitted to Colby's synergistic and antagonistic response model for pesticide combinations (Coby, 1967).

Weeds	Weeks after treatment	Spotlight	2,4-D	Combination	Coby's expected response if mixture is additive	Observed vs Expected
Broadleaf Plantain	2	10	13.5	33.8	22.2	11.7
	4	43.8	68.8	96.3	82.5	13.8
	6	50	73.8	96.3	86.9	9.4
	8	57.5	71.3	100	87.8	12.2
Dandelion	2	20	10	56.3	28.0	28.3
	4	41.3	68.8	92.5	81.7	10.8
	6	42.5	71.3	92.5	83.5	9.0
	8	66.3	75	100	91.6	8.4
White Clover	2	22.5	1.8	30	23.9	6.1
	4	51.3	30	96.3	65.9	30.4
	6	58.8	43.8	100	76.8	23.2
	8	62.5	41.3	100	78.0	22.0

References

Colby, S. R. 1967. Calculating synergistic and antagonistic responses of herbicide combinations. Weed Sci. 5:20-22.

Sulfonylurea Herbicides: Key to a Successful Overseeding Program

Sowmya Mitra
Associate Professor, California State Polytechnic University, Pomona, CA 91768

Introduction

Sulfonylurea (SU) herbicides have been used to selectively control various weeds in agricultural crops for the last 25 years but they have recently introduced to control weeds in established turfgrasses. All the sulfonylurea herbicides have a general backbone consisting of an aryl group, a sulfonylurea bridge and a nitrogen-containing heterocycle. Most of the sulfonylurea herbicides have low acute oral, dermal and inhalation toxicity in mammals. The acute oral LD_{50} value of table salt in rats is 3000 mg kg^{-1} while most of the sulfonylurea herbicides have LD_{50} values greater than 4000 mg kg^{-1} of body weight (Sax Irving, 1979).

Study of the mode of action of sulfonylureas was first reported by Ray (1982) and Hatzios and Howe (1982). Sulfonylurea herbicides inhibit the activity of an enzyme called acetolactate synthase(ALS) also known as acetohydroxyacid synthase (AHAS), which is a key enzyme in the branched chain amino acid biosynthetic pathway of bacteria, fungi, and higher plants. The branched chain amino acid pathway is responsible in producing three essential amino acids, valine, isoleucine and leucine (Hatzios and Howe 1982). All the sulfonylurea herbicides display unusual "slow-binding" behavior with the enzyme, and this behavior may help explain the efficacy of the herbicides. These herbicides are also called as ALS or AHAS herbicides.

Sulfonylurea herbicides can be used as selective post-emergence control of certain sedges, grasses and broadleaf weeds in warm-season turfgrasses like bermudagrass, and zyosiagrass (Yulverton, 2004). These herbicides can also be used a tools in a successful overseeding program. They can be used on the bermudagrass before overseeding with cool-season turfgrasses like perennial ryegrass or *Poa trivialis* in the fall or can be used during spring transition to remove the cool-season turfgrass in the spring. Several sulfonylurea herbicides have been registered for use on golf courses like metsulfuron (Manor or Blade), chlorsulfuron (Corsair), foramsulfuron (Revolver), halosulfuron (Manage), rimsulfuron (TranXit GTA), flazasulfuron (Katana), trifloxysulfuron (Monument) and sulfosulfuron (Certainty). Another new herbicide bispyribac-sodium (Velocity) has also been introduced which works on the same ALS enzyme.

Poa Control before Overseeding

Poa annua infestation in an overseeded stand of perennial ryegrass is a major problem for golf course superintendents. Introduction of various sulfonylurea herbicides has given golf course superintendents new tools in managing *Poa annua*. The best strategy to control *Poa* is to apply sulfonylurea herbicides before overseeding but care should be taken not to apply the herbicides to close to overseeding. Trifloxysulfuron, foramsulfuron, rimsulfuron and sulfosulfuron are very effective in controlling annual bluegrass. Since sulfonylurea herbicides are systemic in nature, the absorption, translocation and inhibition of the ALS enzyme takes at least 14 days to observe optimum control of *Poa*.

Trifloxysulfuron application at 7.06 g/acre (0.24 ounces/acre) can control over 90% of the *Poa annua* population within 28 days after application. Lower rate of application of trifloxysulfuron (7.06 g/acre) was as effective as higher rate of application (9.33 g/acre) for controlling *Poa* (Figure 1). Formasulfuron applied at 6 ml 1000 sq. ft^2 (0.2 fl. ounces/1000 ft^2) controlled over 90% of *Poa* within 28 days after treatment (DAT). Optimum control was achieved between 30 and 60 DAT (Figure 1).

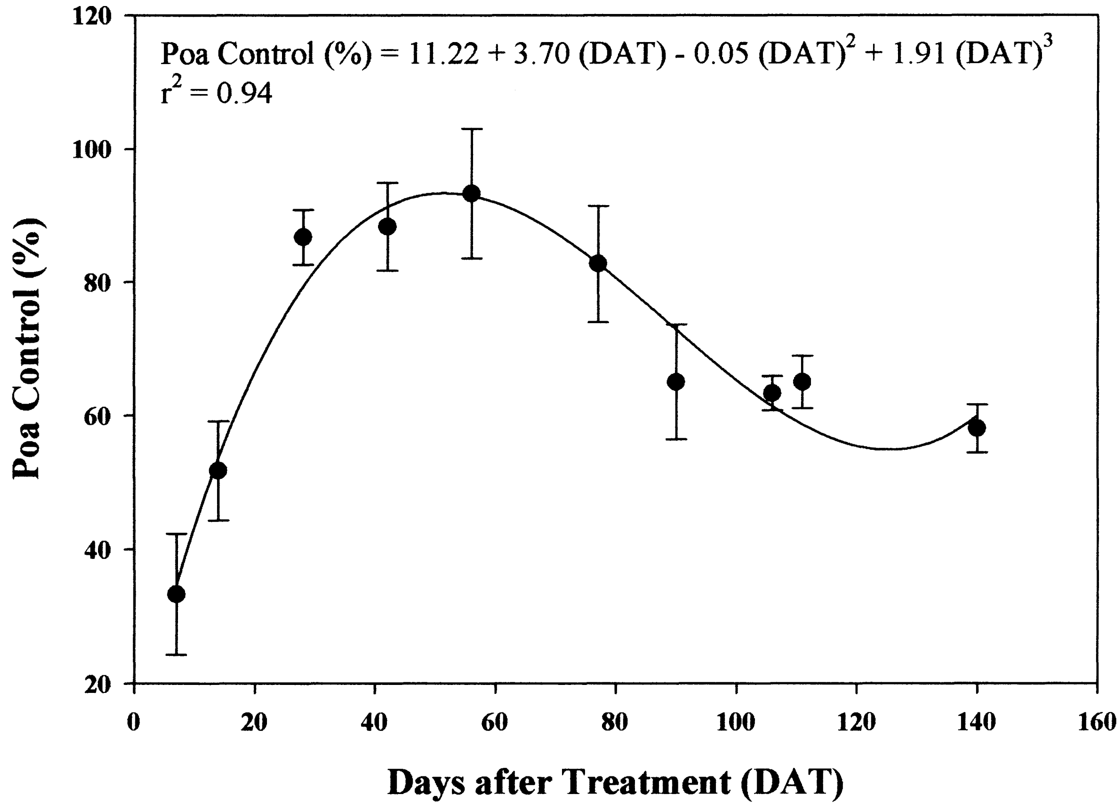


Figure 1. *Poa annua* control with a single application of foramsulfuron at 6 ml/1000 ft^2.

Efficacy of a single application of foramsulfuron reduced after 90 DAT. Sequential application of sulfonylurea herbicides are more effective in controlling *Poa* compared to a single application. Sequential application of foramsulfuron within 4 to 6 weeks after the first application would increase the efficacy of foramsulfuron in controlling *Poa* over a longer period.

Sulfosulfuron is also very effective in controlling *Poa* when applied at 75 g/acre rate. Optimum control was achieved between 21 and 45 DAT with a single application of sulfosulfuron (Figure 2). The efficacy of a single application of sulfosulfuron reduced after 75 DAT. Sequential application would increase the window for *Poa* control. *Poa* plants are very aggressive and are prolific seedhead producers so they start to produce new plants as soon as the efficacy of sulfonylurea herbicides reduces. Hence sequential applications are needed to achieve long term control of *Poa* population.

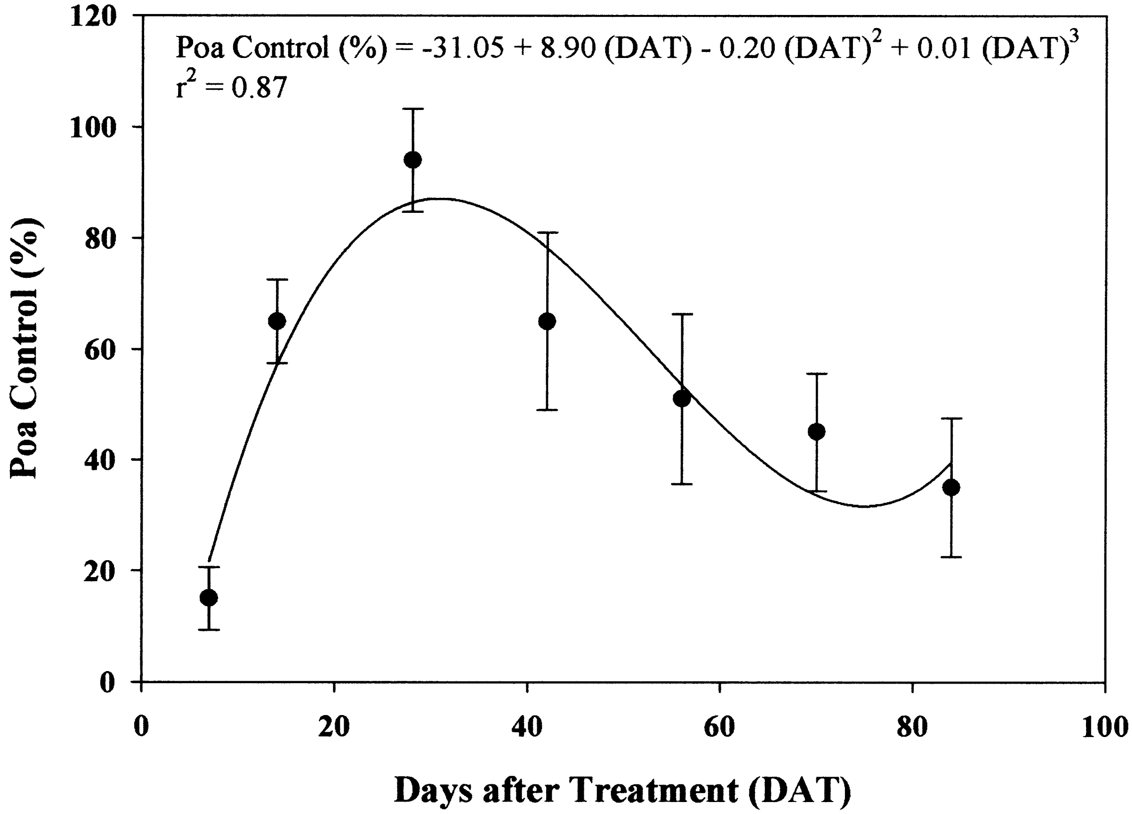


Figure 2. *Poa annua* control with a single application of sulfosulfuron at 75 g/Acre applied 10 days before overseeding.

Trifloxysulfuron application at 9.33 g/acre controlled *Poa* effectively and the optimum level of control was achieved between 30 and 70 DAT (Figure 4). The efficacy of a single application of trifloxysulfuron reduced after 80 DAT. An experiment was conducted on dormant bermudagrass to evaluate the efficacy of *Poa* control with two different rates of Monument (7.03 and 9.33 g/acre). *Poa annua* plants were counted in a 25 sq. ft grid and then extrapolated to no. of plants in 1000 sq. ft. Sequential application of trifloxysulfuron at 9.33 g/acre and formasulfuron application at 257 ml/acre were very effective in controlling *Poa annua* till 140 DAT (Figure 3).

Ryegrass Injury

SU herbicides are wonderful tools in controlling weeds before overseeding bermudagrass tees and fairways but the biggest problem with these products is the chances of injury to ryegrasses. Hence, the application timing of the SU herbicides is very important. In our experiments minimum injury to perennial ryegrass was observed with 9.33 g/acre rate of trifloxysulfuron when applied 21 days before overseeding (DBO) compared to the application made 10 DBO. The extent of injury was not very severe (approximately 12% injury). The ryegrass was stunted and showed some yellowing after 8 weeks after overseeding (WAO).

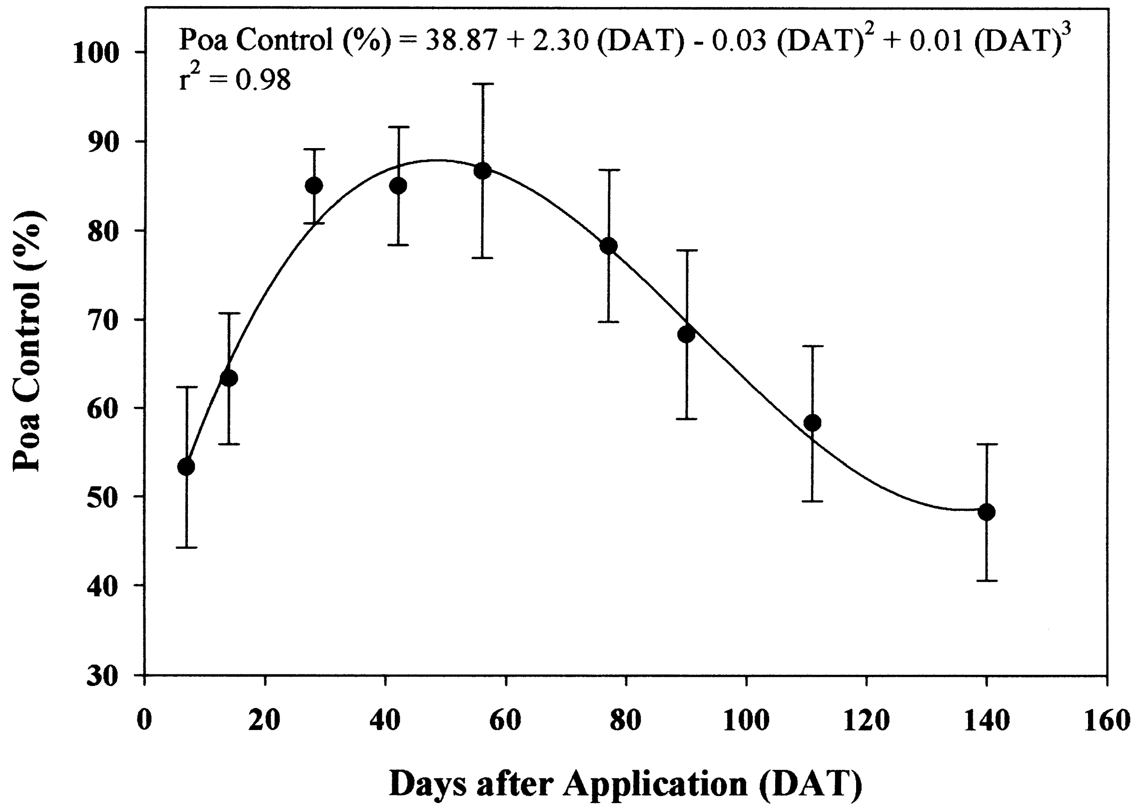


Figure 3. *Poa annua* control with a single application of trifloxysulfuron at 9.33 g/Acre.

Maximum ryegrass injury (about 12% injury, 3 WAO) with sulfosulfuron applied at 36 g/acre rate was observed in our experiments when the herbicide was applied 7 days before overseeding (Figure 4). No injury to ryegrass was observed when sulfosulfuron was applied at 27 g/acre 10 DBO. Application of glyphosate at 6 oz/acre (0.4 L/ha) on dormant bermudagrass applied 3 DBO controlled over 90% of annual bluegrass and injured only 6% of the perennial ryegrass 3 WAO. The stand of perennial ryegrass recovered from the injury by 7 WAO. When glyphosate (6 oz/acre) was tank-mixed with 140 g/acre of sulfosulfuron and applied 3 DBO it resulted in 48% injury of ryegrass 3 WAO which increased to over 70% injury to ryegrass by 7 WAO.

Rimsulfuron at 54g/acre applied 7 days before overseeding resulted in over 45% injury of perennial ryegrass 3 weeks after overseeding (Figure 5). The injury increased to 60% at 5 WAO and even at 7 WAO 50% of the perennial ryegrass stand was lost. Rimsulfuron was very effective in controlling annual bluegrass within 3 WAO. In order to minimize injury to ryegrass rimsulfuron has to be applied 10 or 14 days before overseeding and probably lower rates can be used.

Clumpy Ryegrass Control

When perennial ryegrass survives the summer or when it escapes the overseeded area, this turf species can become clumpy and is unsightly (Yelverton, 2003). Clumpy ryegrass is more difficult to control than an overseeded stand of dense perennial ryegrass. Pronamide is not effective in controlling clumpy ryegrass but some of the SU herbicides have been reported to be very effective (Yelverton, 2003).

In our experiments foramsulfuron applied at 0.4 fl. oz (11.8 ml) per 1000 sq. ft was very effective on controlling clumpy ryegrass 5 weeks after application. A sequential application at 4-6 weeks after the initial application provided superior control of clumpy ryegrass compared to a single application. Formasulfuron applied during late spring or early summer provided optimum control of clumpy ryegrass compared to early spring applications. Foramsulfuron is mainly taken up by plants through the foliage hence under higher temperatures when the plant is actively growing the herbicide is absorbed and translocated in the plant faster compared to translocation at lower temperatures.

The early application of foramsulfuron (spring) was not as effective as the later application (early and late summer) in controlling clumpy ryegrass for all rates of application as observed by the slopes of the regression curves (Figure 4). For all the application times the optimum rate was around 0.6 fl. oz/1000 sq. ft as observed by the maxima of the regression curves for percent control of clumpy ryegrass at 4 weeks after each treatment (WAT).

The highest rate of foramsulfuron (1.2 oz/1000 sq. ft) controlled 100% of the clumpy ryegrass at 8 WAT. The sequential application of foramsulfuron at 0.6 oz/acre during the early application (spring) did not result in significantly higher percentage control of clumpy ryegrass. At 4 WAT the 1.2 oz/1000 sq. ft rate of application controlled 68% of the clumpy ryegrass when applied during the spring while it controlled 88% when applied during early summer and 100% control when applied during late summer. Hence a higher level of control was achieved when foramsulfuron was applied later on during the summer. The higher summer temperatures exposed the clumpy ryegrass plants to heat stress and may have increased the activity of foramsulfuron due to increased uptake and translocation of the herbicide when applied at the later application date.

A single application of 0.6 oz/1000 sq. ft of foramsulfuron controlled 37% of the clumpy ryegrass at 4 WAT compared to 85% control when applied at early summer and 100% control when applied during late summer. The role of the sequential application became more critical during the later application timings which resulted in higher levels of clumpy ryegrass control. During the late summer application timing the sequential applications resulted in significantly higher level of clumpy ryegrass control at all rating dates (Figure 4).

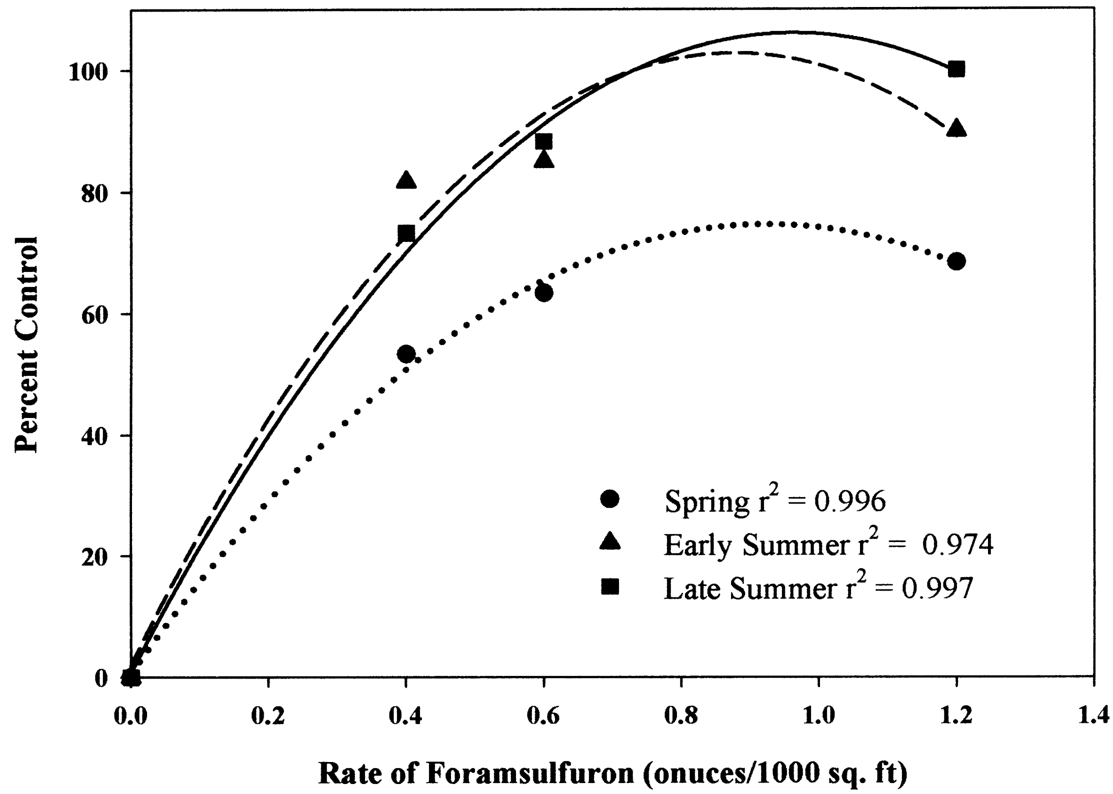


Figure 4. Effect of application timing and rate of foramsulfuron 4 weeks after each application on clumpy ryegrass control

References

Hatzios, K. K., and C. M. Howe. 1982. Influence of the herbicides hexazinone and chlorsulfuorn on the metabolism of isolated soybean leaf cells. Pesticide Biochemistry and Physioliogy. 17:207-214.

Ray, T. B. 1982. The mode of action of chlorsulfuron: A new herbicide for cereals. Pesticide Biochemistry and Physiology. 17:10-17.

Sax Irving. N. 1979. (ed.) Dangerous Properties of Industrial Materials. Van Norstr and Reinhold Com. New York. 5:978.

Yelverton, F. 2003. "A new herbicide for weeds in bermudagrass and zoysiagrass". *Golf Course Management*. May 2003:119-122.

Yelverton, F. 2004. "New weed control in warm-season grasses". *Golf Course Management*. January 2004:203-206.

Application Timing Affects Herbicide Options for Oxalis Control in Bermudagrass Turf

Michelle Le Strange, UC Cooperative Extension Tulare & Kings Counties
Pamela Geisel, UC Cooperative Extension, Fresno County

Introduction

Creeping woodsorrel (*Oxalis corniculata L.)* is a common perennial broadleaf weed in California landscapes. It is a particular problem in warm season turfgrasses, especially bermudagrass, because there are limited herbicides known to control oxalis without causing some phytotoxicity to the turf. Cultural management practices have not proven to be effective in controlling oxalis.

Brief description of *Oxalis corniculata*

The cotyledons of creeping woodsorrel are oval in shape, whereas the true leaves are compound with three heart-shaped leaflets that resemble clover leaves. Leaves often close and droop at night or under intense light. An oxalis plant can contain leaves of various shades of green to deep purple. Yellow flowers with five petals are borne singly or in small groups. The mature plant has creeping stems emerging from a slender taproot. Stems root at nodes and the plant spreads. Roots also survive cold temperatures and regrow. Seed pods are about 1/3-inch long and bear a resemblance to miniature okra. Each pod produces 10-50 seeds and it is estimated that each plant averages 5000 seeds. Pods burst open spreading reddish seeds 10 feet or more. Since the plants spread by seeds, roots, and stems that root at the nodes, eventually a carpet of oxalis occurs in a lawn.

Background and Justification

In the late 1980s triclopyr (Turflon®) was tested on lawns for broadleaf weed control and was soon registered for use in cool season lawns for the postemergence control of creeping woodsorrel and other broadleaf weeds. Because it was found harmful to bermudagrass lawns, triclopyr was not registered for use in warm season turfgrasses. Common postemergence broadleaf herbicides (two or three way combinations of 2, 4-D, mecoprop, and dicamba) have provided limited control of oxalis in warm season grasses. Several preemergence herbicides claim to control or suppress oxalis from seed, yet it continues to be a serious weed problem. In recent years new herbicide chemistry and products have been introduced.

Objectives of herbicide field trials

There are several objectives for these experiments:

- to determine which active ingredients control oxalis;
- to compare similar products available to both professional applicators and homeowners, but formulated at different concentrations;
- to evaluate the impact of preemergence herbicides in the weed management plan;
- to evaluate the relationship of application timing; and
- to develop a best treatment plan for the control of oxalis in bermudagrass.

Methods and materials

Two field experiments were conducted in established common bermudagrass sites in Fresno County: one was initiated in November of 2003 (winter experiment) in a city park and the second experiment was established in May 2005 (summer experiment) at the UC Kearney Research and Extension Center in Parlier, CA. Each experiment was designed as a split plot with 4 replications. Main plots were preemergence herbicide treatments and subplots were postemergence herbicides.

Three common preemergence herbicides and six postemergence broadleaf herbicides were evaluated for reducing oxalis weed populations and for turf phytotoxicity. At each site label rate applications of Dimension® (dithiopyr), Pendulum® (pendimethalin), and Barricade® (prodiamine) were applied to a uniform, dense stand of oxalis (minimum 70% cover at trial initiation).

Postemergence materials included 2,4-D, MCPP, dicamba, MSMA, carfentrazone, and fluroxypyr or combinations of these products. Professional and homeowner products containing the same active ingredients but differing in percentages of active ingredients were compared for their effectiveness on oxalis control. Fluroxypyr, related to triclopyr, and Speedzone®, containing carfentrazone, were developed specifically for broadleaf weed control in warm season lawns.

Each experiment received a minimum of two applications of all herbicides. Herbicide applications were made with a CO_2 backpack sprayer at 30 psi using 1.5 gal/1000 ft^2 water volumes. Experiment details including application dates and rates for the products tested are listed in Table 1. Plots were evaluated for weed control using a visual rating system of 1 to 10 with 1 being no control, 5 being less than satisfactory, and 10 being excellent control. Plots were also evaluated for percent cover of weeds and bermudagrass.

WINTER Experiment 2003-04: Pre- and postemergence applications were made on November 18 and February 24. Plots were visually evaluated for oxalis control on December 9, February 20, April 30, and August 12.

SUMMER Experiment 2005: Preemergence applications were made on May 13 and October 17. Postemergence herbicides were applied on May 13, June 23, and November 4. Weed control ratings and % cover ratings were made June 9, July 13, and November 4.

RESULTS (Table 2 and Figures 1 and 2)
WINTER Experiment: There were no significant differences between preemergence herbicides at any rating dates. All three preemergence herbicides were effective in keeping oxalis from germinating and over time had significantly higher weed control ratings than untreated plots. These herbicides were very effective in preventing oxalis germination for over six months after the second application.

Visual ratings in December 2003 and February 2004 indicated that oxalis control was better in all plots receiving a postemergence herbicide application compared to the untreated check and to plots receiving only a preemergence application. In the December rating, weed control with the trimec products was unsatisfactory (a control rating less than 5.0) and there was little difference between homeowner and professional products. Speedzone Southern had higher ratings than common broadleaf weed killers, and fluroxypyr treatments exhibited the highest weed control ratings. By February weed control ratings were significantly better and there were no differences in any of the postemergence products, meanwhile untreated areas had significant oxalis populations. No bermudagrass phytotoxicity was observed.

To summarize, initially there were significant differences between postemergence treatments with Speedzone and Spotlight providing more rapid and better oxalis control. These differences waned over time and all products provided more than adequate control of oxalis (rating > 9.0) by the end of the winter trial.

SUMMER Experiment: Significant differences in oxalis control were noted with both pre- and postemergence products, which is a different result from the WINTER experiment.

Postemergence: Spotlight and Trimec 992 (professional concentration) provided the best oxalis control overall with a weed control rating of 9 that persisted over time. Although the professional "trimec" products were significantly better than the homeowner "trimec" products, relatively good (rating >7.0) oxalis control was observed with the homeowner products. Trimec Plus (professional and homeowner) provided good crabgrass control in addition to oxalis control. Speedzone (a professional product) was not significantly different than homeowner products. No bermudagrass phytotoxicity was observed.

Preemergence: A few months after the initial application of preemergence herbicides, significant differences in oxalis weed control were observed. Barricade provided excellent, Dimension provided good, and Pendulum provided inadequate (though significantly better than the check) preemergence control of oxalis seedlings.

Crabgrass: In the SUMMER experiment it became obvious that crabgrass was a factor (Figures 1 and 2). Where there was less crabgrass there was better bermudagrass cover. Where there was more crabgrass there was less oxalis. It appears that crabgrass was more competitive than oxalis and bermudagrass unless managed with herbicides. In this experiment the postemergence weed control products containing MSMA for grassy weed control provided crabgrass control in addition to oxalis control and the bermudagrass cover was significantly better. While it is known that the preemergence herbicide, Dimension, provides early postemergence crabgrass control, we also saw this same result with Barricade. Pendulum was significantly weaker in controlling crabgrass at this timing.

SUMMARY: Oxalis control in established bermudagrass turf was significantly affected by application timing of herbicides. All active ingredients that were tested controlled oxalis to varying degrees depending on application timing. In winter less dramatic weed control results were observed early in the trial, but all products eventually worked equally well over time. An explanation may be that systemic broadleaf herbicides work more slowly in cooler temperatures. In summer differences in product performance were obvious from the beginning. Initially Spotlight was significantly better than the other postemergence products. Trimec Pro also provided good oxalis control and was equal to Spotlight at the end of the trial. Pre- and postemergence materials that controlled oxalis and crabgrass had higher bermudagrass cover and by definition higher turf quality. No bermudagrass phytotoxicity was observed in either experiment at any time.

These experiments demonstrate that *Oxalis corniculata* (creeping woodsorrel) can be successfully controlled in a bermudagrass turf with common broadleaf and preemergence herbicides in either winter or summer with either professional or homeowner products, although professional concentrations tend to provide better control. Success depends on application timing, sequential applications, and combining preemergence and postemergence herbicides in the weed and turfgrass management plan.

References

Carrithers, Vanelle F. 1987. Selective Broadleaf Weed Control in Turf. CWSS Proceedings. P 144-147.

Elmore, Clyde 1997. New Preemergence Turf and Ornamental Herbicides. CWSS Proceedings pp 49-51.

Elmore, Clyde 1998. Weed Management in Turf: Past, Present, and Future. CWSS Proceedings pp 45-47.

Elmore, Clyde and Dave Cudney. 2002 Creeping Woodsorrel and Bermuda Buttercup Pest Note #7444. UC Statewide Integrated Pest Management Website: www.ipm.ucdavis.edu.

Le Strange, Michelle and Pamela Geisel. 2005. Oxalis Control in Common Bermudagrass. CWSS Proceedings pp 93-96.

Table 1: Experiment Descriptions and Treatment List

	WINTER Experiment	SUMMER Experiment
Location:	Fresno City Park	UC KREC, Parlier
Application dates		
Preemergence:	NOV 18, 2003 & FEB 24, 2004	May 13 & OCT 17, 2005
Postemergence:	NOV 18, 2003 & FEB 24, 2004	May 13, June 23, & NOV 4, 2005

Treatments	Amount of Product
Preemergence herbicides	**per 1000 ft^2**
A. **Dimension®** dithiopyr (12.7%)	1½ ozs
B. **Pendulum WDG®** pendimethalin (60%)	1¼ ozs
C. **Barricade WG®** prodiamine (65%)	1½ ozs
D. **Untreated**	
Postemergence herbicides	
1. **Untreated check**	-
2. **Homeowner Trimec** (OSH) 2, 4-D (5.67%) MCPP (2.67%) dicamba (0.63%)	1½ oz
3. **Professional Trimec 992** 2, 4-D (30.56%) MCPP (16.34%) dicamba (2.77%)	1½
4. **Homeowner Trimec Plus** (Bayer) 2,4-D (3.18%) MCPP (1.60%) dicamba (0.79%) & MSMA (9.81%)	1½
5. **Professional Trimec Plus** 2, 4-D (5.83%) MCPP (2.93%) dicamba (1.46%) & MSMA (18.0%)	1½
6. **Speedzone Southern** (carfentrazone) 2,4-D ester (10.49%) MCPP (2.66%) dicamba (.67%) carfentrazone (.54%)	1½
7. **Spotlight** fluroxypyr (26.2%)	½

Table 2: Weed Control Ratings with Pre- and Postemergence Herbicide Applications in Winter and Summer Experiments (Visual rating scale 1-10. 1=no control, 10 = excellent control)

	Weed Control Ratings							
	WINTER Experiment 2003-04				SUMMER Experiment 2005			
	Oxalis				Oxalis		Crabgrass	
Preemergence	**9-Dec**		**30-Apr**	**12-Aug**	**9-Jun**	**5-Nov**	**9-Jun**	**5-Nov**
Check	1.5		5.3	1.5	5.4	1.8	2.9	1.8
Dimension	5.0		9.4	9.0	6.1	7.5	5.4	7.5
Pendulum	5.0		9.4	8.6	6.1	5.0	2.8	5.0
Barricade	5.0		9.3	8.8	6.3	9.0	5.1	9.0
LSD (0.05)	**0.2**		**0.2**	**0.5**	**NS**	**0.6**	**0.5**	**1.5**
							Grassy weeds	
Postemergence	**9-Dec**	**20-Feb**	**30-Apr**		**9-Jun**	**5-Nov**	**9-Jun**	
Check	1.4	5.3	5.3		1.8	5.6	1.9	
Trimec HOME	3.5	8.0	9.7		4.7	7.3	2.9	
Trimec PRO	5.0	9.4	9.8		7.8	8.8	3.9	
Tri Plus HOME	3.1	8.8	9.9		6.3	7.4	5.6	
Tri Plus PRO	3.3	8.8	9.8		7.1	8.0	6.4	
Speedzone	6.1	8.3	9.4		5.5	8.1	3.4	
Spotlight	7.9	9.3	9.9		8.8	9.1	4.2	
LSD (0.05)	**0.4**	**0.5**	**0.3**		**0.6**	**0.8**	**0.7**	
CV %	24.6	16.8	8.2	15.5	34	32.8	54.8	15.8

Figure 1: Percent Weed and Turfgrass Cover After Application of Postemergence Herbicides for Oxalis Control

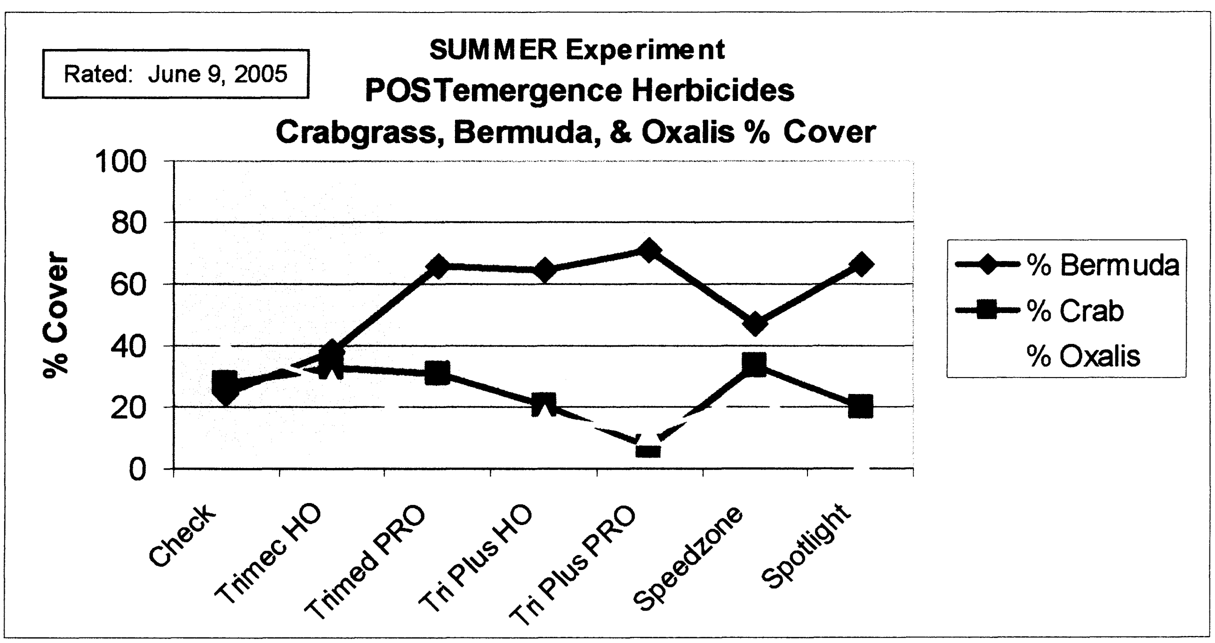
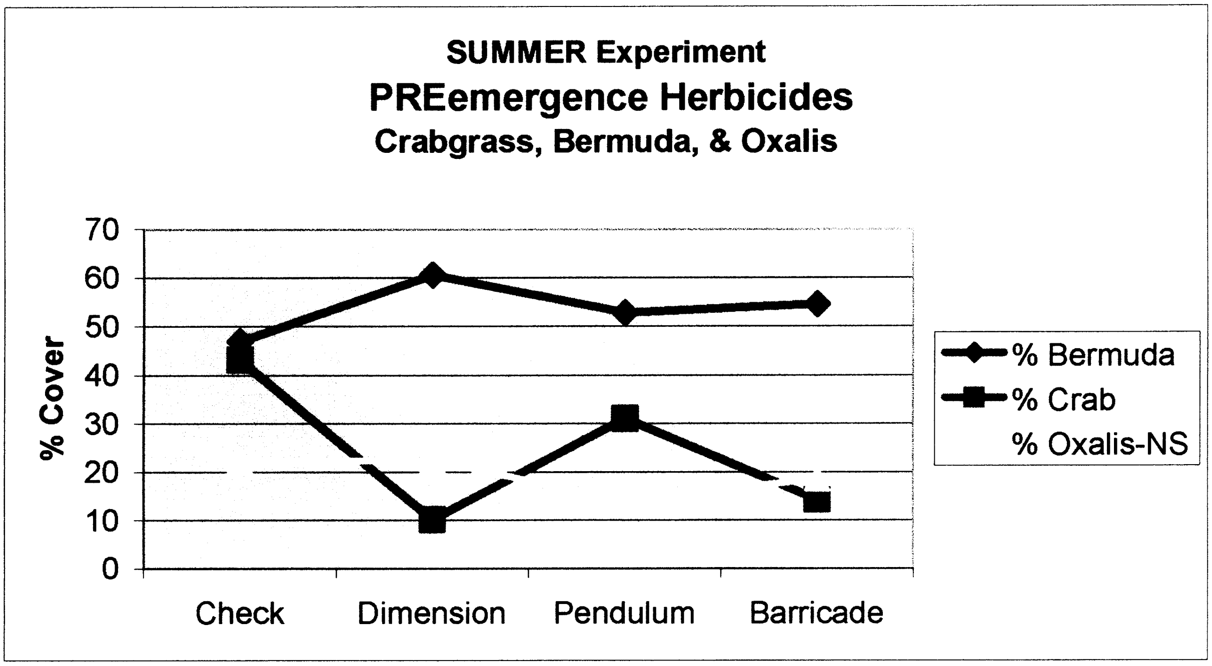


Figure 2. Percent Weed and Turfgrass Cover After Application of Preemergence Herbicides for Oxalis Control



Poa annua Control in Cool Season Grasses with Trimmit 2SC (Paclobutrazol)

Mark M. Mahady, President
Mark M. Mahady and Associates, Inc.

and

Dean K. Mosdell
Western Technical Manager, T&O
Syngenta Professional Products

Introduction

Field research conducted in the eastern United States has shown that Trimmit 2SC (paclobutrazol) exhibits both plant growth regulation and activity on annual bluegrass (*Poa annua*). For years Golf Course Superintendents throughout the Midwest and east coast have been using multiple applications of the old Scotts TGR (paclobutrazol) product on creeping bentgrass putting greens and fairways to regulate biomass and to reduce annual bluegrass populations. Field reports indicate that multiple paclobutrazol treatments applied at very low rates result in plant growth regulator effects including biomass control, darkening of turf and a reduction in annual bluegrass populations. Unfortunately, one of the less than desirable and unusual effects of paclobutrazol applications is the tendency for desirable grasses, particularly creeping bentgrass, to exhibit an increase in leaf texture or leaf widening. This increase in width of individual leaf blades can be an undesirable characteristic particularly on creeping bentgrass greens at private golf clubs with high expectations.

From the years 2000 to 2004 a series of replicated field research trials were conducted in California to determine the potential for Trimmit 2SC to control *Poa annua* in creeping bentgrass putting greens in Northern California, and in bermudagrass fairways over seeded with perennial ryegrass located in the true desert areas of Southern California (Palm Springs). This presentation will highlight the key results of these Trimmit 2SC field research trials.

Trimmit 2SC for *Poa annua* Control in Creeping Bentgrass Putting Greens

The objectives of these two Trimmit/creeping bentgrass field studies were to determine the following: 1) Will multiple spring and fall treatments of Trimmit 2SC exhibit acceptable suppression/control of *Poa annua* in creeping bentgrass putting greens? 2) Will the level of *Poa annua* suppression and control be similar in a coastal and inland microclimate? 3) Is such a program safe for use on high quality bentgrass putting surface? 4) Is Trimmit 2 SC a practical tool for golf course superintendents to consider within the scope of an effective *Poa annua* management program?

Similar field protocols were conducted at two golf courses, Salinas Fairways Golf Course (SFGC) located in the coastal climate of Salinas, California and Poppy Ridge Golf Course

(PRGC) located in the inland climate of Livermore, California. "Dominant" creeping bentgrass practice putting greens were chosen as the trial site location at each course. The creeping bentgrass putting green at SFGC averaged 32.3% *Poa annua* cover on the day of the first Trimmit application on March 30, 2002. The creeping bentgrass putting green at PRGC averaged 14.8% *Poa annua* cover on the day of the first Trimmit application on April 1, 2002. The putting green at SFGC received eight Trimmit applications at rates of 4, 8, 12 and 16 oz/A on March 30, April 26, May 24, June 24, July 30, September 9, October 8, and November 4, 2002. The putting green at PRGC received seven Trimmit applications at rates of 4, 8, 12 and 16 oz/A on April 1, April 28, May 28, September 11, October 9, November 4, and December 12, 2002.

Individual treatment plots at both locations measured 5' x 10' with 2" aisle ways. Treatments were replicated four times in a randomized complete block design. A calibrated CO_2 propelled spray system pressurized to 28 psi and equipped with 11004LP Tee-Jet nozzles applied treatments at a spray volume of 65 gallons per acre. A pacing watch was used for all spray applications to ensure the uniform and accurate delivery of all treatments. At the SFGC location treatment evaluations were conducted on March 30, April 26, May 24, June 24, July 30, September 9, October 8, November 4 and December 11, 2002. At the PHGC location treatments were evaluated on April 1, April 28, May 28, September 11, October 9, November 4, December 12, 2002, and January 23, 2003. Turf color was rated utilizing a 0-10 scale with 0 representing no green color, 6 minimally acceptable green color and 10 very dark green color. Turf quality was rated on a 0-10 scale with 0 representing no live turf and the poorest surface quality possible, 6 minimally acceptable putting green quality and 10 perfect putting green conditions. Turf injury was rated on a 0-10 scale with 0 representing no injury, 3 the maximum level of acceptable injury and 10 dead turf. Percent annual bluegrass cover was estimated with visual evaluations. Percent annual bluegrass control was statistically calculated against the percent *Poa annua* cover in the untreated check plot. Data were summarized and statistically analyzed. Differences between means were determined via LSD.

Eight Trimmit treatments applied at rates of 4, 8, 12 and 16 oz/A during the spring, summer and fall failed to control *Poa annua* in a creeping bentgrass putting green at SFGC located in a cool coastal climate. It is hypothesized that cool coastal climates create an ideal moderate environment for the aggressive year-round growth of *Poa annua*. Under such conditions, *Poa annua* is less susceptible to the plant growth regulating properties of Trimmit. Creeping bentgrass prefers warmer summer conditions for active growth and does not grow aggressively under moderate summer temperatures. These factors combined to change the competitive balance of the grass stand, ultimately favoring the growth of *Poa annua* over creeping bentgrass.

Seven Trimmit treatments applied at rates of 8, 12 and 16 oz/A during the spring, late summer and fall resulted in good control (64% to 77%) of *Poa annua* in a creeping bentgrass putting green at PRGC located in a hot inland climate. It is hypothesized that the much hotter summer temperatures of the inland climate increased the total stress level on *Poa annua* while creating an environment for more aggressive growth of the creeping bentgrass. These two factors combined with the active growth regulation of *Poa annua* with Trimmit, changed the competitive balance of the grass stand, favoring the growth of creeping bentgrass over that of *Poa annua*.

The most dynamic reductions in Poa populations at the inland location were observed following the late summer and fall applications. It is possible that properly timed late summer and fall applications serve to control young emerging *Poa annua* seedlings, which are known to germinate between September and December. Continuing to apply monthly treatments of Trimmit during September, October, November and December is recommended in order to maintain consistent growth regulation of newly emerging Poa seedlings.

When used in inland microclimates with warm to hot summer temperatures, Trimmit would appear to be a very valuable agronomic tool for the suppression/control of *Poa annua* in creeping bentgrass putting greens.

Trimmit 2SC for *Poa annua* Control in Overseeded Bermudagrass Fairways

The objectives of this Trimmit application rate and frequency field trial were as follows: 1) determine the influence of Primo on perennial ryegrass density, 2) evaluate effects of Trimmit on perennial ryegrass surface quality, and 3) compare the effects of Trimmit application frequency (3 versus 4 versus 5 applications) and application rate (8.0 oz/A versus 10 oz/A).

The field trial was conducted on a mixed stand of 328 hybrid bermudagrass and common bermudagrass recently overseeded with perennial ryegrass and located on the fairway of the twelfth hole at the Cove Course at Indian Wells Country Club in Indian Wells, California. This field plot location was chosen for this trial based on the significant *Poa annua* pressure observed on this specific fairway during the spring of 2003. A two-way perennial ryegrass blend consisting of the varieties Stellar and Pearl II was broadcast seeded on October 6, 2003 at a rate of 700 pounds per acre.

Trimmit only program treatments at 8 and 10 oz/A were applied three, four or five times at four-week intervals beginning on December 15, 2003, and compared to a Primo plus Trimmit program receiving sequential Primo applications at 13 oz/A during October and November followed by the described Trimmit treatments.

Individual treatment plots measured 9' x 9' with a 4' x 9' in-plot check. Treatments were replicated four times in a randomized complete block design. A calibrated CO_2 propelled spray system pressurized to 28 psi and equipped with 11004LP Tee-Jet nozzles applied treatments at a spray volume of 65 gallons per acre. A pacing watch was used for all spray applications to ensure the uniform and accurate delivery of all treatments. Treatment evaluations were conducted during November and December of 2003, and then again during January, February, March and April of 2004. Turf color was rated utilizing a 0-10 scale with 0 representing no green color, 6 minimally acceptable green color and 10 very dark green color. Turf quality was rated on a 0-10 scale with 0 representing no live turf and the poorest fairway quality possible, 6 minimally acceptable fairway quality and 10 perfect fairway conditions. Turf injury was rated on a 0-10 scale with 0 representing no injury, 3 minimally acceptable injury and 10 dead turf. Percent annual bluegrass cover and calculated percent annual bluegrass control were rated during March and April 2004. Data were summarized and statistically analyzed. Differences between means were determined via LSD.

Primo Maxx greatly enhanced speed to cover of perennial ryegrass. Two sequential treatments of Primo applied at a rate of 13 oz/A at three-week intervals resulted in a 30% increase in perennial ryegrass cover 35 days after the second application. Primo also greatly reduced the presence of bermudagrass during the first ten critical weeks following overseeding. Suppressing bermudagrass growth and increasing speed to cover of perennial ryegrass are two key components of a successful overseed. Trimmit treatments at the 8 and 10-ounce rates had no statistically significant effect on perennial ryegrass cover when applied to perennial ryegrass that was 70 days old.

Three applications of Trimmit alone at the 8-ounce rate resulted in 77% *Poa annua* control 53 days after the third treatment. Four applications of Trimmit alone at the 8-ounce rate resulted in 83% *Poa annua* control 21 days after the fourth treatment. Three applications of Trimmit alone at the 10-ounce rate resulted in 95% *Poa annua* control 53 days after the third application. Similar trends of 94% *Poa annua* control were observed with four applications of Trimmit alone at the 10-ounce rate. The 10-ounce Trimmit rate showed greater herbicidal activity than the 8-ounce rate with better Poa knockdown and collapse. This effect was particularly noticeable with heavy stands of *Poa annua*. Three applications of the 10-ounce rate performed as well as four applications.

Trimmit alone exhibited almost equivalent *Poa annua* control when compared to Trimmit plus Primo treatment programs. Differences between these two program concepts were not statistically significant. However, there was a trend of improved Poa control with the Trimmit plus Primo program concept. Primo greatly enhanced color and density of perennial ryegrass, while the follow-up Trimmit applications controlled *Poa annua*.

Reducing the number of Primo treatments from two applications to one application, and increasing the number of Trimmit applications to five did not result in an improvement in Poa control. It would appear that sequential Primo applications are an essential component of a successful Primo/Trimmit program.

When used within a properly managed agronomic program, Primo Maxx will improve perennial ryegrass color and density, and Trimmit 2 SC will greatly suppress and control *Poa annua*. This two-prong approach can serve to greatly enhance the surface quality of perennial ryegrass in overseeded bermudagrass fairways.

Acknowledgements

Syngenta Professional Products, The Northern California Golf Association and The Hi-Lo Golf Course Superintendents Association graciously provided funding for these field trials.

* * * * *

Working Together for Noxious Weed Control in Santa Barbara County

Linda L. Hamel, Caltrans Headquarters, Division of Maintenance

Caltrans vegetation control specialists and advisors implemented an Integrated Vegetation Management Program that consists of seven distinct methods for vegetation control. We must consider the correct method or combination of methods for each situation. In this presentation we will focus on four of the seven methods, manual, mechanical, cultural and chemical.

When choosing to partner with others for noxious weed control Caltrans must take into account many factors. Safety for our maintenance workers, safety of the traveling public and effectiveness of the chosen methods.

In the development of the Pampas Grass removal project on highway 225, Santa Barbara County. All of these factors were met:

* Sight distance was restored

* Drainage has been reestablished

* The target pest is under control

* Native habitat has returned and native species restored

The Arroyo Burro Watershed Enhancement Project would not have been possible without all the partners involved. Caltrans, Santa Barbara County Ag., County of Santa Barbara Coastal Resource Enhancement Fund, Southern California Wetlands Recovery Project, Elings Park, Channel Islands Restoration, Enviroscaping, Darlene Chirman, Santa Barbara Audubon Society and Growing Solutions.

The mulch project along highway 154 at the highway 101 on ramps achieved our desired goals:

* Target pests are under control- Lambs quarter, Marestail, Italian thistle, Puncture vine.

* Sight distance was restored

* Decrease in chemical applications

* Homeless population relocated

* Sidewalk is now fully usable by the public

Caltrans has limited resources and with the use of the large mulch blowing system and our partnering with California Conservation Corp personnel this area is now safe for maintenance personnel, pedestrians and the traveling public while being aesthetically pleasing.

Our future partnership with Vandenberg Air Force Base contractors will be a challenge but when the restoration is complete there will be acres of wildlands restored to its native inhabitants.

Remember early detection and rapid response to identified pests will make the treatment and control easier and less costly.
Caltrans has taken a new approach when thinking "**Alternatives**" we now "**ALTER**" to "**NATIVES**" join us in combating exotic species.

Flood Control Vegetation Management in an Environmentally Aware and Cautious Community

Larry L. Fausett, Ph.D., Santa Barbara County Flood Control District
Santa Barbara, California, 93101
lfauset@cosbpw.net

Santa Barbara County has a long history of being aware of the natural environment. Many of the citizens of the county are active in defending, and cautious about dealing with threats to the environment, whether those threats are real such as the oil spill that occurred in the Santa Barbara channel due to the blowout under UNOCAL's Platform A in 1969 or perceived, such as the use of pesticides in agriculture and flood control vegetation management. This paper will describe the Flood Control District's efforts to manage vegetation in the various areas where we do work countywide and how those efforts have changed through the years in response to the concerns of the environmentally aware citizens of Santa Barbara County. One result of the previously mentioned oil spill and other environmental concerns was the enactment of the National Environmental Policy Act (NEPA). The following year the State of California enacted CEQA, the California Environmental Quality Act. Santa Barbara County activists had a direct role in the formalization of both of these far-reaching pieces of legislation. Here in Ventura County, the approval of the Holiday Inn Hotel that is just up the road was a similar galvanizing force for the creation of environmental legislation. In this case, people from Ventura jointed with many of the same activists from Santa Barbara and other counties and convinced the legislature to enact the California Coastal Act in 1976. All of these pieces of legislation have produced regulatory bureaucracies that the Flood Control District deals with on a regular basis.

The District was also formed by an act of the legislature but this was done in 1955 in response to damage from catastrophic flooding in the county in 1953. When the District was formed, there was little thought given to how it would deal with environmental issues because the people who pressed for the formation of a Flood Control District wanted protection from the environment.

As an example of this, you can look at the areas of Santa Barbara County that have concrete channels built where there were previously creeks. There are very few of them and almost all of them were built before the 1970's. In fact, the way that the District has interacted with the development community has changed with time. Prior to 1960, houses were built as close as possible to creeks with little regard to the potential of flood damage. Starting in the early '60's, partly in response to awakening environmental concerns about the value of riparian corridors but in much larger measure due to the foresight of District engineers concern for flood protection, subdivisions were built with a wide greenbelt, open-space area on either side of a creek. On the outer edge of the greenbelt were the streets that also gave the District maintenance access when needed, and then the houses would be built. Thus the private property was set back from the creek, affording increased protection from not only flood damage, but also from erosion that threatens many older homes currently.

So what does the District do? We work to provide a regional benefit to protect the citizens of Santa Barbara County from damage that can be caused by floodwater. We use various methods to clear debris and obstructive vegetation from about 235 miles of rivers and channels countywide. This encompasses an area from Rincon Creek to the Santa Maria River. We also perform work to restore the capacity of channels but that doesn't usually involve vegetation management. Vegetation management methods vary from hand crews to heavy equipment, herbicide spray and various types of mowers, depending on the watershed characteristics. We don't control floods nor can we prevent flooding when truly heavy rain falls. We can reduce the likelihood of flood damage that would be caused by a given storm in the absence of our efforts.

The District is like all forms of local government when it comes to the amount of money we get to perform the service that we were created to provide. We have some severe limitations on the amount of money we can take in (Prop. 13 and other similar measures) and those limitations don't account for inflationary costs.

On the other hand we are not a "use it or lose it" agency nor are we in competition with other County Government Departments that depend on the Board of Supervisors decisions on the apportionment of the County's General Fund money. Our expenses for equipment (purchases and maintenance), supplies and salaries are affected by some accounting structure decisions that were made by upper management years ago. This structure results in our employees "costing" the same amount of money per hour whether they are using a shovel or one of our bulldozers to move dirt. The same is true in vegetation management, it is the same cost per hour for an employee using a chainsaw on big trees or a $100,000.00 spray rig for six inch high willows. Obviously we try to use the best tool for any given job to maximize crew efficiency and cover as much ground as we can in any given time period. It makes a lot of sense financially to treat areas frequently with herbicide before the vegetation achieves any significant size. In addition, when we produced our Program EIR that deals with our maintenance practices and mitigation measures, an independent toxicologist wrote the herbicide use section which concluded that, "The use of approved herbicides in accordance with the label is environmentally preferable to mechanized vegetation management". The adverse effects of erosion and turbidity following treatment of an area are minimal when herbicides are used. In addition, the District has changed practices regarding herbicide use over the years for a variety of reasons. Certain areas used to have a broadcast spray treatment every year. That changed to the broadcast treatment being followed with seeding the area with a fast growing grass that would out-compete weedy species which would otherwise colonize the channel with silt trapping growth. The grass had the added benefit of providing forage for fall migrant birds. The next step in the evolution of the management of these areas was to do a very precise spot treatment of just those species of vegetation that could trap sediment or form obstructions to flood flows. But still there were environmental activists who did not want the District to use any herbicides. This was in spite of the fact that we were not only selective in the manner we used them but were also very careful in our choice of the kinds of materials that were used. We only choose materials that have a long, independently proven record of environmental safety. The District's response to the political pressure attempting to force us to eliminate herbicide use was to develop, in concert with other County Departments, an Integrated Pest Management Strategy. The strategy codified many practices that the District had been following for years. It has caused some reductions in the amount of material we can use, which we have dealt with by making further changes in our methods of vegetation management. In addition, we do an annual report to the Board of Supervisors in the form of a public hearing thus doing a more thorough job of informing the public of our practices and materials used. There is a review and approval process for us to use if we want to add a new material to our list of approved pesticides. This has caused some delays but by and large has not resulted in hampering our work. It has just caused us to do our research further in advance of an anticipated need.

One item in the strategy that has caused a problem is the provision that eliminates our ability to use a material if it appears on the State's "Proposition 65 List", i.e., chemicals that are "known" to cause cancer. For example, two years ago, Diuron showed up on that list. We had to scramble to find a substitute that would work with our equipment. The material we chose has to be applied twice to be roughly as effective as one application of Diuron and it is nearly ten times as expensive. In looking at the research on Diuron, it is not at all clear why it is on the "list" and I am hopeful that the manufacturer is working to rectify this situation. I am sure that this will not be the last time that our Board approved IPM strategy will cause us to change what we do and what we use with very little real benefit in the form of environmental protection. On the other hand I am also sure that if we had not taken this approach there would have been a great deal more pressure put on the Board to just outright ban the use of herbicides altogether. A copy of the Strategy can be accessed through Santa Barbara County's website. Go to www.countyofsb.org/Greenteam then click on Downloads and then "Integrated Pest Management Strategy".

In summary, the District is constantly dealing with environmental issues as we try to provide our community with the best level of flood protection that we can. In so doing, we are always looking for environmentally sound, cost effective methods of vegetation management.

Wildfires and invasive plants in southern California

Carl E. Bell, Joseph M. DiTomaso, Matthew L. Brooks
University of California Cooperative Extension, 5555 Overland Ave., suite 4101, San Diego, CA 92123, cebell@ucdavis.edu; Weed Science Program, University of California One Shields Avenue, 210 Robbins Hall, Davis, CA 95616, ditomaso@vegmail.ucdavis.edu; and Western Ecological Research Center, United States Geological Survey, Henderson, NV 89074

The southern California wildfires of 2003 burnt over 750,000 acres, destroying thousands of homes, causing hundreds of deaths, and changing the face of much of the areas natural habitat. Wildfires are a regular and natural occurrence in southern California. Some of the common native vegetation types, like chaparral, valley grassland, and coastal sage scrub, which occur from near the coast to elevations of 3000 ft., are well adapted to fires and will return to their natural state within a few years of a fire under normal conditions. Conifer forests and oak woodlands, can tolerate low intensity fires that burn through the undergrowth, but are severely damaged by intense fires like those that struck southern California in 2003. Riparian vegetation in the rivers and creeks will resprout vigorously after a fire, but fires were infrequent and typically occured only in drought years. The southern California deserts did not have a history of burning frequently until recently.

In all of these different areas or habitats, the presence of weedy non-native invasive plants creates an abnormal situation that also influences wildfires. Invasive plants often increase the frequency of fires by providing year-round fuels that are easier to ignite. After the fire, these weedy invaders typically re-establish more rapidly than the native plants suppressing the recovery of the natives and allowing the weeds to expand their range. In addition, if fires occur too frequently, some of the native vegetation loses the ability to recover at all and we lose important natural habitat.

Invasive plants can carry fires in riparian habitats (rivers and creeks) that do not normally burn. Our river trees, such as the sycamore and the willows, do not recover well from fires, but the weeds do. In the deserts on the east side of the coastal mountain ranges, invasive grasses have in some areas converted the native desert scrub into annual grassland that may never recover. Wildfires affect animals also, especially those that are small or not very mobile. The more frequent the fires, the greater the negative effect on the native birds, mammals, reptiles, insects, and other creatures.

The invasive plants of greatest concern are:

Annual grasses:

Almost all of the grasses common in southern California today are non-native species from the Old World. These include wild oats (Avena sp.), bromes (Bromus sp.), Italian ryegrass, and a few others. These grasses germinate in the winter and complete their lifecycle before summer. Then they sit there as dry fuel throughout the summer and fall fire season. Their seed fall to the ground in early summer when they are mature, which helps protect them from fire injury. In the desert, Mediterranean splitgrass (Schismus sp.) and cheatgrass (Bromus tectorum) have carried fires that change the ecosystem from desert scrub to grassland.

Perennial grasses;

Giant Reed (Arundo donax) is the most common invasive plant in riparian areas of southern California. Because it grows in dense masses to heights of 20-30 feet, it creates a large amount of biomass that becomes dry and flammable in the fall. When it burns, the fires are big and intense. After the fire, giant reed re-sprouts quickly from the large rhizome system while the natives recover slowly. Gaps left on the river banks provide invasion points for other weedy plants, such as castor bean and poison hemlock. .

Pampasgrass (Cortaderia selloana) is a large clumping grass, about 6 to8 feet tall and about as wide. It is a weed of coastal sage scrub and the upland areas of riparian zones. Although it stays green all year, it still burns fairly readily because of the mass of old leaf litter and dead flower plumes. The large clumps can become massive torches and hinder access to fires for fire fighters.

Fountain grass (Pennisetum setaceum): After the San Diego wildfires of 2003, this was often the first plant to re-sprout along streets and highways. Like pampasgrass, it stays green, but the leaf litter and old shoots burn easily.

Herbaceous broadleaf plants:

Like the grasses, southern California has a legacy of Mediterranean forbs (herbaceous broadleaf plants) introduced by European immigrants that grow readily in the winter and spring, then die or go dormant as the summer progresses. Examples of these are black mustard and other mustards, filaree, fennel, and thistles. These do not usually produce as much fine fuels as the grasses, but their left over seed stalks do burn and the seed are usually not hurt by fire. Also, they are early germinators, like the grasses and compete with the natives. In the desert, Saharan mustard (B tournefortiii) produces large amounts of fuel and has become an important contributor to the wildfire problem.

Woody trees and shrubs:

Several of the woody invaders, such as saltcedar, acacias, and eucalyptus, burn quite readily and recover easily. Like Arundo, these are often invasive in riparian habitats and introduce fire into areas not used to being burned. Saltcedar, in particular, is responsible for intense summer fires along desert rivers. In some cases, the fires associated with saltcedar have eliminated stands of native mesquite along the Colorado River.

What can be done about this problem?

The first defense is to prevent or remove invasive plants from natural habitats. This can be done by supporting efforts of private and public organizations working to get rid of invasive plants. It is especially important to read and follow posted materials at the entrance of parks, forests, and preserves that discuss invasive plants. We should also incorporate invasive plant control into wildfire planning and management. The following are some suggestions;

The creation of fire and fuel breaks is often an essential part of fighting or being prepared to fight a wildfire. The breaks can, however, also be a pathway for non-native plants to invade new territory. Appropriate weed control practices should be part of the fire/fuel break construction and maintenance. These practices might include; cleaning equipment before and after entering fuel/fire breaks, planting native species as ground cover in breaks, mowing breaks in late spring after weedy annuals have stopped growing but have not produced viable seed yet.

After fires there is usually a desire to do something to aid recovery of the vegetation on burnt areas, especially on slopes that might erode during the winter rainy period. In the past it was common to seed areas with quick growing annual plants, typically annual ryegrass or collections of native and non-native forbs. This practice is no longer recommended because the results are not usually worth the effort; either it rains too much and the seed washes away or it does not rain enough to get good seed germination. In addition, some of plants used for re-seeding persisted in the site, became invasive, and competed with the native vegetation recovery.

Mulches, straw bales, and straw wattles are sometimes used to temporarily hold soil in place until the native vegetation gets re-established. Be careful to select and inspect these materials so they are not a source of invasive plants.

Fire for invasive plant control:

Fire is also a tool that can be used to manage ecosystems by removing vegetation. In some grassland areas, controlled burns at the right stage of growth of the native and non-native plants have reduced the weedy plants and increased the native bunch grasses. In other cases, burning damages natives and create gaps for invasive plants. Like all other weed control practices such as herbicides, mowing, or tilling the soil, burning has to be utilized properly and should be integrated with other methods and with planned re-vegetation of native plants.

After a fire, the normal mass of plant material is gone, so access to areas can be easier. This can be a chance to do a lot of weed control for much less cost and effort; such opportunities should not be wasted.

Overview of Drip Fumigation

Husein Ajwa, University of California-Davis, Salina, CA 93905, haajwa@ucdavis.edu

The use of fumigants, such as methyl bromide (MB), has long been regarded as a necessary pre-planting practice to control soilborne fungal pathogens and weeds. Currently, only three MB alternative fumigants are registered and available for use in the USA, and intensive research is being conducted to optimize application technologies to improve the performance and to reduce the cost. The registered chemical alternatives are chloropicrin, 1,3-dichloropropene, and methyl isothiocyanate generators such as metam sodium, metam potassium, and Basamid. Iodomethane (methyl iodide, Midas™) is currently being considered for registration by the USEPA.

Chloropicrin has been used as a pre-plant fumigant to suppress fungal pathogens in soil and as a warning agent for odorless fumigants such as MB. The fumigant 1,3-dichloropropene is an effective nematicide that has been used in combination with chloropicrin (e.g., Telone C35 or InLine) to improves the control of soilborne fungal pathogens. Metam sodium may be used to control pathogenic fungi, nematodes, insects and weeds, although it is most efficacious in controlling weeds. Iodomethane has the potential of serving as a viable replacement for MB. When applied at an equivalent weight, iodomethane is more effective than MB in controlling soil fungal pathogens and most weeds. Our research also found that sequential application of metam sodium after chloropicrin, InLine, or Midas™ enhanced the efficacy of reduced rates of these alternatives.

For control of fungal pathogens and weeds, our research found that application of these alternatives by drip fumigation is more effective than by shank injection. Although the alternative fumigants can be applied to soil by shank injection, these fumigants (except iodomethane) have lower vapor pressure and higher boiling points than MeBr, and their efficacy to control soil pathogens and weeds is more dependent on the application method, soil type and condition, and weather conditions.

Drip irrigation systems could serve as a vehicle to deliver water soluble formulations of fumigants to the target soil volume and may provide a more uniform distribution of chemicals in the soil than shank injection. However, several variables may affect the efficacy of drip fumigation in controlling soilborne pathogenic fungi, nematodes, and weeds. These include fumigant/emulsifier formulation, fumigant application rate, amount and rate of water application, irrigation uniformity, soil characteristics (soil texture, permeability, organic matter, water content, etc.), sealing method (type of tarp), and environmental conditions.

Drip fumigation is still in its infancy, and research is being conducted to optimize parameters for this technology. For example, our research determined optimum water carrier amount needed for successful drip fumigation for various soil type and drip tape flow rates. Table 1 lists the amount of application water per two feet of soil depth recommended for drip fumigation of various soils (raised strawberry beds). Application of fumigants in less than 1.5 inches of water will result in poor fumigant distribution and high volatilization losses that diminish the efficacy to control soilborne pathogens and weeds.

When done correctly, drip fumigation reduces worker exposure and allows for simultaneous or sequential application of a combination of fumigants. This paper discusses ongoing studies to determine optimum application rates, soil conditions, plastic mulches, and amount of irrigation water used to apply these alternative fumigants.

Table 1. Estimated water amount needed to treat *two feet* of soil depth using two drip tapes. Application time and water volume were based on 40 inches average bed width (64 inches center-to-center).

Soil type	Amount of application water Inches (gallons)[a]	Drip tape flow rate (gpm/100ft)	Application time using 2 tapes (hours)	Comments
Fine sand and loamy fine sand	1.6 (27,154)	0.5 – 0.67	5.5 – 4.1	Pre-irrigation with one inch of water is needed
Sandy loam and fine sandy loam	2.0 (33,943)	0.5 – 0.67	6.9 – 5.2	Minimum of 1.5 inches is recommended
Sandy clay loam and loam	2.6 (44,125)	0.2 – 0.45	22.5 – 10.0	Split application may be required
Clay, clay loam, and silty clay loam	3.2 (54,308)	0.2 – 0.45	27.7 – 12.3	Soils not common in strawberry production

[a] One broadcast acre-inch of water is 27154 gallons. One bed acre-inch of water is 16971 gallons.

Weed Control in Strawberries with GoalTender and other Herbicides

Oleg Daugovish, University of California Cooperative Extension, Ventura County, Ventura, California, 93003, odaugovish@ucdavis.edu, Steve Fennimore, University of California Davis, Salinas, CA

Weed control in strawberry is normally accomplished with fumigants. However, since fumigants do not control many common strawberry weeds such as little mallow (cheeseweed), California burclover, Indian sweetclover and filaree, there is a need for herbicides for strawberry. Additionally, fumigants cannot kill weed seeds that blow into the field after fumigation such as hairy fleabane, common groundsel and common sowthistle. Herbicides also may be useful in areas where buffer zones, and proximity to sensitive sites limit fumigant rates. Where drip fumigation is used, the furrow bottom is not fumigated, and herbicides are useful to keep the furrow bottoms relatively weed free. Fields with a history of weed problems and those rotated into strawberries from non-competitive vegetable crops often require multiple weeding operations if clear plastic mulch is used. Weeding through plastic deteriorates the mulch and is time consuming resulting in seasonal costs of up to $700 per acre. Additionally, weeding diverts labor that can otherwise be utilized for fruit harvest.

In studies in Monterey County, CA pre-transplant herbicides Napropamid (Devrinol) and DCPA (Dacthal) provided near 80% control of some broadleaf weed but only 50% or less control of little mallow and sweetclover. Sethoxydim (Poast) and Clethodim (Prism) controlled grasses but missed broadleaf weeds.

Eight studies evaluated oxyfluorfen (Goal XL and GoalTender) in Ventura and Monterey Counties of California pre-transplant following either methyl bromide flat fumigation, Telone C35 or prior to 1,3 D +chlorpichrin (InLine) drip fumigation. No crop injury was observed where strawberries were transplanted through plastic tarp, installed after oxyfluorfen application. However, where no tarp was in place at time of transplanting, oxyfluorfen caused injury to about 8% of plants at Ventura and reduced fruit yield 21% at Monterey. Even in the presence of plastic mulch oxyfluorfen (Goal XL) may cause transplant injury if the large holes around the transplants allow codistillation and vapor-to-plant contact. Narrow planting holes cut with blade knife provide sufficient plant protection from the herbicide injury. The data showed that transplants in bare beds and in large planting holes can outgrow injury in about 5 weeks but fruit yield during the first 3-4 harvests is significantly reduced.

Both oxyfluorfen formulations provided excellent (72 to 100%) control of little mallow at full rate (2 pints /acre for Goal XL and 1 pint /acre for Goaltender) and half-rate at either location. The full rate of oxyfluorfen treatment provided partial control of sweetclover (75-100%) at Monterey and California burclover (67%) at Ventura. However, none of the oxyfluorfen rates controlled hairy fleabane in Ventura County trials. Fleabane was especially troublesome in transplanting holes were soil disturbance during hole cutting and planting likely reduced oxyfluorfen activity and enhanced weed seed germination.

Oxyfluorfen at full rate reduced total weeding time 38% to 61%, compared to no herbicide in three Ventura studies. Estimated material and application costs were less than the potential savings in the weeding costs, suggesting that oxyfluorfen treatment provides cost-effective weed control. Lack of fleabane control in one study resulted in similar weeding costs as in untreated control. These studies show that oxyfluorfen may provide excellent and economical control of the weeds difficult to control with alternative soil fumigants, such as little mallow. However, application of plastic mulch is required before planting to prevent injury to strawberry plants. If soil moisture is lacking in a bed, light sprinkler irrigation should be applied to activate the herbicide.

Weed Control in Strawberries with Fumigants

Steven A. Fennimore, University of California, Davis, Salinas, CA 93905
(safennimore@ucdavis.edu),
Oleg Daugovish, University of California, Ventura CA 93003 and
\Husein Ajwa, University of California, Davis, Salinas, CA 93905

Introduction

Strawberries are highly susceptible to weed competition immediately after planting when the plants are small and frequent irrigation provides ideal conditions for weed germination. Most weeds that invade strawberries are annuals. Weeds such as little mallow (cheeseweed), burclover, sweet clover, and filaree invade during stand establishment and are common because their seeds survive fumigation. Once strawberries are in the bearing stage of growth, weeds with windblown seeds, including sowthistle and common groundsel, may become problems. In conventional strawberry fields, effective weed management requires a combination of cultural practices, preplant soil fumigation, and additional herbicide applications when necessary. Proper field and bed preparation is essential for a good weed control program. For weed and pathogen control, fumigation with a mixture of 1,3-dichloropropene/chloropicrin (Telone C35, Inline) or chloropicrin alone, followed by an application of metam sodium or metam potassium, is emerging as the best alternative method of weed control in California strawberries in response to the phase out of methyl bromide. The use of virtually impermeable film (VIF) enhances weed control provided by Inline. For weeds that escape preplant controls, hand-weeding and/or selective herbicides are used.

Crop Rotation. Rotational crops can be an important part of a weed control program. Rotations can be cash crops such as lettuce or cole crops, or small grains (barley, cereal rye, oats, or wheat) grown as cover crops or green manure crops. Where the cropping cycle permits, sudangrass may be included in the rotation cycle as a summer annual green manure crop. Intensive cultivation of a vegetable crop rotation such as lettuce or a cole crop helps control many problem weeds. A densely planted cereal rye cover crop or small grain crop is highly competitive with weeds and provides better weed control than a legume cover crop. In addition, alternative herbicides are available in rotations. Difficult to control weeds such as field bindweed must be controlled in fallow ground with timely applications of glyphosate. Strawberry production should not be attempted while a field is infested with field bindweed, because no fumigant or herbicide available for strawberry can control this weed.

Killing weed seeds with fumigants

Fumigation. Fumigation with methyl bromide, Telone C35, Inline, chloropicrin, and metam sodium (Vapam, Sectagon 42) before bed preparation kills the seeds of most weeds and the reproductive structures of some perennials. Nearly all fumigant applications are either immediately covered with plastic mulch or are injected through the drip irrigation system under plastic mulch. Drip injection of fumigants such as Inline or chloropicrin often improves the weed control compared to shank fumigation. However, it is important to thoroughly wet the bed during fumigant injection to ensure weed control on the edges of the bed. Where drip fumigation is used, only the bed is treated, and the row middles are left unfumigated. Soil-applied herbicides such as napropamide can be used to control weeds in the row middles. Soil fumigants control weeds by killing both germinating seedlings and ungerminated seeds. Methyl bromide, Inline, Telone C35, and metam sodium kill weed seedlings and seeds by respiration inhibition. However, to kill weed seeds, fumigants must be able to penetrate the seed coat and kill the seed embryo. It is more effective to kill moistened seed, because the seed tissues swell with water and allow the fumigant to penetrate more thoroughly. Moist seeds also have higher respiration rates and are more susceptible to fumigants than dry seed with low respiration rates. Proper irrigation before fumigation is one of the keys to effective weed control with all fumigants.

Weed seeds in the soil are called the weed seedbank. Most weeds in the soil are dormant and only a fraction of the seeds are available to germinate under good conditions. Preemergence herbicides kill germinating seedlings, and therefore act on only a small fraction of the weed seedbank. Similarly, postemergence herbicides, cultivators and hoes only kill emerged weeds. Therefore, most of our weed control tools do not affect the dormant weed seedbank. Soil fumigants such as methyl bromide, and metam sodium are an exception and can kill dormant and nondormant weed seeds. Methyl bromide and other fumigants are respiration inhibitors. Dormant, nondormant, and germinating weed seeds are living organisms that respire, and therefore most can be killed with fumigants such as methyl bromide. However, not all weed species are susceptible to fumigants. Among those species that are tolerant to fumigants are: California burclover, sweet clover, little mallow and filaree. Those weed species are tolerant due to the presence of hard seed coats that prevent penetration of the fumigant through the seed

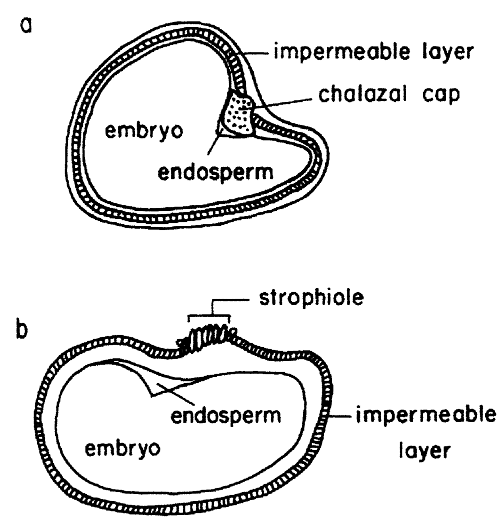


Figure 1. Hard-coated seeds that are difficult to kill with fumigants: a) little mallow, b) clover.

coat (Figure 1). The hard seed coat also means that water cannot penetrate and the embryo is dry.

Wetting of seeds is necessary to make them swell and respire. Weed seeds that are dry are highly resistant to fumigants. Plant cells in the embryos of dry seed are tightly compacted and the fumigants can only move slowly through dry seed. In contrast, the wet weed seed has cells that are fully expanded and full of free water that allows the fumigant molecule to move more freely. Many people state that before fumigation you need to irrigate the field to "germinate weed seeds". While it is true that fumigants do a good job of killing weed seedlings, fumigants can also kill ungerminated weed seeds with soft seed coats such as common chickweed. For hard coated seed such as clover, the only seed that will be killed are those that germinate. In summary, if you can get a lethal dose of fumigant through the seed coat and into the embryo cells of a wet seed, then you can kill soft-coat weed seed whether it is germinating or not, but hard coated seeds can only be killed if they germinate.

Where weeds must be controlled

Weeds must be controlled on the top and shoulders of raised beds and in the furrow bottoms. Weed control on the bed top and shoulders are controlled by 1. fumigants, 2. herbicides, 3. mulches, 4. hand weeding.

Most weed seeds are small and emerge from shallow layers in the soil (Table 1). Because of this, the most critical zone for controlling weeds is the surface soil layer. To kill weed seeds in the surface layer, the fumigant concentration there must reach the critical dose required to kill the weed seed.

Table 1. The optimum and maximum depths of emergence for several weeds (Radosevich and Holt 1984).

Weed	Optimum emergence depth (inches)	Maximum emergence depth (inches)
Annual bluegrass	0.4	0.8
Calif. burclover	0.5	--
Common chickweed	0.4	0.8
Common lambsquarters	0.2	1.9
Little mallow (cheeseweed)	0.5	--
Shepherd's-purse	0.2	0.8

Lethal fumigant doses. The objective of using a fumigant is to temporarily create conditions that are lethal for pests. Lethal conditions are created by keeping the concentration of the fumigant above a critical concentration for a sufficient amount of time. The lethal conditions are usually described as the lethal dose required to kill 50 or 90 percent of a pest population ($LD_{50's}$ or $LD_{90's}$). For example, Inline maintained at or above 130 lbs/A for 72 hours will kill 90 out of 100 chickweed seeds (Table 2).

Because weed seeds can emerge from shallow layers anywhere on the bedtop and bed shoulders, good lateral distribution of the fumigants within the bed is necessary. Fumigants applied by drip irrigation must be applied in sufficient water to move them to the edge of the bed at a dose sufficient to kill weed seeds. The edge of the bed is a particularly difficult area for the fumigant to penetrate at concentrations necessary to kill weed seeds there (see arrow in Figure 2). Proper soil moisture conditions are required to get the lateral distribution necessary for effective weed control at the edge of the bed. See the fumigant application section for details about optimizing fumigant application conditions.

Table 2. Inline dose (lbs/A) required to control 90% (LD_{90}) of weed seeds.

Weed species	LD_{90} lab (24 hour)	LD_{90} field (72 hour)
	Lbs/A	
Knotweed	480	180
Common chickweed	240	130
Common purslane	180	80
Little mallow (cheeseweed)	>1250	>400
Filaree	>1250	>400

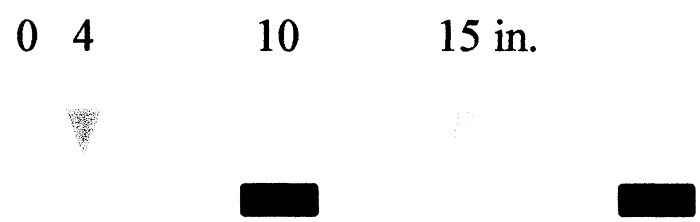


Figure 2. A strawberry bed fumigated by drip irrigation (drip cross-section marked in red). The arrows show the locations in the center and edge of the bed (distance in inches from the edge) where it is more difficult to get the fumigant at concentrations needed to kill weed seeds.

<u>Sequential applications of metam sodium</u>. With the phase out of methyl bromide, the most effective soil fumigation is a sequential application of chloropicrin or Inline followed 5 to 7 days later by metam sodium or metam potassium. This combination of materials can provide effective control of weeds as well as soilborne pathogens, soil insects and nematodes.

Chloropicrin is effective on soilborne diseases, but less effective on weeds. Inline (1,3-dichloropropene plus chloropicrin) tends to provide better weed control than pure chloropicrin, but in many cases Inline can also provide less effective weed control than methyl bromide. One way to improve weed control with chloropicrin and Inline is to use a sequential application of metam sodium or metam potassium.

Metam sodium (Sectagon 42, Vapam HL and others) or metam potassium (Kpam) are used as sequential fumigants following drip applications of chloropicrin or Inline. In this procedure, chloropicrin or Inline can be applied through the drip irrigation system followed 5 to 7 days later by metam sodium/potassium applied through the drip irrigation system. It is necessary to have a 5 to 7 day interval between the chloropicrin or Inline application and the metam application due to chemical incompatibility between the products. Critical aspects to be aware of when using a sequential application of metam sodium/potassium are that: 1) soil must be in seed bed condition with clods no larger than 0.5 inches in diameter, 2) beds must be shaped and ready for planting, and 3) soil moisture must be 50 to 80% of field capacity at time of application. These factors are important to ensure good fumigant distribution throughout the soil profile and to ensure that viable weed seed are wet and easier to kill. It is important to avoid soil disturbance after treatment to avoid movement of viable weed seeds from deeper layers to the soil surface.

Use of virtually impermeable film

Virtually impermeable films are designed to reduce fumigant emissions to near zero (Figure 3). Husein Ajwa and others have found that, if VIF can be installed intact with minimal stretching or tearing, then fumigant emission is reduced. Reduction of fumigant emissions by VIF causes an increase in the fumigant concentration under the tarp. Because fumigant concentrations are higher under VIF, more weed seeds are killed and weed control is improved.

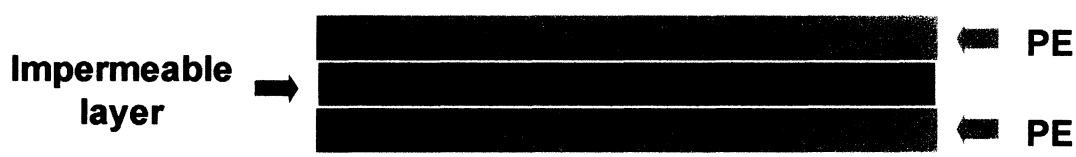


Figure 3. Virtually impermeable film consists of at least three layers. In the three layer film shown above, the top and bottom layers consist of normal polyethylene tarp, and the middle layer consists of an impermeable layer.

There are other types of films called cross polymer films. These films lack the impermeable layers of VIF films, but cross polymer films reduce fumigant emissions more so than standard films. Research is currently under way to determine if cross polymer films improve weed control.

Summary

The keys to effective weed control with fumigants in strawberry are:

1. Careful field selection to avoid difficult to control weeds and severe weed populations.
2. Ensure proper soil moisture at time of fumigation so that weed seeds either germinate, or that ungerminated seed can absorb fumigants.
3. Ensure good lateral distribution of fumigant in the planting bed.
4. Sequential applications of metam sodium or metam potassium can improve weed control following chloropicrin or Inline.
5. Increased retention of fumigants with VIF can improve weed control.

Overview of Drip Fumigation

Husein Ajwa, University of California-Davis, Salina, CA 93905, haajwa@ucdavis.edu

The use of fumigants, such as methyl bromide (MB), has long been regarded as a necessary pre-planting practice to control soilborne fungal pathogens and weeds. Currently, only three MB alternative fumigants are registered and available for use in the USA, and intensive research is being conducted to optimize application technologies to improve the performance and to reduce the cost. The registered chemical alternatives are chloropicrin, 1,3-dichloropropene, and methyl isothiocyanate generators such as metam sodium, metam potassium, and Basamid. Iodomethane (methyl iodide, Midas™) is currently being considered for registration by the USEPA.

Chloropicrin has been used as a pre-plant fumigant to suppress fungal pathogens in soil and as a warning agent for odorless fumigants such as MB. The fumigant 1,3-dichloropropene is an effective nematicide that has been used in combination with chloropicrin (e.g., Telone C35 or InLine) to improves the control of soilborne fungal pathogens. Metam sodium may be used to control pathogenic fungi, nematodes, insects and weeds, although it is most efficacious in controlling weeds. Iodomethane has the potential of serving as a viable replacement for MB. When applied at an equivalent weight, iodomethane is more effective than MB in controlling soil fungal pathogens and most weeds. Our research also found that sequential application of metam sodium after chloropicrin, InLine, or Midas™ enhanced the efficacy of reduced rates of these alternatives.

For control of fungal pathogens and weeds, our research found that application of these alternatives by drip fumigation is more effective than by shank injection. Although the alternative fumigants can be applied to soil by shank injection, these fumigants (except iodomethane) have lower vapor pressure and higher boiling points than MeBr, and their efficacy to control soil pathogens and weeds is more dependent on the application method, soil type and condition, and weather conditions.

Drip irrigation systems could serve as a vehicle to deliver water soluble formulations of fumigants to the target soil volume and may provide a more uniform distribution of chemicals in the soil than shank injection. However, several variables may affect the efficacy of drip fumigation in controlling soilborne pathogenic fungi, nematodes, and weeds. These include fumigant/emulsifier formulation, fumigant application rate, amount and rate of water application, irrigation uniformity, soil characteristics (soil texture, permeability, organic matter, water content, etc.), sealing method (type of tarp), and environmental conditions.

Drip fumigation is still in its infancy, and research is being conducted to optimize parameters for this technology. For example, our research determined optimum water carrier amount needed for successful drip fumigation for various soil type and drip tape flow rates. Table 1 lists the amount of application water per two feet of soil depth recommended for drip fumigation of various soils (raised strawberry beds). Application of fumigants in less than 1.5 inches of water will result in poor fumigant distribution and high volatilization losses that diminish the efficacy to control soilborne pathogens and weeds.

When done correctly, drip fumigation reduces worker exposure and allows for simultaneous or sequential application of a combination of fumigants. This paper discusses ongoing studies to determine optimum application rates, soil conditions, plastic mulches, and amount of irrigation water used to apply these alternative fumigants.

Table 1. Estimated water amount needed to treat *two feet* of soil depth using two drip tapes. Application time and water volume were based on 40 inches average bed width (64 inches center-to-center).

Soil type	Amount of application water Inches (gallons)[a]	Drip tape flow rate (gpm/100ft)	Application time using 2 tapes (hours)	Comments
Fine sand and loamy fine sand	1.6 (27,154)	0.5 – 0.67	5.5 – 4.1	Pre-irrigation with one inch of water is needed
Sandy loam and fine sandy loam	2.0 (33,943)	0.5 – 0.67	6.9 – 5.2	Minimum of 1.5 inches is recommended
Sandy clay loam and loam	2.6 (44,125)	0.2 – 0.45	22.5 – 10.0	Split application may be required
Clay, clay loam, and silty clay loam	3.2 (54,308)	0.2 – 0.45	27.7 – 12.3	Soils not common in strawberry production

[a] One broadcast acre-inch of water is 27154 gallons. One bed acre-inch of water is 16971 gallons.

Weed Control in Strawberries with GoalTender and other Herbicides

Oleg Daugovish, University of California Cooperative Extension, Ventura County, Ventura, California, 93003, odaugovish@ucdavis.edu, Steve Fennimore, University of California Davis, Salinas, CA

Weed control in strawberry is normally accomplished with fumigants. However, since fumigants do not control many common strawberry weeds such as little mallow (cheeseweed), California burclover, Indian sweetclover and filaree, there is a need for herbicides for strawberry. Additionally, fumigants cannot kill weed seeds that blow into the field after fumigation such as hairy fleabane, common groundsel and common sowthistle. Herbicides also may be useful in areas where buffer zones, and proximity to sensitive sites limit fumigant rates. Where drip fumigation is used, the furrow bottom is not fumigated, and herbicides are useful to keep the furrow bottoms relatively weed free. Fields with a history of weed problems and those rotated into strawberries from non-competitive vegetable crops often require multiple weeding operations if clear plastic mulch is used. Weeding through plastic deteriorates the mulch and is time consuming resulting in seasonal costs of up to $700 per acre. Additionally, weeding diverts labor that can otherwise be utilized for fruit harvest.

In studies in Monterey County, CA pre-transplant herbicides Napropamid (Devrinol) and DCPA (Dacthal) provided near 80% control of some broadleaf weed but only 50% or less control of little mallow and sweetclover. Sethoxydim (Poast) and Clethodim (Prism) controlled grasses but missed broadleaf weeds.

Eight studies evaluated oxyfluorfen (Goal XL and GoalTender) in Ventura and Monterey Counties of California pre-transplant following either methyl bromide flat fumigation, Telone C35 or prior to 1,3 D +chlorpichrin (InLine) drip fumigation. No crop injury was observed where strawberries were transplanted through plastic tarp, installed after oxyfluorfen application. However, where no tarp was in place at time of transplanting, oxyfluorfen caused injury to about 8% of plants at Ventura and reduced fruit yield 21% at Monterey. Even in the presence of plastic mulch oxyfluorfen (Goal XL) may cause transplant injury if the large holes around the transplants allow codistillation and vapor-to-plant contact. Narrow planting holes cut with blade knife provide sufficient plant protection from the herbicide injury. The data showed that transplants in bare beds and in large planting holes can outgrow injury in about 5 weeks but fruit yield during the first 3-4 harvests is significantly reduced.

Both oxyfluorfen formulations provided excellent (72 to 100%) control of little mallow at full rate (2 pints /acre for Goal XL and 1 pint /acre for Goaltender) and half-rate at either location. The full rate of oxyfluorfen treatment provided partial control of sweetclover (75-100%) at Monterey and California burclover (67%) at Ventura. However, none of the oxyfluorfen rates controlled hairy fleabane in Ventura County trials. Fleabane was especially troublesome in transplanting holes were soil disturbance during hole cutting and planting likely reduced oxyfluorfen activity and enhanced weed seed germination.

Oxyfluorfen at full rate reduced total weeding time 38% to 61%, compared to no herbicide in three Ventura studies. Estimated material and application costs were less than the potential savings in the weeding costs, suggesting that oxyfluorfen treatment provides cost-effective weed control. Lack of fleabane control in one study resulted in similar weeding costs as in untreated control. These studies show that oxyfluorfen may provide excellent and economical control of the weeds difficult to control with alternative soil fumigants, such as little mallow. However, application of plastic mulch is required before planting to prevent injury to strawberry plants. If soil moisture is lacking in a bed, light sprinkler irrigation should be applied to activate the herbicide.

Weed Control in Strawberries with Fumigants

Steven A. Fennimore, University of California, Davis, Salinas, CA 93905
(safennimore@ucdavis.edu),
Oleg Daugovish, University of California, Ventura CA 93003 and
\Husein Ajwa, University of California, Davis, Salinas, CA 93905

Introduction

Strawberries are highly susceptible to weed competition immediately after planting when the plants are small and frequent irrigation provides ideal conditions for weed germination. Most weeds that invade strawberries are annuals. Weeds such as little mallow (cheeseweed), burclover, sweet clover, and filaree invade during stand establishment and are common because their seeds survive fumigation. Once strawberries are in the bearing stage of growth, weeds with windblown seeds, including sowthistle and common groundsel, may become problems. In conventional strawberry fields, effective weed management requires a combination of cultural practices, preplant soil fumigation, and additional herbicide applications when necessary. Proper field and bed preparation is essential for a good weed control program. For weed and pathogen control, fumigation with a mixture of 1,3-dichloropropene/chloropicrin (Telone C35, Inline) or chloropicrin alone, followed by an application of metam sodium or metam potassium, is emerging as the best alternative method of weed control in California strawberries in response to the phase out of methyl bromide. The use of virtually impermeable film (VIF) enhances weed control provided by Inline. For weeds that escape preplant controls, hand-weeding and/or selective herbicides are used.

Crop Rotation. Rotational crops can be an important part of a weed control program. Rotations can be cash crops such as lettuce or cole crops, or small grains (barley, cereal rye, oats, or wheat) grown as cover crops or green manure crops. Where the cropping cycle permits, sudangrass may be included in the rotation cycle as a summer annual green manure crop. Intensive cultivation of a vegetable crop rotation such as lettuce or a cole crop helps control many problem weeds. A densely planted cereal rye cover crop or small grain crop is highly competitive with weeds and provides better weed control than a legume cover crop. In addition, alternative herbicides are available in rotations. Difficult to control weeds such as field bindweed must be controlled in fallow ground with timely applications of glyphosate. Strawberry production should not be attempted while a field is infested with field bindweed, because no fumigant or herbicide available for strawberry can control this weed.

Killing weed seeds with fumigants

Fumigation. Fumigation with methyl bromide, Telone C35, Inline, chloropicrin, and metam sodium (Vapam, Sectagon 42) before bed preparation kills the seeds of most weeds and the reproductive structures of some perennials. Nearly all fumigant applications are either immediately covered with plastic mulch or are injected through the drip irrigation system under plastic mulch. Drip injection of fumigants such as Inline or chloropicrin often improves the weed control compared to shank fumigation. However, it is important to thoroughly wet the bed during fumigant injection to ensure weed control on the edges of the bed. Where drip fumigation is used, only the bed is treated, and the row middles are left unfumigated. Soil-applied herbicides such as napropamide can be used to control weeds in the row middles. Soil fumigants control weeds by killing both germinating seedlings and ungerminated seeds. Methyl bromide, Inline, Telone C35, and metam sodium kill weed seedlings and seeds by respiration inhibition. However, to kill weed seeds, fumigants must be able to penetrate the seed coat and kill the seed embryo. It is more effective to kill moistened seed, because the seed tissues swell with water and allow the fumigant to penetrate more thoroughly. Moist seeds also have higher respiration rates and are more susceptible to fumigants than dry seed with low respiration rates. Proper irrigation before fumigation is one of the keys to effective weed control with all fumigants.

Weed seeds in the soil are called the weed seedbank. Most weeds in the soil are dormant and only a fraction of the seeds are available to germinate under good conditions. Preemergence herbicides kill germinating seedlings, and therefore act on only a small fraction of the weed seedbank. Similarly, postemergence herbicides, cultivators and hoes only kill emerged weeds. Therefore, most of our weed control tools do not affect the dormant weed seedbank. Soil fumigants such as methyl bromide, and metam sodium are an exception and can kill dormant and nondormant weed seeds. Methyl bromide and other fumigants are respiration inhibitors. Dormant, nondormant, and germinating weed seeds are living organisms that respire, and therefore most can be killed with fumigants such as methyl bromide. However, not all weed species are susceptible to fumigants. Among those species that are tolerant to fumigants are: California burclover, sweet clover, little mallow and filaree. Those weed species are tolerant due to the presence of hard seed coats that prevent penetration of the fumigant through the seed

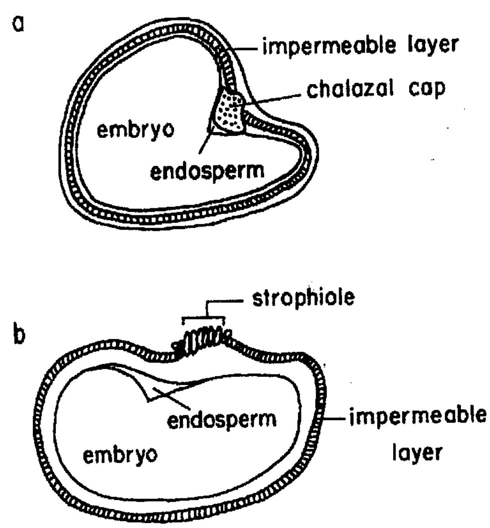


Figure 1. Hard-coated seeds that are difficult to kill with fumigants: a) little mallow, b) clover.

coat (Figure 1). The hard seed coat also means that water cannot penetrate and the embryo is dry.

Wetting of seeds is necessary to make them swell and respire. Weed seeds that are dry are highly resistant to fumigants. Plant cells in the embryos of dry seed are tightly compacted and the fumigants can only move slowly through dry seed. In contrast, the wet weed seed has cells that are fully expanded and full of free water that allows the fumigant molecule to move more freely. Many people state that before fumigation you need to irrigate the field to "germinate weed seeds". While it is true that fumigants do a good job of killing weed seedlings, fumigants can also kill ungerminated weed seeds with soft seed coats such as common chickweed. For hard coated seed such as clover, the only seed that will be killed are those that germinate. In summary, if you can get a lethal dose of fumigant through the seed coat and into the embryo cells of a wet seed, then you can kill soft-coat weed seed whether it is germinating or not, but hard coated seeds can only be killed if they germinate.

Where weeds must be controlled

Weeds must be controlled on the top and shoulders of raised beds and in the furrow bottoms. Weed control on the bed top and shoulders are controlled by 1. fumigants, 2. herbicides, 3. mulches, 4. hand weeding.

Most weed seeds are small and emerge from shallow layers in the soil (Table 1). Because of this, the most critical zone for controlling weeds is the surface soil layer. To kill weed seeds in the surface layer, the fumigant concentration there must reach the critical dose required to kill the weed seed.

Table 1. The optimum and maximum depths of emergence for several weeds (Radosevich and Holt 1984).

Weed	Optimum emergence depth (inches)	Maximum emergence depth (inches)
Annual bluegrass	0.4	0.8
Calif. burclover	0.5	--
Common chickweed	0.4	0.8
Common lambsquarters	0.2	1.9
Little mallow (cheeseweed)	0.5	--
Shepherd's-purse	0.2	0.8

Lethal fumigant doses. The objective of using a fumigant is to temporarily create conditions that are lethal for pests. Lethal conditions are created by keeping the concentration of the fumigant above a critical concentration for a sufficient amount of time. The lethal conditions are usually described as the lethal dose required to kill 50 or 90 percent of a pest population ($LD_{50's}$ or $LD_{90's}$). For example, Inline maintained at or above 130 lbs/A for 72 hours will kill 90 out of 100 chickweed seeds (Table 2).

Because weed seeds can emerge from shallow layers anywhere on the bedtop and bed shoulders, good lateral distribution of the fumigants within the bed is necessary. Fumigants applied by drip irrigation must be applied in sufficient water to move them to the edge of the bed at a dose sufficient to kill weed seeds. The edge of the bed is a particularly difficult area for the fumigant to penetrate at concentrations necessary to kill weed seeds there (see arrow in Figure 2). Proper soil moisture conditions are required to get the lateral distribution necessary for effective weed control at the edge of the bed. See the fumigant application section for details about optimizing fumigant application conditions.

Table 2. Inline dose (lbs/A) required to control 90% (LD_{90}) of weed seeds.

Weed species	LD_{90} lab (24 hour)	LD_{90} field (72 hour)
	------ Lbs/A ------	
Knotweed	480	180
Common chickweed	240	130
Common purslane	180	80
Little mallow (cheeseweed)	>1250	>400
Filaree	>1250	>400

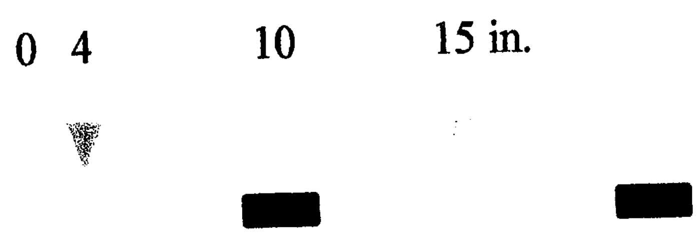


Figure 2. A strawberry bed fumigated by drip irrigation (drip cross-section marked in red). The arrows show the locations in the center and edge of the bed (distance in inches from the edge) where it is more difficult to get the fumigant at concentrations needed to kill weed seeds.

Sequential applications of metam sodium. With the phase out of methyl bromide, the most effective soil fumigation is a sequential application of chloropicrin or Inline followed 5 to 7 days later by metam sodium or metam potassium. This combination of materials can provide effective control of weeds as well as soilborne pathogens, soil insects and nematodes.

Chloropicrin is effective on soilborne diseases, but less effective on weeds. Inline (1,3-dichloropropene plus chloropicrin) tends to provide better weed control than pure chloropicrin, but in many cases Inline can also provide less effective weed control than methyl bromide. One way to improve weed control with chloropicrin and Inline is to use a sequential application of metam sodium or metam potassium.

Metam sodium (Sectagon 42, Vapam HL and others) or metam potassium (Kpam) are used as sequential fumigants following drip applications of chloropicrin or Inline. In this procedure, chloropicrin or Inline can be applied through the drip irrigation system followed 5 to 7 days later by metam sodium/potassium applied through the drip irrigation system. It is necessary to have a 5 to 7 day interval between the chloropicrin or Inline application and the metam application due to chemical incompatibility between the products. Critical aspects to be aware of when using a sequential application of metam sodium/potassium are that: 1) soil must be in seed bed condition with clods no larger than 0.5 inches in diameter, 2) beds must be shaped and ready for planting, and 3) soil moisture must be 50 to 80% of field capacity at time of application. These factors are important to ensure good fumigant distribution throughout the soil profile and to ensure that viable weed seed are wet and easier to kill. It is important to avoid soil disturbance after treatment to avoid movement of viable weed seeds from deeper layers to the soil surface.

Use of virtually impermeable film

Virtually impermeable films are designed to reduce fumigant emissions to near zero (Figure 3). Husein Ajwa and others have found that, if VIF can be installed intact with minimal stretching or tearing, then fumigant emission is reduced. Reduction of fumigant emissions by VIF causes an increase in the fumigant concentration under the tarp. Because fumigant concentrations are higher under VIF, more weed seeds are killed and weed control is improved.

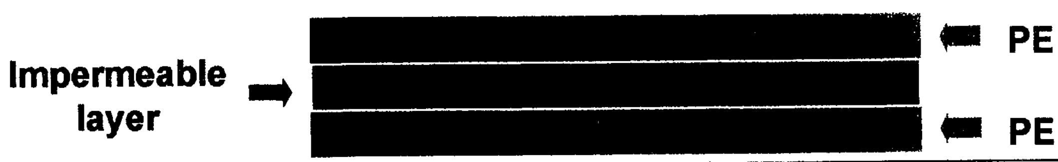


Figure 3. Virtually impermeable film consists of at least three layers. In the three layer film shown above, the top and bottom layers consist of normal polyethylene tarp, and the middle layer consists of an impermeable layer.

There are other types of films called cross polymer films. These films lack the impermeable layers of VIF films, but cross polymer films reduce fumigant emissions more so than standard films. Research is currently under way to determine if cross polymer films improve weed control.

Summary

The keys to effective weed control with fumigants in strawberry are:

1. Careful field selection to avoid difficult to control weeds and severe weed populations.
2. Ensure proper soil moisture at time of fumigation so that weed seeds either germinate, or that ungerminated seed can absorb fumigants.
3. Ensure good lateral distribution of fumigant in the planting bed.
4. Sequential applications of metam sodium or metam potassium can improve weed control following chloropicrin or Inline.
5. Increased retention of fumigants with VIF can improve weed control.

Weed Control in Strawberries: Grower's Perspective

Jon Rippee, Reiter Bro. Inc. Strawberry Production Manager, Camarillo, California; jrippee@berry.net

Difficult to control weed species. Weed species that are most difficult to control are: yellow nutsedge, clovers (primarily sweet clover) and little mallow. Occasionally, fleabane or horseweed (*Conyza* spp.) is a problem because the seed of these species may blow into the field and are not controlled by Goaltender (oxyfluorfen) herbicide. It is important to control these wind-spreading weed species at neighboring areas and use Roundup herbicide on plant in rosette stage before they transition to flowering.

Yellow nutsedge is the most expensive weed to control due its perennial nature and lack of chemical control options, and therefore considerable labor costs. Yellow nutsedge persists in non-fumigated field edges, spreads with equipment within the field and to other fields, and is not controlled by drip fumigation with InLine (1, 3D +Chloropicrin) or Goaltender. Black or dark plastic mulches normally prevent weed growth in strawberry beds (and are best control option for clovers); however, nutsedge grows through plastic regardless of color and thickness. Oxyfluorfen provides adequate control of little mallow.

Fumigation. Fumigation with methyl bromide followed by chloropicrin provided best weed control. Chloropicrin is also applied after InLine with a primary purpose of controlling soil-borne pathogens, but also germinating weed seed. InLine is a preferred alternative fumigation material, however, we use methyl bromide every third year to 'clean-up' weed and other pest problems that may have accumulated in the fields fumigated by InLine. Additionally, pre-irrigation 8 to 10 days prior to fumigation is very affective in enhancing weed control during fumigation. We observed greater weed germination and thus, greater kill during fumigation.

Weed control in furrow. Furrows are not fumigated when drip-fumigation is used and are very weedy, especially with water from sprinkler irrigation during plant establishment runs down to furrows. Devrinol herbicide provides only partial weed control in furrows; GoalTender is effective in controlling weeds in furrows but if applied post-transplant can lift-off/co-distil and injure establishing transplants. Additionally, GoalTender looses effectiveness due to disturbance in furrows (which also enhances weed germination).

Water as weed transport. Surface water that is supplied by United Water contains weed seed. It is unfiltered and is differentiated by higher pH. When applied through sprinkler irrigation the filters, initially small weed seed are spread out with irrigation, and later the filters get plugged up and pressure builds unevenly in irrigation system.

Weed Eradication: Realistic Goal or Pipedream?

J Robert C. Leavitt,
President of the California Weed Science Society;
Program Supervisor, California Department of Food and Agriculture, Sacramento, CA 95832,
rleavitt@cdfa.ca.gov

The concept of pest eradication in general and weed eradication in particular is somewhat controversial; many people believe that pest eradication is an impossible goal. However, the experience of the California Department of Food and Agriculture (CDFA) is that pest eradication is an achievable goal, given the right approach. The objective of this paper is to illustrate some of the principles of weed eradication and to outline some of the characteristics of a successful eradication program.

What exactly does eradication mean? It means that every plant or plant-part capable of reproduction is removed from a defined area. By tradition, the CDFA uses the county as the defined area. To contrast eradication with control: whereas eradication is the removal of all plants or plant-parts capable of reproduction, control means the temporary suppression of plant germination, emergence, or growth sufficiently so that crop, forest, or range production, or other goals such as highway safety or water movement, can be achieved for a season. Once eradication is achieved, treatments can stop; with control, treatments must continue year-after-year into the future, without end.

Weed eradication programs are most effective at the "pioneer" stage of weed invasion. Non-native weeds can be thought of as invaders. A new weed can move from an alien situation (outside California's borders) to be introduced into the state via various pathways. Pathways to introduction include man-made vectors such as car and truck traffic, aircraft, boats and ships, and pack animals and hikers; they also include natural vectors such as wind, rivers and streams, water fowl, and wild life. Once introduced, the new weed forms what I'll call "pioneer" populations: populations that are relatively small, and are not yet a permanent feature of the plant community. Many new weed infestations probably die out at this stage from natural causes such as competition from native vegetation. However, a small number of new weeds have the biological and agronomic ability to adapt and grow well in their new home, and they begin to proliferate and overcome the native vegetation. I'll call this the "colonization" stage. If nothing is done to stop the spread of the weed, it eventually becomes a part of the state's ecology; I'll call this the "establishment" stage. (See Figure 1).

The appropriate weed control strategy depends upon the stage of invasion on a new weed. While the weed is alien, outside California, prevention and exclusion strategies are appropriate and effective. These include the California CDFA Border Stations that intercept truck and trailer traffic, and in some locations passenger car traffic, to inspect for agricultural products that could bring unwanted insects, diseases, and weeds into the state. Once a weed has entered the "pioneer" stage of invasion, the most appropriate control strategy is eradication. It is at this stage, and the beginnings of the "colonization" stage, that eradication techniques have a reasonable chance of being successful. Once well into the "colonization" stage, and into the "establishment" stage of invasion, weed populations are too large and extended for eradication to work, and control strategies must be adopted. (See Figure 1).

Weed eradication is most effective at the "pioneer" stage of invasion, but can also be effective at the beginning of the "colonization" stage, depending upon the nature of the weed and the resources available to eradicate it. In any case, the smaller the original population, the greater is the likelihood of eradication success. The World Conservation Union states in its guidelines "The best opportunities for eradicating or containing an invasive species are in the early stages of invasion, when populations are small and localized" (IUCN 2006). Rejmanek and Pitcairn studied the history of successful weed eradication projects by the CDFA (Table 1) and concluded "With the exception of *Cucumis* [dudaim melon] …, all gross infestations were smaller than one hectare when they were detected" (Rejmanek and Pitcairn 2002).

In addition to the successfully completed eradication programs listed in Table 1, the CDFA also has many on-going weed eradication programs including hydrilla, alligatorweed, wormleaf salsola, Scotch thistle, and camelthorn. Based on this experience, I believe that weed eradication can be divided into three phases, as follow: the "discovery" phase, the "control" phase, and the "eradication" phase. The "discovery" phase starts with the first discovery of a new weed in California, and can usually be described by a population that is limited in area, but growing and spreading, with many "pioneer" populations around the main infestation. This phase usually requires treatment with a low cost weed control method that can be applied over a larger area. This usually means herbicide use, though some mechanical treatments may also be effective. The "control" phase starts after weed control treatments begin and the initial population begins to decline. Small "pioneer" populations are controlled or eradicated. As the number of plants declines, weed control treatments need to become more directed. Spot sprays of herbicides and hand removal may become effective treatments. In the "eradication" phase, only isolated plants or zero plants or plant-parts are found. This phase requires the use of highly directed treatments when these isolated plants are detected. At this stage, spot sprays of herbicides and hand removal of individual plants and underground plant-parts are the most commonly used weed control techniques. The "eradication" phase is also characterized by long-term survey and monitoring of previous infested sites to ensure that no new plants emerge. The level of total effort may not decrease in the eradication phase, but the bulk of the work shifts from treatment of existing populations to survey and search for surviving plants or plant-parts (seeds, tubers).

To be successful, weed eradication requires adequate government authority and support of the local community. In general, government authority is required to establish quarantine zones and support eradication programs. Quarantine zones are needed to prevent movement of a new weed into non-infested areas, but also to ensure that new introductions are not being made into an area with an active eradication program. Government support of eradication programs is generally necessary for two reasons: first, the complete removal of all plants or plant-parts from even a small area often requires considerable costs, which individual landowners are usually not willing or able to make; and second because all infested properties in given area must cooperate with the eradication effort if it is going to succeed. It makes no sense to eradicate a given weed from one property only to allow it to grow and spread unimpeded across the fence.

The California Legislature has given the CDFA authority and responsibility to eradicate noxious weeds from California. The Legislature has specifically named two weeds in the Food and Agriculture Code to be eradicated, hydrilla and camelthorn (Food and Agriculture Code Sections 7303 and 6048, respectively.) The Legislature has given the CDFA authority to control or eradicate other weeds (Food and Agriculture Code Sections 403, 5004, 5021-5027) and those weeds are named by regulation (California Code of Regulations Title 3 Section 4500.) In addition, the CDFA acts on behalf of the United States Department of Agriculture in the control and eradication of federally listed noxious weeds within the state.

To carry out the responsibility to control and eradicate noxious weeds, the CDFA classifies weeds according the actions it intends to take (CDFA 2006). Based on the results of an ecological and economic risk analysis, the CDFA rates weeds in four classes: A, B, C, or Q. For A-rated weeds, the CDFA rates them as an ecological or economic a threat to California's agriculture or environment, and limited in extent of infestation. A-rated weeds are subject to statewide eradication and cannot be sold by plant nurseries or in other channels of trade. B-rated weeds are also considered a threat to agriculture or the environment, but are more widespread in distribution. B-rated weeds are subject to local eradication, at the discretion of the county Agricultural Commissioner, and cannot be sold by plant nurseries. C-rated weeds are also considered a threat to the state, but are generally widespread and subject to local control activities. The Q rating is a temporary rating and the CDFA treats these weeds as A-rated weeds until a full risk analysis can be completed. This rating system may be refined in the near future, but the essential goal of rating weeds according to the size of the infestation and potential risk/impacts to agriculture and the environment will be maintained.

The CDFA has found that local community support is also vital to the success of an eradication program. Local community groups include, but are not limited to, Native American tribes, environmental groups, fishing, hunting, and boating and other outdoor recreational enthusiasts, and local city and county governments. The CDFA conducts extensive public education and outreach to explain the actions that it is taking and the reasons for those actions, including the consequences of inaction. The CDFA has found that local communities can be very supportive of eradication programs once they understand the rationale behind them.

In addition to authority and local community support, a successful eradication effort needs an on-the-ground program. Based on the CDFA experience, I can define four components to such a program: early detection, rapid response, environmental compliance and monitoring, and long-term commitment. Early detection means finding an introduction of a new weed as early in the "pioneer" stage of invasion as possible. It requires constant survey of high risk areas (highways, airports, marinas, campgrounds) by as many "eyes" as possible. In addition, it requires help from the public to see and report a new weed. Early detection also requires that the CDFA maintain a Botany Laboratory to correctly identify any suspect new weed. Rapid response means that the CDFA and landowners bring all appropriate resources to bear against the new introduction in a timely manner. This can mean that plans, required permits, and funding sources be identified ahead of time. It also means that appropriate control strategies be implemented, usually including, but not limited to, herbicides and mechanical control. Environmental compliance means that the treatment program must be in compliance with all environmental laws, including the California Environmental Quality Act, and the federal Endangered Species Act. In addition the CDFA has a policy of conducting an environmental monitoring program for all of its eradication programs, including monitoring foliage, soil, air, and water, depending upon the nature of the treatment program. Long-term commitment means that funds and manpower be dedicated to follow up survey and treatment for several years after the last plants are detected to ensure that hidden seeds or tubers don't germinate, become established, and start a new introduction.

In conclusion, I believe that pest eradication in general and weed eradication in particular is an achievable goal. The CDFA has been conducting weed eradication projects for decades, with an impressive track record. The key is to detect new weed introductions as early as possible, especially in the "pioneer" phase, respond rapidly with appropriate weed control techniques, maintain environmental compliance, and stay the course with follow up survey and treatments for the long term.

REFERENCES

CDFA 2006. *The California Department of Food and Agriculture Action Oriented Pest Rating System*, California Department of Food and Agriculture, Sacramento, CA 95814. http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/winfo_weedratings.htm

IUCN 2006. *IUCN GUIDELINES FOR THE PREVENTION OF BIODIVERSITY LOSS CAUSED BY ALIEN INVASIVE SPECIES 6. Eradication and Control.* IUCN SSC Invasive Species Specialist Group, Gland, Switzerland and Cambridge, UK. http://www.iucn.org/themes/ssc/pubs/policy/invasivesEng.htm

Rejmanek, M and M.J. Pitcairn 2002. *When is eradication of exotic pest plants a realistic goal?*, pages 249-253, *In* Veitch, C.R. and Clout, M.N. (eds.) Turning the Tide: the eradication of invasive species. IUCN SSC Invasive Species Specialist Group, Gland, Switzerland and Cambridge, UK. http://www.issg.org/Eradicat.html

Figure 1. Stages of Invasion for Weed Pests and Appropriate Control Strategies.

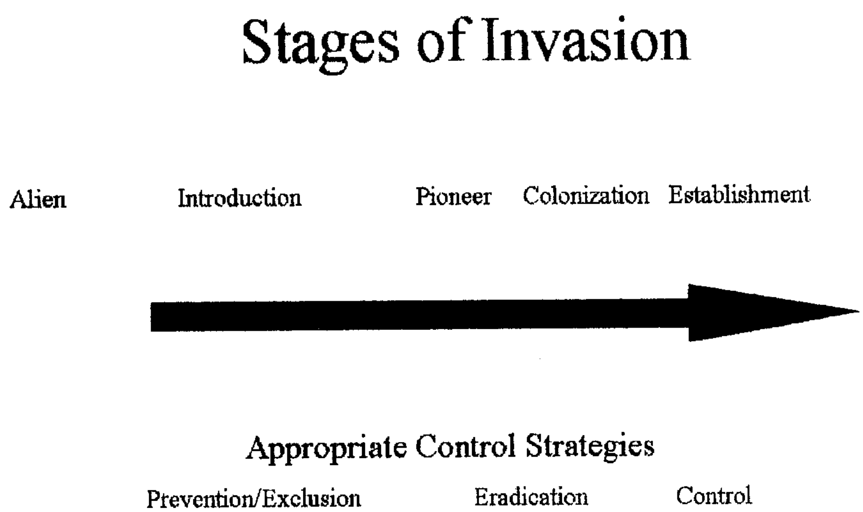


Table 1. Weeds Eradicated by the CDFA in California.

Whitestem distaff thistle	Heartleaf nightshade
Dudaim melon	Torrey's nightshade
Giant dodder	Austrian peaweed
Serrate spurge	Wild marigold
Russian salttree	Syrian beancaper
Blueweed	Meadowsage
Tanglehead	Creeping mesquite

The Ag/Urban Interface – Land Use Principles to Preserve Agriculture

Earl McPhall
Ventura County Agricultural Commissioner
P.O. Box 889 Santa Paula, California 93061-0889

Introduction

A coalition named the Ag Futures Alliance (AFA) was formed by agriculturalists in late 1999 to address some of the more critical challenges facing agriculture in Ventura County. The initial purpose of AFA was to create a framework for implementing actions to ensure the existence and enhancement of agriculture in Ventura County in perpetuity. Recognizing a need for broad-based public commitment to and participation in the AFA, participants agreed that Ventura County agriculture must make the environmental and health concerns of non-farming residents a top priority. The alliance invited representatives from a variety of social and environmental concerns to participate, and with few exceptions the offer was accepted. It became clear to AFA participants that the first step must be to create meaningful two-way communication. The second step would be to build trust and the third step would be to discover win-win solutions based on mutual respect and appreciation. It was during the third step in 2002 that that AFA formed the subcommittee on Land Use Principles. The subcommittee identified the problems and challenges for agriculture in this county related to land use, then came to consensus on a set of principles and recommended actions for addressing the challenges. The Land Use subcommittee and Ag Futures Alliance, Ventura County respectfully present these principles and recommendations to decision makers and others as a platform for sustaining agriculture as a vital component of Ventura County's quality of life.

PREAMBLE

Ag Futures Alliance (AFA) of Ventura County is a collaborative forum for members of the agricultural, environmental, and civic communities, to develop strategies for preserving agriculture as an essential part of life in Ventura County.

Ventura County's productive farmland is a valuable yet finite natural resource. Agriculture is an essential foundation for a strong and self-sufficient society, producing fundamental food and fiber and contributing an estimated $3.5 billion into Ventura County’s economy annually. Agriculture is not a temporary or interim land use. Agricultural sustainability is a long-term commitment measured over generations, not in the current planning model of 20 years.

Land use practices of building residential neighborhoods directly next to farmland cause continual conflicts, resulting in the steady erosion of the agricultural industry. The principles set forth in this document suggest buffers and reasonable boundaries between agricultural and urban uses to reduce conflicts and allow the best use for each segment of society, allowing both to survive and prosper.

PURPOSE

The AFA proposes this set of land use principles for the residents and leaders of the cities and the County to promote meaningful consensus on an applicable, long-term strategy for protection of agriculture in Ventura County. These principles are consistent with previously published reports of the County of Ventura, and with the efforts of other land-use coalitions and "smart growth" urban planning concepts. It is important that there be a consistent, comprehensive commitment to supporting agriculture throughout Ventura County as disparate planning policies make for contradictory objectives and encourage conflicts.

This document reflects the collective experience of diverse stakeholders who want to move beyond the policy position and into active implementation of the principles.

It is hoped that each city will adopt these principles into their standard procedures as outlined in their general plans, comprehensive plans, specific plans or any other such planning document. Ventura County has often led the way in agricultural practices and slow growth principles. However, as the County strives to meet growing population demands, it is imperative that both cities and the County come to agreement about a set of policies and effective procedures to guide land use decisions into this new century.

Four Principles are presented below:

Principle 1: Buffers are necessary between agriculture and neighboring uses.
Principle 2: Permanent boundaries are needed between agricultural production areas and urban uses.
Principle 3: Development strategies should encourage protection of agricultural lands.
Principle 4: Regulatory structure should allow flexibility for agricultural operations.

PRINCIPLES

Principle 1: Buffers are necessary between agriculture and neighboring uses.
Agricultural operations adjacent to urban uses too often result in conflicts leading to restraints on the grower. Buffers protect neighbors while allowing agricultural operations to continue.

1. Create and maintain buffers between agricultural lands and urban uses. Buffers can include both (a) physical separators such as set backs, vegetative barriers and/or fencing, and (b) use-related through transitional zoning, restrictions and conditions.

2. Buffer zones between urban and agricultural areas in all cities should be based on consistent standards. The Ventura County Agricultural Policy Advisory Committee (APAC) and the Agricultural Commissioner should develop these consistent standards and monitor compliance by cities and the County.

3. Responsibility for the buffer rests with the encroaching urban use, not the pre-existing agricultural use. Without buffers, urban uses can build right up to agricultural

operations or the CURB/SOAR1 line, jeopardizing adjoining agriculture.

4. Where no buffer exists or is feasible, the grower should be compensated for any loss of production or value due to the interfering urban use.

Principle 2: Permanent boundaries are needed between agricultural production areas and urban uses. *Boundaries are distinguished from buffers in that boundaries are permanent, major, visible separators between areas of different land uses, while buffers occur between parcels.*

5. Boundaries between agriculture and urban should, whenever possible, be longlasting physical features, natural or manmade, that are true dividers such as rivers, major roads and freeways, drainage channels, airports, etc.

6. CURB and SOAR lines are sometimes arbitrary and not based on consistent, longterm physical features as outlined in #5. These lines should be reviewed and modified where appropriate to ensure logical, enforceable, long-term boundaries.

7. Boundaries should encompass large swaths of land for efficient agricultural operation. Smaller parcels of farmland that are surrounded neighbored by urban uses that cannot be adequately buffered should be allowed to develop, upon request of the landowner.

8. Where appropriate, allow public open space (passive parkland, wildlife habitat) to serve as a permanent boundary for agriculture.

9. Proven land conservation tools that create protection boundaries should be encouraged, such as Land Conservation Act (Williamson Act) Contracts, Farmland Security Zone contracts, conservation easements and TDRs (transfers of development rights). These compensate owners who agree to keep their land in agriculture and provide a growth boundary.

Principle 3: Development strategies should encourage protection of agricultural lands. *Currently adopted land use plans call for further encroachment into areas of prime agricultural soils, which are widely regarded as being among the most fertile in the world.*

10. Cities and County general and specific plans should contain an Agricultural Element that reflects the principles stated herein.

11. Urban development should be directed to those areas least desirable for agriculture based on factors of soil, slope, water, wind, climate and location.
12. Investments in infrastructure improvements should be directed into existing urban areas in order to increase urban population capacities and to avoid positioning agricultural lands for eventual development.

13. Encourage creative models of mixed-use development and higher density in designated urban areas to reduce encroachment into productive agricultural areas. This will require zoning/regulatory changes in various jurisdictions.

14. Every city and the County must promote development and maintenance of housing for farm workers and their families.

15. If farmland conversion must occur, ensure that nearby agricultural operations are protected from a "domino" effect through use of buffers and other policies as presented in this document.

16. Protection and preservation efforts should be directed toward large blocks of farmland positioned to allow for viable agricultural operation and maintenance.

17. Recognizing that existing SOAR ordinances have a limited tenure, policies and agreements need to be created that will continue the preservation of agricultural resources before conversion pressures intensify.

18. Particularly sensitive urban functions such as schools (public and private), child day care centers, elderly care units, and health care facilities should be located on sites that do not place them in conflict with existing agriculture uses and/or that are required to provide generous buffers.

19. Encourage LAFCO to adopt regulations based on these principles and recommendations when reviewing annexation applications affecting agricultural lands.

20. The Board of Supervisors and the Ventura County Agricultural Commissioner should continue to fund staff to monitor land use projects affecting agriculture and to continue the level of support provided by that office and the APAC.

Principle 4: Regulatory structure should allow flexibility for agricultural operations.
There are currently laws, zoning and regulations by cities and the County that unnecessarily restrict agricultural operations.

21. Zoning, codes, use permits, planning requirements and other regulations should be flexible and not unduly restrict the use of agricultural land, such as the crops that may be grown, buildings and structures, equipment in view, or how production may occur.

22. The widest definition of agricultural uses should be allowed in agricultural areas to permit growers to adapt to changing markets. This recognizes greenhouses, shade structures, hoop houses, and others as legitimate agricultural methods in a highly competitive industry.

23. Encourage public education and greater awareness of agricultural operations and provisions of the Ventura County "Right to Farm" ordinance.

24. The County and cities must continue to support, through zoning and appropriate infrastructure, agriculture-support business such as packinghouses, chemical distribution facilities, tractor and irrigation supply companies, etc. that are critical for the agricultural industry.

REFERENCES:

1. VC Farm Bureau Land Use Policy: http//members.aol.com/vcfb1/landuse.htm.
2. California laws: www.leginfo.ca.gov "current laws."
3. "The Impacts of Farmland Conversion in California" (1991 study for state Office of Land Conservation) UC Davis, Sustainable Agriculture Research & Education Program www.sarep.ucdavis.edu/NEWSLTR/v2n4/sa-2.htm.
4. Excerpt (7 pages) from North Ventura Avenue Elementary School Mitigated Negative Declaration, Rincon Consultants for the Ventura Unified School District (example of how a project addressed its own impacts on agriculture) www.ventura.k12.ca.us.vusd/ag/htm
5. Ventura County LAFCO School Siting Criteria (2002) www.ventura.org.LAFCO
6. $3.5 billion estimate is approximate value of crops times three for economic multiplier.

AFA Land Use Committee, 2003

Jake Blehm, Rob Corley, Dulanie Ellis, John Grether, Susan Johnson
Sheri Klittich, Craig Mason, Richard Pidduck, Steve Sprinkel
With assistance from Julie Bulla, Agricultural Commissioner's Office

AG INNOVATIONS NETWORK (AGIN)

The Ventura County Ag Futures Alliance partners with Ag Innovations Network in the organization and facilitation of its efforts. Ag Innovations Network is a small group of professionals dedicated to helping preserve and protect our unique agricultural heritage by helping farmers and ranchers develop new practices and new revenue streams that keep land in agriculture.

The mission of AG Innovations Network (AGIN) is to enhance the long-term sustainability of communities by assisting agriculture to fulfil its essential role as the keystone in a healthy eco-system, economy, and society.

AGIN creates and facilitates public processes that bring together divergent groups with a stake in agriculture to find common ground and implement solutions that address local needs. AGIN also designs and implements marketing programs, resource stewardship programs, and public education campaigns.

All these activities focus on solutions that increase the use of sustainable farming practices, increase the awareness of the importance of a healthy agricultural base to a sustainable society, and reduce the friction between farmers, governments, and the general public.

To contact or learn more about AGIN, visit their website at *www.aginnovations.net.*

PPO Inhibiting Herbicides: What are They and How do They Work

Steven Fennimore, CE Weed Specialist, UC Davis
Kurt Hembree, Farm Advisor, UCCE, Fresno County

Herbicides play a vital role in sustaining crop production throughout the world. There are literally hundreds of different herbicides on the market, each with a unique set of chemical and physical characteristics. Herbicides are classified into different families based according to their modes of action. One of the important herbicide families is the "Protox" inhibitors. The primary herbicides in this group include oxyfluorfen (Goal), carfentrazone (Shark), and flumioxazin (Chateau). While Goal has been used in California for more than 25 years, Shark, and Chateau are relatively new to agriculture in the state. Some common uses of these herbicides in agronomic crops are shown in table 1. They are used primarily for controlling broadleaf weeds.

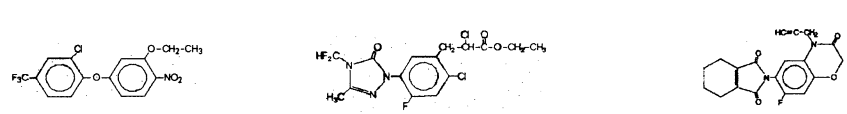
Table 1. Some use patterns for Protox inhibiting herbicides in agronomic crops in California

Oxyfluorfen (Goal 2XL, GoalTender, etc.)
Cotton – fallow bed and early postemergence directed 6" tall Garbanzo –preemergence
Carfentrazone (Shark)
Cereals – 30 days before planting to early jointing stage by ground or air Rice – 2-4 leaf stage by air Cotton, corn, dry beans – postemergence directed with hooded sprayer
Flumioxazin (Chateau)
Cotton, field corn, sorghum, wheat, sunflower – 30 days before planting

While these herbicides have different chemistries (see figure), they all kill weeds by the same mode of action. They are readily absorbed into leaf tissue where cell membranes are destroyed. Little or no absorption occurs by roots. The primary target site of these herbicides is in the chlorophyll synthesis pathway, where they inhibit the enzyme protoporphyrinogen oxidase. Hence, they are referred to as "Protox" or "PPO" inhibitors (named after the enzyme affected). These herbicides kill ultimately by lipid peroxidation. In other words, they break down cell membranes, causing the cells to break open, killing the leaves and stems.

Common symptoms associated with these herbicides include rapid leaf bleaching, desiccation, and necrosis, usually localized around the site of contact with the herbicide. Death of leaf tissue may be observed in as few as 3-5 days after contact. Since these herbicides do not translocate in susceptible plants, complete coverage of the weed foliage is necessary for control.

Figure. Chemistries of PPO inhibiting herbicides



oxyfluorfen (Goal) carfentrazone (Shark) flumioxazin (Chateau)

Of the PPO inhibiting herbicides discussed, Goal and Chateau have both foliar contact and soil activity. Shark is thought to have only minimal soil activity. Consequently, Goal and Chateau can be applied both to the soil, and as a contact spray for killing weeds. These materials are fairly strongly adsorbed to the soil, and not readily desorbed. Adsorption generally increases as soil organic matter increases. When applied to the soil as preemergence herbicides, both Goal and Chateau kill weeds through direct contact with the emerging weed hypocotyl. If the soil is disturbed following application, weed control will be significantly reduced, since the "barrier" of treatment has now been broken.

Of these herbicides, only Goal is know to have the potential to "lift-off" from the soil following application. This process is called codistillation and occurs when molecules of oxyfluorfen are trapped in water molecules evaporating from the soil surface. Rainy or foggy conditions following application can lead to an increased risk of "lift-off", whereby the molecules can be deposited onto nearby susceptible crop and non-crop foliage. Table 2 shows some differences between these herbicides regarding potential soil residues, "lift-off" potential, and potential for drift.

Table 2. Comparisons of PPO inhibiting herbicides and paraquat (a bipyridylium herbicide)

Factor	Goal	Shark	Chateau	paraquat
Soil residues	Long	Short	Long	None
Lift-off Potential	Yes	No	No	No
Drift concerns	Yes	Yes	Yes	Yes

Since these herbicides do not translocate, but require direct contact with the developing weed foliage (or with the emerging seedling as in the case of Goal or Chateau), uniform coverage of the target site is critical for control of susceptible weeds. In some cases, it is necessary to use shielded sprayers when making within-crop treatments to protect the crop. Since most crops grown in California are sensitive to damage from these "Protox" or "PPO" inhibiting herbicides, extreme care should be used to prevent off-target injury.

Benefits & Problems of Herbicide Tolerant and Conventional Herbicides in Cotton and Corn

Steve Wright[1], *Ron Vargas*[2]
[1]*University of California Cooperative Extension, Tulare & Kings Counties*
4437B S Laspina St, Tulare, CA 93274, sdwright@ucdavis.edu
[2]*University of California Cooperative Extension, Madera & Merced Counties*
328 Madera Ave, Madera, CA 93637, rnvargas@ucdavis.edu

Herbicide tolerant crop acreage has increased dramatically in the United States and amounts to approximately 42 percent of the California cotton and 50 percent of the corn acreage. The herbicide tolerant acreage of both cotton and corn should continue to increase as higher yielding varieties receive these traits. Because of air pollution concerns growers are given credits by reducing cultivations and other tillage as part of the San Joaquin Valley Air Pollution restrictions.

Integrating herbicide resistant crop technology and conventional herbicides makes sense for many reasons. One of the main concerns is preventing weed resistance. There is a high probability of developing resistant weed species and/or weed shifts when solely relying on one type of herbicide. For example, we have Roundup resistant annual ryegrass and horseweed in California. Cotton growers have also reported poor control of barnyardgrass and lambsquarter in some cases. Some of this reduction in control could also be due to applying glyphosate to drought stressed weeds. Resistance issues are not just unique to glyphosate. Herbicide resistance has shown up where there are many reports of reduced control of barnyardgrass with continual use dinitroanilines in cotton in the San Joaquin Valley. Some California growers have observed reduced nutsedge control with continuous use of thiocarbamate herbicides in corn.

Roundup Ready Technology in Cotton

The Roundup Ready technology has provided growers with an excellent tool for managing many annual and perennial grasses, broadleaves such as nightshades and annual morningglory, and nutsedge in cotton. Some of the advantages to this system include the following: 1) Glyphosate can be applied post emergence so growers can wait and see the weeds present. 2) There are no plant back restrictions. 3) Glyphosate has a wide spectrum of weed control controlling or suppressing many annuals and perennials.

Some of the problems associated with the older Roundup Ready system include the following: 1) there is a narrow window of application, 2) it must be applied before cotton has 5 leaves, 3) hooded sprayers were needed to safely apply later directed applications, 4) nutsedge and annual morningglory can still be a challenge and 5) variety selection can be limited in that the technology is somewhat behind. The highest yielding varieties often do not have this trait.

The new "Roundup Ready Flex" systems can be applied early and much later in the season. Even with the herbicide tolerant technology weeds like annual morningglory, lambsquarter, and barnyardgrass are increasing especially when growers are only relying on glyphosate. In other cotton growing states where Roundup Ready cotton is grown on greater than 70 percent of the acreage a weed shift has developed after 7 years of a reduced tillage systems coupled with extensive use of glyphosate. These weeds include amaranth, horseweed, giant ragweed, and tropical spiderwort.

Texas Extension Specialist Dr. Peter Dotray reported at the 2005 Beltwide Cotton conference that the adoption of glyphosate-tolerant cotton expressed in terms of percent of acres planted was approximately 20% in 1998, 68% in 2001, and 73% in 2004. The overall amount of herbicide active ingredients used in U.S. upland cotton has not changed much from 1996 to 2003. Reduced use of preplant and preemergence herbicides such as trifluralin (-22%), pendimethalin (-26%), prometryn (- 28%), fluometuron (-84%), clomazone and norflurazon (both -97%) has been offset by the increased use of glyphosate (753%) and diuron (101%) from 1997 to 2003 when expressed in terms of percent of adjusted U.S. upland cotton acreage. In many regions, reduced tillage, spot treatments, early postemergence-directed applications, and hand hoeing has decreased because of this technology. Increased seed cost and technology fees are making this technology difficult to afford for many producers.

Dr. Dotray also stated that the number of herbicide options in the future excluding generics will likely decrease, but some of the traditional (standard) options will continue to play an important role in weed management. If glyphosate usage continues to increase, the industry incentive to support existing and older active ingredients may decrease. If glyphosate resistant weeds continue to develop and major shifts in weed populations occur, fewer herbicide options may be available due to the number of older herbicides lost to re-registration and the decline in the number of herbicides brought to market.

Dr. Stanley Culpepper reported that a recent survey of weed scientists focused on weed shifts in GR cotton systems. Six scientists in six states (AL, GA, FL, MO, NC, and TX) responded to the survey. All scientists noted weed shifts have occurred, and *Amaranthus* species, annual grasses, dayflower species (*Commelina* sp.), morningglory species (*Ipomoea* sp.), and winter annuals were becoming more problematic in response to currently utilized GR management systems. Four of six states noted these shifts are of economic concern and all specialists are addressing weed shift issues by recommending 1) the use of residual herbicides in current GR programs, 2) the addition of other herbicides in mixture with glyphosate, 3) rotation to other herbicide chemistry, and 4) rotation away from GR crops when feasible.

Cultural practices can also increase the selective pressure for the development of herbicide resistant biotypes. In general, complete reliance on herbicides for weed control can greatly enhance the occurrence of herbicide resistant weeds. Other factors include, shifting away from multi crop rotations towards mono cropping, reduced or no till productions systems, continuous or repeated use of a single herbicide or several herbicides that have the same mode of action, high and/or low herbicide use rate relative to the amount needed for weed control and growing an herbicide tolerant crop where the same herbicide is applied repeatedly

Weed characteristics conducive to rapid development of resistance to a particular herbicide include:

1. Annual growth habit.
2. High seed production.
3. Relatively rapid turnover of the seed bank due to high percentage of seed germination each year (i.e., little seed dormancy).
4. Several reproductive generations per growing season.
5. Extreme susceptibility to a particular herbicide.
6. High frequency of resistant gene(s), (e.g. *Lolium rigidum*).

Herbicide characteristics that lead to rapid development of herbicide resistance in weed biotypes include 1. a single site of action, 2. broad-spectrum control and 3. long residual activity in the soil.

Cultural practices can also increase the selective pressure for the development of herbicide resistant biotypes. In general, complete reliance on herbicides for weed control can greatly enhance the occurrence of herbicide resistant weeds. Other factors include:

1. Shift away from multi crop rotations towards mono cropping (orchard and vineyard systems).
2. Reduced or no till productions systems.
3. Continuous or repeated use of a single herbicide or several herbicides that have the same mode of action (transgenic herbicide tolerant crops).
4. High and/or low herbicide use rate relative to the amount needed for weed control.

Integrated Weed Management Costs

The herbicide tolerant cotton and corn systems have allowed growers to effectively control most annual and perennial weeds, to reduce or eliminate hand hoeing, and reduce the number of cultivations. Cost savings range from $25 to $120/acre is achieved. Even if growers use an herbicide tolerant system, it is still advisable to use one of the following preplant incorporated herbicides in cotton: Prowl, Treflan, Caparol, or Caparol + Treflan/Prowl. The cost is low ($6-$8/A) and controls most annual grasses and many broadleaves. Ultimately, the decision to use one herbicide tool over another and how to integrate different herbicides will depend on costs and effectiveness.

There has been considerable interest in reduced tillage corn. A crucial aspect of no-till corn management revolves around weed control. Keeping noxious weeds and grasses out of dairy silage is essential if the highest quality silage is to be harvested. Corn growers have used a variety of different herbicide programs, but the Roundup Ready® corn system is the easiest in terms of managing weeds when the tillage is eliminated or used less frequently. Interestingly, the market penetration for Roundup Ready corn technology is higher in California than in any Corn Belt state. It is the highest market penetration in the nation, according to Monsanto. Just a couple of years ago, Roundup Ready Corn was planted on just over 30 percent of the state's corn acres. By the 2003 season, we had planted Roundup Ready Corn on 50 percent or more acreage. Growers have a wide selection of corn hybrids available with Roundup Ready technology. The new Pioneer® corn varieties with the Roundup Ready gene will further fuel the adoption of transgenic corn.

Most no-till corn growers who use the Roundup Ready system do not use a pre-emergence herbicide, preferring instead to rely on over-the-top applications of Roundup UltraMAX® herbicide, often alone but sometimes in either tank mixes with 2,4-D, dicamba, halsulfuron (Sempra) or in conjunction with separate treatments of these herbicides. Corn growers who use dairy manure as fertilizer need to work extra hard to stay on top of weed control. Some tillage once in awhile, and combined with use of different herbicides, may be necessary where dairy manure is applied to fields.

Summary

The herbicide tolerant systems in cotton and corn has reduced weed control costs and given growers greater flexibility. This has allowed growers and researchers to explore alternative production systems such as conservation or reduced tillage, double row configurations, and ultra narrow row systems. We now have available Roundup Ready varieties that have more crop safety with a greater application window. Liberty Link Cotton by Bayer using gluphosinate (Ignite) should have a good fit in California.

The potential for herbicide resistance should receive serious and thoughtful attention. As weed management systems change with new herbicides and herbicide resistant crops are introduced, resistant management must be an integral part of the production system. If selection pressure is maintained through the continuous use of the same herbicide, herbicide resistance will soon render it ineffective.

A resistance management approach must incorporate crop/herbicide rotation and control of weed escapes by tillage or hand. An integrated weed management system supplements an existing transgenic or conventional weed control program and uses a variety of the available pre-plant, selective over-the-top and layby herbicides along with tillage. Keep in mind many of the weeds were not being easily controlled before herbicide tolerant technology was available.

Therefore, it will continue to be necessary to use every available tool in the future to economically control weeds in this year's crop and effectively control weeds from building up in the seed bank for future crops.

References:

1. Vargas, Ron, Steve Wright. Principles of Weed Resistance Management. Beltwide Cotton Research Conference Proceedings. January 2005, New Orleans.

2. Vargas, Ron, Steve Wright. A Comparison of Roundup Ready and Roundup Ready Flex Cotton Systems. Beltwide Cotton Research Conference Proceedings. January 2005, New Orleans.

3. Culpepper A. Stanley. Weed Shifts and Volunteer Crops in Roundup Ready Systems. Beltwide Cotton Research Conference Proceedings. January 2005, New Orleans.

4. Dotray, Peter. Impact of Roundup Ready Technology on Cotton Production in the U.S. Beltwide Cotton Research Conference Proceedings. January 2005, New Orleans.

5. Shrestha, Anil, T. Lanini, J. Mitchell, S. Wright, R. Vargas. An Update of Weed Management Issues in Conservation Tillage Systems. California Weed Science Society Proceedings. January 10-12, 2005. Monterey. pp. 58-63.

6. Vargas, R., S. Wright, T. Martin-Duvall, G. Banuelos. Ignite and Liberty Link Cotton for the California Production System. Mar. 2005. Western Society of Weed Science proceedings pg. 16. Vol. 58.

7. Elam. S., Wright S., G. Banuelos. Tall Annual Morningglory Control Studies in California Cotton. California Weed Science Society. January 21, 2003. Santa Barbara. (Contributed to field research, data collection and editing.)

8. Dasilva M., R. Vargas, T. Martin Duvall, S. Wright. January 20, 2003. New Methods for Yellow and Purple Nutsedge Control in the San Joaquin Valley. California Weed Science Society. January 21, 2003. Santa Barbara.

9. Vargas, R., S. Wright, T. Martin-Duvall, G. Banuelos. Ignite and Liberty Link Cotton for the California Production System. California Weed Science Society. 2004.

10. Wright, S., R. Vargas. Integrating Weed Management Tools in Cotton and Corn: GMO's and Conventional Herbicides. California Weed Science Society. 2003. Vol. 55. pp. 117-121.

11. Wright, S. Nutsedge Management in Agronomic Crops. California Weed Science Society. 2003. Vol.55. pp. 152-156.

12. USDA NASS for 2002

13. Vargas, R., and S. Wright. 1996. Integrated Pest Management for Cotton in the Western United States. Weed Control in Cotton Chapter Pg. 136-138.

14. Vargas, R., S. Wright. 2002-2005. University of California Cotton Weed Management Research Progress Report. .

15. Wright, S., K. Hembree and R. Vargas. 1997. Nutsedge Control in Field Crops. California Weed Science Society Proceedings. Vol. 49, pp. 102-105.

16. Wright, S., R. Vargas, M. Canaveri, C. Frate, M. Mathews, et al... 2006. Integrated Pest Management for Corn Weed Control. University of California.

17. Wright, Steve, 2003. Nutsedge Control in Field Crops. California Weed Science Society.

18. Wright, Steve. 2005. Integrating Weed Control in Cotton and Corn. California Weed Science Society.

Evaluation of Grass Herbicides in Wheat

Barry R. Tickes,
University of Arizona Cooperative Extension
Yuma, Arizona 85364
btickes@ag.arizona.edu

Introduction

Weed problems in all crops reflect the characteristics of the weeds and the technology available to control them. Weeds are rarely completely eliminated but constantly changing in response to these conditions. Broadleaf weeds in grain crops and the herbicides used to control them have changed little over the past several years. Numerous broadleaf weeds are a problem and controlled with growth regulators (2,4-D, MCPA, dicamba and clopyralid), contact herbicides (bromoxynil, carfentrazone) or sulfonylureas (chlorsulfuron, metsulfuron, thifensulfruon). Grass weeds and the herbicides available to control them have, on the other hand, changed significantly in recent years. This report will concentrate upon grass weeds and recent herbicide developments.

Grass Weed in Grain

Wild oat (Avena fatua) was the major grass weed in grain throughout California and Arizona for many years. This weed is very competitive and yield reductions as high as 50% have been documented when even moderate infestations occur. Wild oat is sensitive to many of the available herbicides and it has been replaced over the years by grasses that are more difficult to control. Wild oat has been replaced in many regions by littleseed (Phalaris minor) and hood canarygrass (Phalaris paradoxa) and to a lesser extent by rabbitfootgrass (Polyprogon sp), wild barley (Hordeum sp), brome (Bromus sp.) and ryegrass (Lolium sp.) Canarygrass has become the predominant of these grasses and this report will concentrate upon these.

Canarygrass

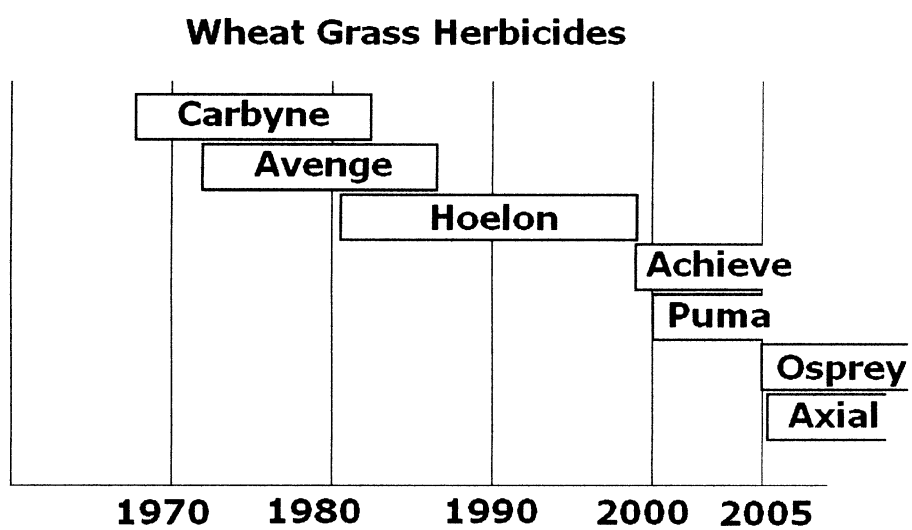
Canarygrass (Phalaris spp.) has become the predominate weed in grain fields in many regions of California and Arizona. There are seven species of this weed which occur throughout the region, two of which cause major agricultural problems. Reed Canarygrass (P. caroliniana),short-spike Canarygrass (P. brachystachys), Common Canarygrass (P. canariensis), Carolina Canarygrass (P. caroliniana) and Harding grass (P. aquatica) normally are found in riverbeds, wildlife refuges, recreational areas and urban landscapes. They occasionally are found in agricultural fields. Littleseed Canarygrass (P. minor) and Hood Canarygrass (P. paradoxa) are major agricultural pests.

Littleseed and Hood canarygrass are prolific and competitive weeds. More than 125 seedlings per square foot are sometimes found in fields that have had wheat grown in them year after year. Yield reduction of greater than 50% have been documented as a result of heavy infestations. Littleseed canarygrass typically begins to germinate in October in the low deserts and continues to germinate until spring. It emerges from both shallow depths (top 1/2 inch) with the crop seed and much deeper (1-5 inches) where soils crack. It is common for canarygrass to be at variable growth stages, from 1 leaf to tillering, at the same time within a grain crop. These characteristics have contributed to the difficulty in controlling this weed with herbicides.

The first case of widespread herbicide resistance in the low desert has involved the resistance of Littleseed canarygrass to ACCase inhibitors in the Imperial Valley, California. This was documented in 2002 and 2003 by Joe DiTomaso and Guy Kyser at the University of California, Davis. They found that the rate required to produce adequate control (90%) in the resistant population was 88 pt/A with sethoxydim, 69 pts. with fenoxaprop and 8 pts with fluazifop. Some resistance to clethodim was also found although the rate needed to produce adequate control was 0.25 pt./A of Prisim/select which is still practicable (unpublished data). Resistance of P. minor to ACCase inhibitors was previously reported in Israel (1993) and Mexico (1996). Although all of the herbicides that are commonly used to control canarygrass in grain in the Imperial Valley are ACCase inhibitors, problems have largely been encountered in onions and alfalfa, not in grain.

Control – Herbicides

The grass weed problems in grain reflect the herbicides available to control them. Diagram 1 illustrates the herbicides that have historically been available for grass control in grain from 1970 to present. Four grass herbicides have been registered within the last six years while only three were available during the previous thirty years. Additionally, the four registered within the last six years are more effective and safer to the crop. A brief discussion of each follows.



Carbyne(barban) Discovered in the 1960's carbine was the principal herbicide used for the control of wild oat and canarygrass until the early 1980's when it was no longer available. Carbyne was better in controlling canarygrass than wild oat. Timing was critical as it would only control canarygrass to the 2 leaf stage of growth. Spray volume was also important and it was recommended that the volume be less than 10gpa. When the crop was under stress from cold, drought and other factors, yield reducing injury could occur. Tank mixes with broadleaf herbicides could occasionally cause reduction in weed control and crop injury.

Avenge (difenzoquat) registered in 1975 by American Cyanamide as a wild oat herbicide. It was effective on wild oat but weak on some other winter annual grasses including canarygrass. The use of this product was limited by the crop injury it caused to durum and some red wheat varieties. It has been replaced by other wild oat herbicides.

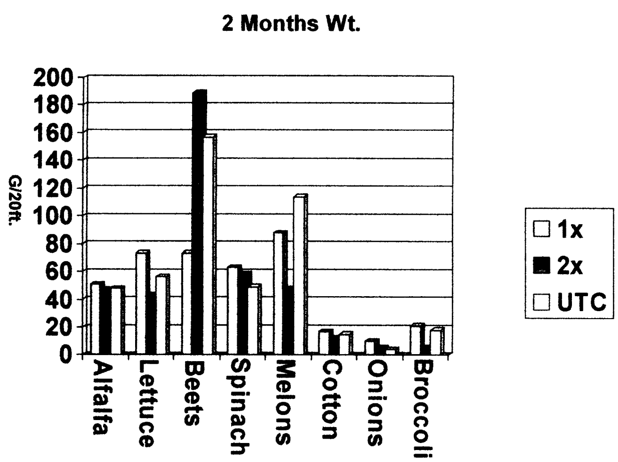
Hoeon (diclofop) registered in 1980 as one of the first ACCase inhibitors used for selective grass control in grain. This was one of the only herbicides available for annual grass control in grain between 1980 and 1999. It was very good on wild oats and only partially effective on canarygrass. Because of this, canarygrass became an increasingly problem and wild oat populations declined during this 20 year period. Partial control was related to the importance of the growth stage at the time of application of most annual grasses. Weeds at the 1 to 3 leaf stage were controlled while those at later growth stages or subsequent flushes were uncontrolled. Hoelon controls wild oat at growth stages up to 4 leaves. Applications could be delayed until all of these weeds had emerged with excellent results.

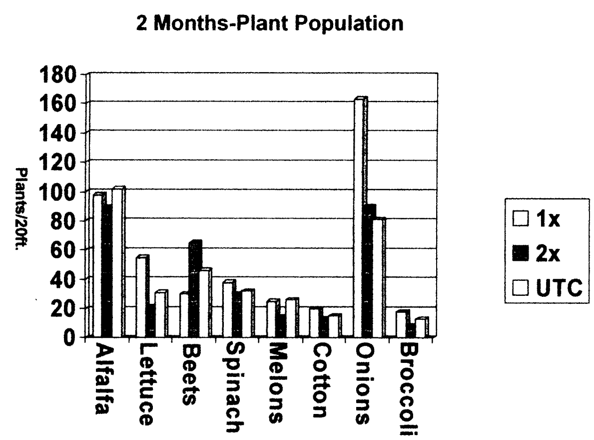
Achieve (tralkoxydim) available in 1999, Achieve was the first new grain herbicide registered in almost 20 years that was highly effective on several annual grasses. Achieve is an ACCase inhibitor that will control canarygrass, wild oat and other annual grasses up to the 5 leaf stage of growth. The multiple emergences of canarygrass can be controlled by waiting until they have all emerged and the crop is not too advanced to limit coverage. The use of Hoelon dropped off significantly when this herbicide was registered.

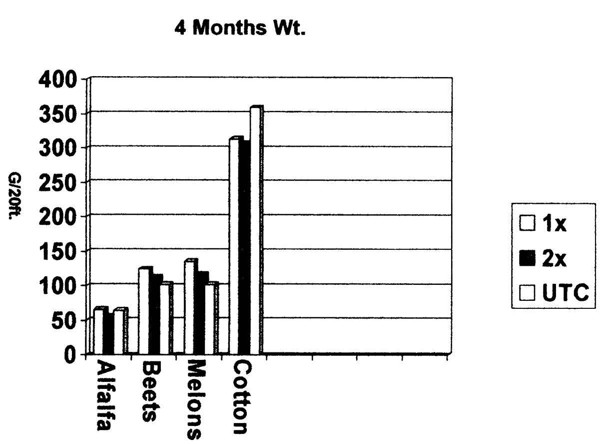
Puma (fenoxaprop) registered in 2000, one year after Achieve, this herbicide is similar in timing of application, weed control and crop safety to Achieve. It has been slightly more consistent than Achieve in our trials. Not registered in Arizona due to the requirement for additional environmental data. Puma will control most annual grasses including canarygrass, up to the 5 leaf stage and is effective on weeds that continually emerge and are at various growth stages at the time of application.

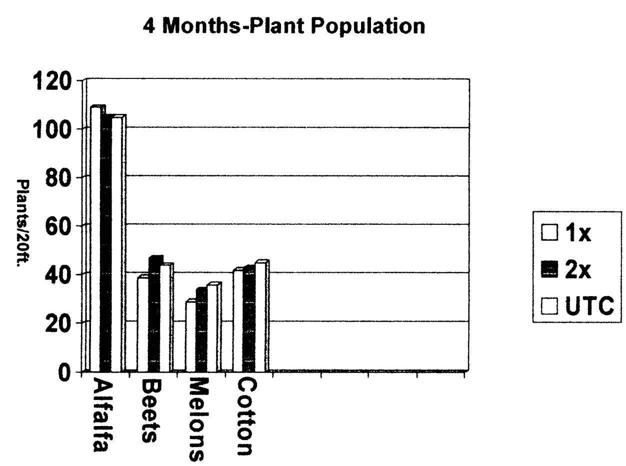
Osprey (mesosulfuron) registered in 2004, Osprey is a sulfonylurea. This different mode of action helps avoid the ACCase resistance that is spreading in canarygrass and some other annual grasses. Osprey has been highly effective in controlling wild oat and canarygrass in our trials and will also control some broadleaf weeds such as wild mustard, pigweed and wild radish. It can be applied at growth stages of up to 2 tillers for canarygrass. This overcomes the problem of multiple emergences of this weed. Crop safety is lower than with the ACCase inhibitors but has not resulted in reduced yields. The rotational crop restriction of 10 months to all crops except cotton (90 days), beans

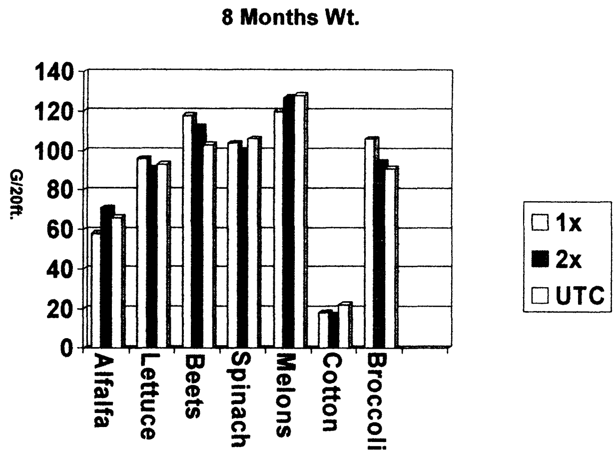
(90 days) and some other crops will limit the use of this herbicide in many diversified agricultural areas in the southwest. A recropping study was conducted in 2004/2005 to determine if 10 months was needed to avoid injury to rotational crops. Charts 1 thru 6 illustrate the results of this study in which a 1 X rate (4.75 oz per acre) and 2 X rate (9.5 oz per acre) were applied to a fallow field and planted to 8 crops at a 2, 4 and 8 month interval. Dry weights and plant population were measured. At two months the only significant reduction which occurred was in the weight of broccoli at the 2 X rate. No other reductions were measured at the 2, 4 or 8 month intervals. The crops that were planted were alfalfa, lettuce, sugarbeets, spinach, cantaloupe, cotton, onions and broccoli. The 4 month planting was made in July when only the warm weather crops, cotton, melons, sugarbeets and alfalfa would grow. This study indicated that a 10 month plantback interval was unneeded and the herbicide is gone after a normal grain growing season.

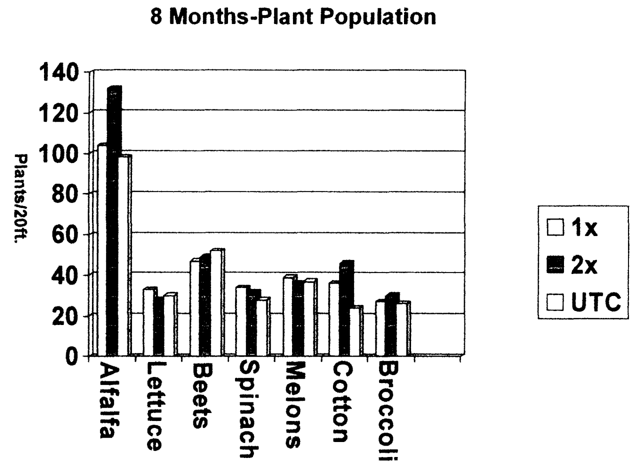












Axial (pinoxaden) Just registered in December 2005, penoxaden is a little different from the other group I ACCase inhibitors. It is in a new class called phenylpyrazolin herbicides. The mode of action is the same as that of aryloxyphenody propionate (FOP) and cyclohexanedione (DIM) herbicides but this new class will be termed DENS. This herbicide may be active on some of the group I resistant biotypes including littleseed canarygrass. The 2004/05 season was the first time we had this in a trial and it was very effective on canarygrass. It can be applied up to the tillering stage of the weeds and will control multiple flushes of canarygrass. Crop injury was a problem in durum wheat especially when mixed with some broadleaf herbicides, and it is not currently registered for use in durum.

Tank Mix Combinations

Growers frequently like to mix grass herbicides with broadleaf herbicides for convenience, cost savings and to avoid driving over the field an additional time. Osprey and Axial both control some broadleaf weeds. The best time for application for both grass and broadleaf weeds often does not coincide and the spectrum of weeds controlled with Osprey and Axial is not as large as it is with many of the broadleaf herbicides available. For these reasons, broadleaf weed control with Osprey and Axial is an added benefit but often not a substitute for broadleaf herbicides.

Tank mix combinations of grass and broadleaf herbicides often causes either increased crop injury or reduced weed control. Grass weed control can be reduced when mixing Puma and Achieve with many of the broadleaf herbicides while crop injury can result when doing the same with Osprey and Axial. Often it is the adjuvant used with the tank mix partner rather than the active ingredient that causes the problem.

Herbicide	# of tests	Canarygrass Control			Phototoxicity		
		High	Low	Ave.	High	Low	Ave.
Carbyne	8	95	70	85	40	0	10
Avenge	6	40	0	25	85	0	65
Hoelon	13	95	50	70	10	0	4
Achieve	8	96	75	85	10	0	2
Puma	6	99	83	90	10	0	2
Osprey	6	99	90	95	15	0	10
Axial	1	99	95	97	30	5	-

Evaluation of Garbanzo Bean Herbicides

Kurt Hembree and Neil Va
Farm Advisor, and Staff Research Associate, UCCE, Fresno County

Introduction:

In the southern San Joaquin Valley, garbanzos are grown as a dry bean. They are typically planted in December and harvested the following mid-summer. Because they grow rather slowly the first two months, they offer poor competition with weeds. Therefore, growers must use preplant and/or preemergence herbicides to protect the stand. Although growers in California have a fairly large arsenal of herbicide tools at their disposal, most of the products used lose their efficacy in mid-spring, just as the plant canopy begins to develop and close-in. Weeds like nightshade, prickly lettuce, and annual sowthistle then become major problems. Nightshade, in particular, can produce dark purplish berries that stain the mature beans, reducing quality. Additionally, some of the more important herbicides used (namely oxyfluorfen and metribuzin) can cause crop injury and delayed growth after emergence when conditions are cold and wet.

To battle these and other weed escapes, growers have to rely on costly hand weeding to achieve clean fields, sometimes adding an additional $150/acre or more to production costs. A Study was conducted in 2004/05 to determine the effectiveness of preemergence herbicides on weed efficacy, crop response, and yield.

Method:

A field trial was conducted at the West Side Research & Extension Center in Five Points, CA. The soil is a Panoche clay loam. The herbicides evaluated were oxyfluorfen (Goal), Pendimethalin (Prowl), metribuzin (Sencor), dimethenamid (Outlook), Metolachlor (Dual Magnum), flumioxazin (Chateau), imazamox (Raptor), and sulfentrazone (Aim). Thirty-inch beds were listed, fertilized, and shaped in November 2004. A single variety (HB-14) was used for the study. The treatments were arranged in a randomized complete block design with four replications each. Plots were four beds-wide and 40' long. The trial was planted on December 14, 2004 and harvested on July 20, 2005. The trial area was watered with furrow irrigation.

Herbicide treatments were applied preplant incorporated (PPI) or post-plant, preemergence (PRE). All treatments were applied using a ground sprayer that delivered the spray broadcast in a spray volume of 20 gpa. When mature, the beans were undercut and allowed to dry in windrows for about two weeks, then harvested. Sub-samples were taken to determine bean size and the number seeds/oz (can count) was determined. Data were analyzed using ANOVA and significant means were determined using LSD at a level of $p=0.05$.

Prowl EC and Prowl H_2O were applied before planting as standard treatments to the soil and incorporated with a power bed mulcher. Garbanzos were then planted and the other herbicide treatments were applied and the field was irrigated the next day. An untreated and hand weeded treatment was included in the study. The field was cultivated and weeds were hoed from the hand weeded treatment on March 2, 2005.

The center 35' of each plot was pitch forked into a mechanical thrasher and beans were weighed. Bean yield was expressed in lbs of clean beans/acre, bean size, and can count (number seeds/oz). All data was analyzed using ANOVA and significant means were determined using the LSD at a significant level of p=0.05.

Results:

When compared to the untreated or hand weeded plots, garbanzo stand was not reduced where Chateau was used at 0.094 lb ai/acre, but was reduced by 20% at 0.188 lb ai/acre (table 1). However, even some of the standard treatments (Sencor and Goal 2X) showed a similar reduction in stand as the high rate of Chateau. Initial winter weed control was excellent in all treatments, except where Prowl was applied alone. Prowl is typically weak on weeds in the mustard family (including shepherd's-purse and London rocket). Later evaluations (tables 2 and 3) showed that Chateau provided excellent control of prickly lettuce in addition to the winter annuals, but was not different from the standard Prowl/Goal combination. Raptor provided poor control of prickly lettuce and Aim was weak on all weeds present in the field.

Table 1. Garbanzo and weed stand per 10' of row on 2/4/05

Treatment	Timing	Lb ai/A	Garbanzos	Shepherd's -purse	London rocket	Volunteer cereals
1. Prowl 3.3E	PPI	1.2	38.8	2.0	0.8	0.0
2. Prowl H_20	PPI	1.2	38.3	2.0	1.5	0.0
3. Sencor DF	PRE	0.25	35.0	0.0	0.0	0.0
4. Goal 2XL	PRE	0.25	33.8	0.0	0.0	0.0
5. GoalTender 4F	PRE	0.25	36.0	0.0	0.0	0.0
6. Prowl H_20 GoalTender 4F	PRE PRE	1.0 0.25	35.8	0.0	0.0	0.0
7. Outlook	PRE	0.75	33.0	0.0	0.0	0.0
8. Dual Magnum	PRE	1.6	36.0	0.0	0.0	0.0
9. Chateau 50DF	PRE	0.094	38.0	0.0	0.0	0.0
10. Chateau 50DF	PRE	0.188	31.8	0.0	0.0	0.0
11. Raptor	PRE	0.047	37.8	0.0	0.0	0.0
12. Aim EC	PRE	0.25	40.3	0.0	0.0	3.8
13 Dual Magnum Aim EC	PRE PRE	1.6 0.25	40.5	0.0	0.0	0.0
14 Handweeded	3/2/05	---	44.8	29.3	13.8	3.8
15 Untreated	---	---	43.0	29.8	15.8	3.5
Statistical notation @ p=0.05		CV: LSD:	13.11% 7.4	19.41% 1.2	31.38% 1.0	57.88% 0.6

Table 2. Weed control on 2/28/05

Treatment	Timing	Lb ai/A	Shepherd's -purse	London rocket	Prickly lettuce	Volunteer cereals
1. Prowl 3.3E	PPI	1.2	9.2	9.3	0.0	10.0
2. Prowl H_20	PPI	1.2	8.8	8.7	0.0	10.0
3. Sencor DF	PRE	0.25	9.5	9.8	0.0	0.0
4. Goal 2XL	PRE	0.25	10.0	10.0	10.0	8.4
5. GoalTender 4F	PRE	0.25	10.0	10.0	10.0	8.4
6. Prowl H_20 GoalTender 4F	PRE PRE	1.0 0.25	9.9	10.0	10.0	10.0
7. Outlook	PRE	0.75	8.6	9.6	9.9	10.0
8. Dual Magnum	PRE	1.6	8.9	8.9	0.0	0.0
9. Chateau 50DF	PRE	0.094	9.9	10.0	10.0	9.7
10. Chateau 50DF	PRE	0.188	10.0	10.0	10.0	10.0
11. Raptor	PRE	0.047	9.4	9.8	0.0	9.2
12. Aim EC	PRE	0.25	9.6	9.3	9.8	0.0
13 Dual Magnum Aim EC	PRE PRE	1.6 0.25	9.8	9.4	9.5	0.0
14 Handweeded	3/2/05	---	0.0	0.0	0.0	0.0
15 Untreated	---	---	0.0	0.0	0.0	0.0
Statistical notation @ p=0.05		CV: LSD:	4.56% 0.57	3.44% 0.4	1.45% 0.1	3.64% 0.3

Table 3. Weed control on 5/17/05

Treatment	Timing	Lb ai/A	Shepherd's -purse	London rocket	Prickly lettuce	Volunteer cereals
1. Prowl 3.3E	PPI	1.2	9.0	9.0	0.0	9.9
2. Prowl H_20	PPI	1.2	9.0	9.0	0.0	9.8
3. Sencor DF	PRE	0.25	10.0	9.9	0.0	0.0
4. Goal 2XL	PRE	0.25	9.5	10.0	10.0	7.5
5. GoalTender 4F	PRE	0.25	10.0	10.0	10.0	7.5
6. Prowl H_20 GoalTender 4F	PRE PRE	1.0 0.25	10.0	10.0	10.0	10.0
7. Outlook	PRE	0.75	8.5	9.5	9.5	10.0
8. Dual Magnum	PRE	1.6	9.6	9.0	0.0	0.0
9. Chateau 50DF	PRE	0.094	9.9	10.0	10.0	9.5
10. Chateau 50DF	PRE	0.188	10.0	10.0	10.0	10.0
11. Raptor	PRE	0.047	9.5	9.5	0.0	9.0
12. Aim EC	PRE	0.25	9.5	9.5	9.6	0.0
13 Dual Magnum Aim EC	PRE PRE	1.6 0.25	9.8	9.5	9.5	0.0
14 Handweeded	3/2/05	---	9.9	10.0	9.9	9.9
15 Untreated	---	---	0.0	0.0	0.0	0.0
Statistical notation @ p=0.05		CV: LSD:	3.51% 0.6	1.73% 0.2	3.50% 0.4	1.28% 0.2

There was no visible crop injury in any of the plots treated with Chateau, Raptor, or Aim (table 4). There was some injury (necrosis of stem and leaves) associated with the standard Goal treatments 60 days after treatment, but no injury was observed in those plots 30 days later. Although garbanzo plants were reduced in growth in the Chateau plots by as much as 8%, 90 days after treatment, standard treatments of Goal and Dual Magnum, and Outlook (not registered) showed a similar response. Similar reductions in plant growth were seen with these treatments in a trial conducted in 2003/04. Raptor did not result in reduced plant growth.

Table 4. Garbanzo growth and injury

			2/28/05		3/17/05	
Treatment	Timing	Lb ai/A	Growth	Injury	Growth	Injury
1. Prowl 3.3E	PPI	1.2	9.7	0.0	9.8	0.0
2. Prowl H_20	PPI	1.2	9.7	0.0	9.9	0.0
3. Sencor DF	PRE	0.25	9.5	0.0	9.7	0.0
4. Goal 2XL	PRE	0.25	6.9	2.3	9.1	0.0
5. GoalTender 4F	PRE	0.25	7.5	1.8	9.6	0.0
6. Prowl H_20 GoalTender 4F	PRE PRE	1.0 0.25	8.0	1.5	9.8	0.0
7. Outlook	PRE	0.75	8.4	0.0	8.8	0.0
8. Dual Magnum	PRE	1.6	9.2	0.0	9.1	0.0
9. Chateau 50DF	PRE	0.094	8.5	0.0	9.4	0.0
10. Chateau 50DF	PRE	0.188	7.0	0.0	9.2	0.0
11. Raptor	PRE	0.047	9.9	0.0	10.0	0.0
12. Aim EC	PRE	0.25	9.9	0.0	10.0	0.0
13 Dual Magnum Aim EC	PRE PRE	1.6 0.25	9.9	0.0	10.0	0.0
14 Handweeded	3/2/05	---	9.0	0.0	10.0	0.0
15 Untreated	---	---	9.0	0.0	8.5	0.0
Statistical notation @ p=0.05		CV: LSD:	4.03% 0.5	59.02% 0.3	2.72% 0.4	n.s.
Growth based on a visual scale of 0-10; 0 = no growth and 10 = vigorous Injury based on a visual scale of 0-10; 0 = no injury and 10 = all plants killed						

Yield was reduced with both rates of Chateau and Raptor treatments (20%, 25%, and 16%, respectively) when compared to the hand weeded control, which yielded 3100 lbs/acre (table 5). The Goal 2XL and Goal/Prowl combination also showed similar reductions in yield. There were no differences seen in bean size classes and can counts with any of the treatments.

Table 5. Garbanzo yield on 7/20/05

			Yield	% Beans by size			Can Count
Treatment	Timing	Lb ai/A	Lbs/Acre	<20	20-24	>24	Beans/oz
1. Prowl 3.3E	PPI	1.2	2638.5	3.0	51.3	45.7	56.8
2. Prowl H_2O	PPI	1.2	2661.0	4.4	55.1	40.6	57.8
3. Sencor DF	PRE	0.25	3058.8	3.8	54.4	41.8	58.5
4. Goal 2XL	PRE	0.25	2417.5	4.2	48.0	47.6	56.5
5. GoalTender 4F	PRE	0.25	2731.8	3.6	49.8	46.6	57.8
6. Prowl H_2O GoalTender 4F	PRE PRE	1.0 0.25	2610.5	4.0	50.1	45.9	56.5
7. Outlook	PRE	0.75	2675.8	4.1	58.1	37.8	57.3
8. Dual Magnum	PRE	1.6	2902.8	3.7	52.8	43.5	56.3
9. Chateau 50DF	PRE	0.094	2504.5	3.7	44.5	51.8	56.8
10. Chateau 50DF	PRE	0.188	2327.5	3.4	47.6	49.0	57.0
11. Raptor	PRE	0.047	2592.0	4.6	48.9	46.6	57.5
12. Aim EC	PRE	0.25	2705.0	4.9	48.5	46.7	56.5
13 Dual Magnum Aim EC	PRE PRE	1.6 0.25	2722.5	4.5	49.4	46.1	57.5
14 Handweeded	3/2/05	---	3100.4	5.3	46.8	47.9	55.8
15 Untreated	---	---	1976.0	4.8	47.4	47.9	57.3
Statistical notation @ p=0.05		CV: LSD:	11.46% 446.4	26.71% n.s.	15.71% n.s.	18.55% n.s.	4.02% n.s.

Yield is based on harvesting the center 35' of 2 rows of each plot and running plants through a mechanical thrasher. Samples were cleaned and weighed and a sub-sample (cut sample 4X) was used for bean size and can counts.

Discussion:

There was a reduction in both the growth and yield of HB-14 where Chateau and Raptor were used. The excessively cold and wet season in 2004/05 may have contributed to this reduction in growth and yield. Similar treatments tested in 2003/04 did not show a reduction in growth or yield under milder conditions. Similarly, we did not see a reduction in yield where Raptor was used in previous studies, as we did in the 2004/05 trial. The medium soil type of the trial site is not likely to have contributed to this response. However, similar reductions in yield have shown up occasionally in other replicated trials in the state. In order to take advantage of the positive attributes these herbicides can offer garbanzo weed control, it will be necessary to further evaluate the response of HB-14 and other garbanzo varieties to different rates of Chateau and Raptor.

Invasive Weeds from the Nursery

Joseph M. DiTomaso. University of California, Davis, California, 95616, jmditomaso@ucdavis.edu

Nursery Industry

The California nursery industry is the largest in the United States and represents 21% of the national production. It is estimated to generate over $13 billion in annual revenue. Of this, about $3 billion is in production sales and $10 billion is in retail sales. The farm values from the nursery industry ranks third in California, behind only dairy and grape farm values. San Diego County is the largest nursery plant producer in the state, accounting for 27% of the total production. In total, the nursery industry provides over 160,000 jobs a year in California.

These trends in production and demand are expected to increase in California as the population of the state is projected to increase from 33 million people in 2000 to 50 million in 2025 (Public Policy Institute of California 2002). This will lead to increased housing demands and, concomitantly, greater need for landscaping and gardening products.

In addition, retail sales of nursery plants in California has shifted dramatically in the past 10 years from a garden center and independent nursery market to more of a large retail home center market. This shift is likely to reduce the level of expertise of employees selling ornamental plants. Thus, in addition to being a significant economic entity, the nursery industry is also a complex value driven customer market.

Invasive Plants

Of the 189 species listed on the 2006 California Invasive Plant Council (Cal-IPC) Invasive Plant Inventory (www.cal-ipc.org), about 57% were introduced through the nursery industry. This includes plants on the high, moderate and limited invasive lists. More importantly, 73% of those plants on the highly invasive list are escaped ornamentals. Of the 235 introduced woody plants that have become invasive in the United States, 85% were introduced for landscape purposes (Stanton et al. 2002).

The reason for this close association with ornamental plants and invasive species is not surprising. The qualities of an economically successful nursery plant would include ease of propagation, rapid establishment and growth rates, early maturity, abundant flower production, fitness under a variety of environmental conditions, and the absence of major pathogen or insect pests. These same qualities are present in many of the most invasive plant species of wildland areas. In addition, ornamentals often have the advantage of being widely distributed through the activity of humans, which gives then increased opportunities to escape to wildland areas.

In an unpublished study conducted by Cal-IPC, they surveyed 25 wholesale nurseries throughout the state to determine to what extent 52 invasive ornamental species or varieties were still being sold. Results indicated that 72% of the nurseries carried at least one invasive plant species and 88% carried at least one invasive plant or variety of an invasive plant. Thus, most nurseries play a role, or have a stake, in the introduction of invasive plants to California landscapes. The average number of invasive plants sold in the surveyed nurseries was 3.2 (5.5 including varieties), with one nursery selling 14 invasive species. Of the total of 52 species surveyed, 32 were still being sold, with 20 no longer available. Of these 32 species, each was sold by an average of 2.5 of the 25 nurseries. Varieties also played an important role. There were 13 varieties being sold from the 32 species and each was sold by an average of 4.5 nurseries. Although some varieties may not be invasive, there are many unresolved questions surrounding their impacts.

Table 1. Most frequently sold invasive species (with ranking) and the percentage of nurseries that provided these plants.

Scientific name	Common name	Cal-IPC ranking	Percentage of nurseries selling plant
Pennisetum setaceum and varieties	crimson fountaingrass	Moderate	48
Hedera helix and varieties	English ivy	High	36
Cortaderia selloana and varieties	pampasgrass	High	28
Vinca major and varieties	big periwinkle	Moderate	28
Cotoneaster lacteus	Parney's cotoneaster	Moderate	20
Schinus molle	Peruvian peppertree	Limited	20

Collaborative Solution

Once a state designates a plant as "noxious", it has the regulatory authority to prevent interstate movement. In California, there are 144 plant species designated as "noxious", of which only 34% overlap with the Cal-IPC invasive weed inventory, and only 21 (15%) are ornamental species on both lists. Of these 21, only 12 (8%) are still being sold in any capacity. Thus, there is little regulatory authority for prohibiting the sale of most invasive nursery species in the state. As an alternative solution to prohibiting the sale of all invasive species, Cal-IPC initiated a collaborative effort with the nursery industry to produce brochures that provide alternative native and non-native plants that are not known to be invasive. Collaborating in this effort were experts from the University of California Cooperative Extension, commercial and retail nurseries, growers, botanical gardens, gardeners, state and local agencies, non-profit organizations, and land managers.

The goal of this effort is to provide a positive educational solution that focuses on building awareness and responsible use of ornamental plants. The brochures target either plant growth forms, such as woody species, or geographical regions within the state (i.e., Bay Area, Southern California, Central Coast, etc.).

The design of these "Don't Plant a Pest" brochures is such that alternative non-invasive species provide the same landscape function, ease of propagation, hardiness, maintenance requirements, availability, and cost as the invasive species they are intended to replace. This requires that they match the various qualities related to flower or foliage color, growth rate, size and habit, foliage type and texture, season of interest, and disease resistance. The brochures are education tools for Cal-IPC members and others to use in approaching their local nurseries. They are also important educational materials for Master Gardeners, gardeners and consumers, and a template for other organizations that wish to produce similar materials. Each of the brochures includes general information on the invasiveness of 10 to 15 species and briefly describes several native and non-native alternatives. Since the publication of the first San Francisco Bay Area brochure in 2003, over 60,000 copies have been distributed through requests. Future efforts will focus on specific "Don't Plant a Pest" brochures for most growing regions within the state.

To view or order any of the "Don't Plant a Pest" brochures see www.cal-ipc.org.

Literature Cited

Public Policy Institute of California. 2002. US Census, California Department of Finance, Construction Industry Research Board

Stanton, A.E., C.E. Bell, and C. Wilen. 2002. Keep it in the Garden: Invasive plants and the nursery trade. Proc., California Weed Sci. Soc. 54:145-148.

Fumigant Alternatives after Methyl Bromide

Husein Ajwa, University of California-Davis, Salina, CA 93905, haajwa@ucdavis.edu

The cut flower and ornamental bulb industry relies heavily on the use of methyl bromide (MB) as a key pest management tool. Because of the broad-spectrum pest control provided by MB plus chloropicrin (Pic), hundreds of species and thousands of varieties of flowers can be grown on relatively few acres. The primary reasons for MB dominance in the marketplace include its excellent diffusion through the soil and its effective control of pathogens, nematodes and weeds.

The registered alternative fumigants to MB are Pic, 1,3-dichloropropene, and methyl isothiocyanate generators such as metam sodium, metam potassium, and Basamid (Table 1). Iodomethane (methyl iodide, Midas™) is under consideration for registration by the US EPA. Chloropicrin has been used as a pre-plant fumigant to suppress fungal pathogens in soil. The fumigant 1,3-dichloropropene is an effective nematicide that has been used in combination with chloropicrin (e.g., Telone C35 or InLine) to improve the control of soilborne fungal pathogens. Metam sodium (or metam potassium) may be used to control pathogenic fungi, nematodes, insects and weeds. Iodomethane has the potential of serving as a viable replacement for MB. When applied at an equivalent weight, IM is more effective than MB in controlling soil fungal pathogens.

Table 1. Application Rate and Activity of Fumigants.

			Activity against:			
Common Name	Trade Name	Broadcast rates/A	Nematodes	Fungi	Weeds	Comments
Chloropicrin	TriClor MetaPicrin	15-30 gal (shank)	Fair	Excellent	Poor	Liquid that diffuses as a gas through soil. Very effective for control of soil-borne fungal pathogens and insects.
		15-22 gal (drip)	Good	Excellent	Fair†	Drip application requires an emulsifier. (1 gal = 13.7 lbs).
1,3-dichloropropene	Telone II	9-12 gal (shank)	Excellent	Poor	Fair	Liquid that diffuses as a gas through soil. Effective against nematodes and insects. Rates vary with soil texture and efficacy strongly affected by soil moisture and temperature. (1 gal = 10.1 lbs).
1,3 dichloropropene plus chloropicrin	Telone C35	28-33 gal (shank)	Excellent	Very good	Fair	Most effective for control of nematodes, fungal pathogens, and insects. (1 gal = 11.1 lbs).
	InLine	23 gal (drip)	Excellent	Excellent	Good†	InLine requires plastic mulch. (1 gal = 11.2 lbs).
Metam sodium	Vapam HL Sectagon	37.5-75 gal	Good	Good	Good	Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. (1 gal contains 4.26 lbs metam sodium).
Metam potassium	K-Pam HL Sectagon-K	30-60 gal	Good	Good	Good	Same as metam sodium. (1 gal contains 5.8 lbs metam potassium).
Iodomethane‡	Midas™	8-20 gal	Excellent	Very good	Excellent	Activity is similar to that of methyl bromide.

† Using higher rates or plastic mulch (especially virtually impermeable film) improves weed control.
‡ Several formulations of Midas™ (iodomethane plus chloropicrin) are under consideration for federal registration.

For control of fungal pathogens and weeds, our research found that application of these alternatives by drip fumigation is more effective than by shank injection. Also, sequential drip application of metam potassium (KPam) after chloropicrin, InLine, or Midas enhanced the efficacy of reduced rates of these alternatives. Drip fumigation with Midas (33/67) at 200 lbs/ac, chloropicrin at 200 lbs/ac, or Inline at 300 lbs/ac gave similar Ranunculus bulb yields to MB/Pic at 200 lbs/ac, and was significantly better than untreated control (Figure 1). Drip application of KPam (30 gal/ac) one week after MB/Pic, Midas, Pic, or InLine significantly increased total yields and enhanced weed control (significantly reduced little mallow and clover numbers).

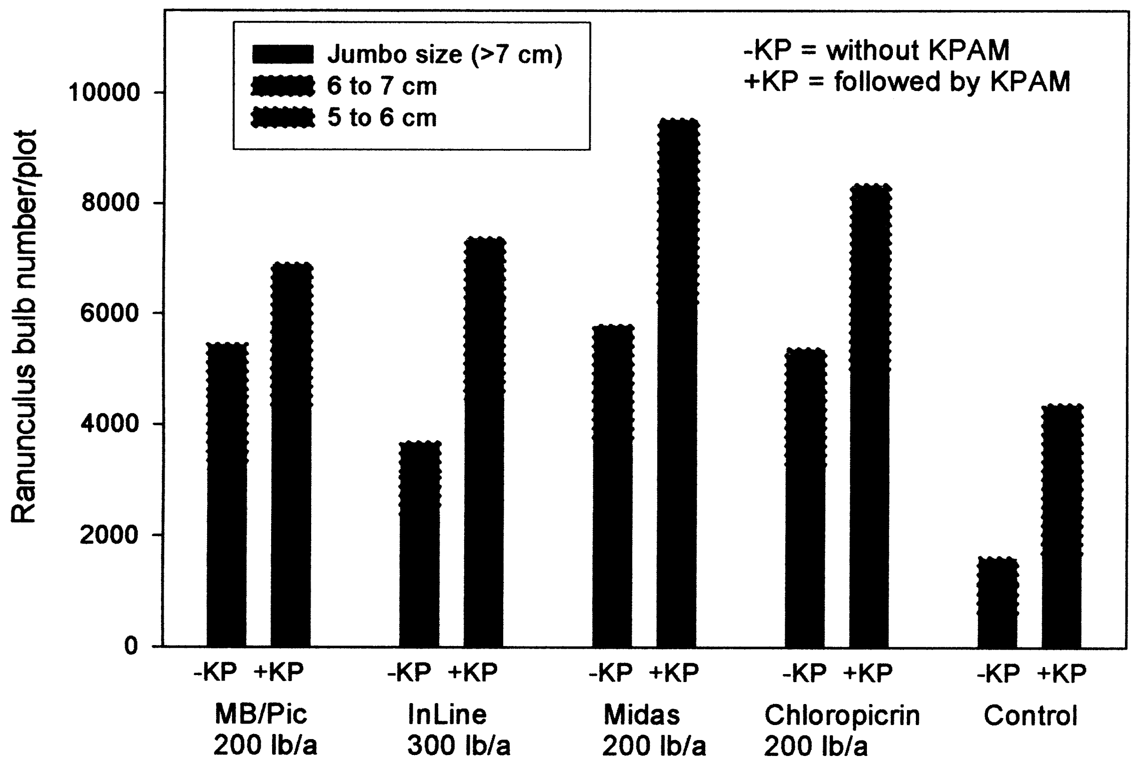


Figure 1. Ranunculus bulb yield by size class.

Soil Fumigation for Nutsedge Control

Steven A. Fennimore, University of California-Davis, Salinas, CA 93905
safennimore@ucdavis.edu and Jose Aguiar,
University of California, Indio, CA 92201, jlaguiar@ucdavis.edu

Introduction

Control of yellow and purple nutsedge has long been a difficult weed to control in the vegetable production areas of the low desert. In the development of the Pest Management Strategic plan for lettuce, growers in the Coachella area identified nutsedge as a difficult pest to manage (PMSP 2003). None of the available lettuce herbicides, benefin, bensulide or pronamide control nutsedge. Herbicides such as halosulfuron could conceivably be used to control nutsedge in rotational crops and reduce overall nutsedge densities in a field. However, lettuce may not be planted for 18 months following a halosulfuron application. EPTC does have a SLN label for control of nutsedge in fallow ground in California, and lettuce can be planted 90 days after EPTC application (Syngenta 2002). However, growers are looking for something better to control nutsedge than EPTC alone (PMSP 2003). Soil fumigants used in combination with pebulate improved control of nutsedge in Florida (Locascio 1997). The objective of this work was to determine if sequential application of fumigants followed by EPTC could be used to control nutsedge in fallow ground, and to determine if this control was sufficient to reduce nutsedge densities in rotational crops grown 3-16 months after application.

Methods

These experiments were conducted in commercial fields in the Coachella Valley of California, to determine if nutsedge can be managed with sequential applications of 1,3-D plus chloropicrin (Telone C35™) or metam sodium/potassium followed by (fb) EPTC in fallow ground prior to lettuce planting. Metam sodium was applied by water run at 40 GPA, and Telone C35 at 28 GPA was applied by shank injection on June 19, 2003 near Indio, CA. An untreated control was also included. EPTC (Eptam™ 7 E) at 7 pts/A was applied to all plots, including the untreated, on July 1, 2003. Lettuce was planted at the Indio site on Oct. 13, 2003. The study at Coachella, CA was initiated June 15, 2004; where 50 GPA metam potassium and 20.5 and 26 GPA Telone C35™ were shank injected. The study at Thermal, CA was initiated Aug. 19, 2004 with 60 GPA metam sodium (Sectagon 42™) and 20.5 and 26 GPA Telone C35™. Following fumigant applications, both trials were treated with 7 pts./A EPTC. The studies were arranged in a randomized complete block with two replicates at Indio and three replicates at both Coachella and Thermal. Lettuce was planted at the Indio site Oct. 2003, at the Coachella site Sept. 2004 and again Sept. 2005. At the Thermal site, lettuce was planted Nov. 2004 and again Sept. 2005.

Nutsedge control assessments were made at Indio Nov. 2003, at Coachella during Oct. and Dec 2004, and Sept. 2005, and at Thermal in Mar. and Oct. 2005.

Results

In 2003 fallow applications of Telone C35™ at 28 gallons/A (GPA) followed by (fb) EPTC at 7 pts. /A resulted in excellent nutsedge control at Indio (Table 1). We lost access to the Indio field in 2004 due its development for housing, so no follow up ratings were possible. At Coachella, sequential applications of Telone C35™ at 20.5 to 26 GPA fb EPTC at 7 pt/A provided better nutsedge control than EPTC alone both in 2004 and 2005 (Table 2). The metam potassium fb EPTC treatments reduced nutsedge densities compared to EPTC alone in 2004, and in 2005. At the Thermal site there were no treatment effects on nutsedge densities in Mar. 2005 (Table 3). At Thermal on Oct. 5, 2005, there were no differences in nutsedge densities between Telone C35™ fb EPTC and EPTC alone (Table 3). At this same site, metam sodium fb EPTC had more nutsedge than EPTC alone. These results indicate clearly that Telone C35™ fb EPTC provides better suppression of nutsedge in the first crop, compared to EPTC alone. However, long-term nutsedge suppression results from Telone C35™ fb EPTC were mixed, with long-term benefits at 16 months after application at Coachella, but not at Thermal. Metam potassium and metam sodium fb EPTC treatments do not appear to provide consistent short- or long-term nutsedge suppression.

Table 1. Nutsedge control at Indio, CA.

Product [1]	**Rate**	**Nutsedge densities (no./A)** [2]
		Nov. 2003
EPTC	7 pts	1287 a
Metam potassium fb EPTC	40 GPA fb 7 pts	1023 ab
Telone C35 fb EPTC	28 GPA fb 7 pts	46 b

[1] Followed by (fb) means a sequential application.
[2] Data within a column sharing the same letter(s) were not different at P = 0.05.

Table 2. Nutsedge control at Coachella, CA.

Product [1]	**Rate**	**Nutsedge densities (no./A)** [2]	
		Oct.-Dec. 2004	Oct. 2005
EPTC	7 pts	710 a	365 a
Metam potassium fb EPTC	50 GPA fb 7 pts	203 b	75 c
Telone C35 fb EPTC	20.5 GPA fb 7 pts	57 b	225 b
Telone C35 fb EPTC	26 GPA fb 7 pts	29 b	116 bc

[1] Followed by (fb) means a sequential application.
[2] Data within a column sharing the same letter(s) were not different at P = 0.05.

Table 3. Nutsedge control at Thermal, CA.

Product [1]	Rate	Nutsedge densities (no./A) [2]	
		Mar. 2005	Oct. 2005
EPTC	7 pts	210	6163 b
Metam sodium fb EPTC	60 GPA fb 7 pts	110	11851 a
Telone C35 fb EPTC	20.5 GPA fb 7 pts	14	3661 b
Telone C35 fb EPTC	26 GPA fb 7 pts	45	4986 b

[1] Followed by (fb) means a sequential application.
[2] Data within a column sharing the same letter(s) were not different at P = 0.05.

LITERATURE CITED

Locascio, S. J., J. P. Gilreath, D.W. Dickson, T. A. Kucharek, J. P. Jones and J. W. Noling. 1997. Fumigant alternatives to methyl bromide for polyethylene mulched tomato. HortScience 32(7):1208-1211.

[PMSP] 2003. Pest Management Strategic Plan for California and Arizona Lettuce Production 2003. Available online at http://pestdata.ncsu.edu/pmsp/index.cfm

Syngenta. 2002. Eptam 7E nutsedge suppression label for fallow land. SLN no. CA-900039.

Control of Scotch Broom ***(Cytisus scoparius)***

Scott Oneto[1*], Joseph M. DiTomaso[2], Guy B. Kyser[2]
[1]University of California Cooperative Extension
[2]Department of Plant Sciences, University of California, Davis
*Email: sroneto@ucdavis.edu

Scotch broom is a native of Central and Southern Europe and North Africa. It is a deciduous shrub, 1-3 meters high with bright yellow flowers from April to June. Scotch broom was introduced into California in the 1850's as an ornamental and for roadside erosion control. It is highly competitive with natives and forms dense monotypic stands that are inaccessible and unpalatable to wildlife. As the plants age, the inner stems dieback increasing fuel loads. In fall 2003 and spring 2004 two identical trials were established in El Dorado County, California, to test mechanical techniques and several herbicides using different application techniques. The herbicides tested were Chopper® (imazapyr), Garlon 4® (triclopyr ester), and Roundup Max® (glyphosate). Application methods included foliar, drizzle, and cut stump. The two mechanical treatments included a weed wrench and lopping. Each treatment was replicated 10 times in a randomized block design with an individual shrub serving as a replicate. Results showed that Roundup Max®, and Garlon 4®, both gave excellent control as a foliar spray or drizzle application in the fall or spring, whereas Chopper® was most effective in the fall. As a cut stump application, both Chopper® and Garlon 4® were effective in the fall, whereas Garlon 4® was most effective in the spring. In the mechanical treatments, the weed wrench was very effective as a fall or spring treatment, whereas the lopping was most effective in the spring.

Weed Control in Celery

Oleg Daugovish, University of California Cooperative Extension, Ventura County, Ventura, California, 93003, odaugovish@ucdavis.edu, Steve Fennimore, University of California Davis, Salinas, CA, and Richard Smith, , University of California Cooperative Extension, Monterey County.

Weed control in celery produced in Ventura County is accomplished by using herbicides and by rotating to strawberries, a crop that is fumigated annually for the purpose of pest control. Fumigation controls many broadleaf weed species but often fails to control hard-seeded weed species such as little mallow (cheeseweed) and California burclover. Fumigant alternatives to methyl bromide that are increasingly used in California provide partial or no control of yellow nutsedge, a major troublesome perennial weed in Southern California vegetable production.

There are three preemergence and/or postemergence weed control materials currently registered for use on celery: Prometryn (Caparol), linuron (Lorox) and trifluralin (Treflan), and in 1999 were applied to 72, 28 and 1% of the California celery acreage, respectively. The original impetus for this research project was the uncertainties of the regulatory situation for each of these herbicides as they passed through the first round of the Food Quality Protection Act (FQPA) review. It appears that each material has made it through the first round of the FQPA process. However, it seems prudent to explore other herbicide options for celery, given that EPA has classified linuron as a possible human carcinogen. Additionally, Caparol and Lorox do not control yellow nutsedge and thus, new materials should be evaluated.

Three trials at Oxnard, CA and five trials at Salinas, CA compared performance of pre-transplant (PRE) herbicides to the standard post-transplant (POST) applications of Caparol (1.5 lb ai /acre) or Lorox (1 lb ai/acre) in 2001-2004. Pre-plant herbicides were (lbs ai/acre): S-metolachlor (Dual Magumat 0.5, 0.63 and 0.95), flufenacet (Define 0.4, 0.5 and 0.6), flumioxazin (Chateau 0.06, 0.094 and 0.188), oxyfluorfen (GoalTender 0.125) and carfentrazone (Shark 0.032).

Dual Magnum and Define at all rates provided 90% control of yellow nutsedge grown in pots (Salinas) and reduced the weed density at Oxnard from 19 plants per 45 ft^2 plot . However, when yellow nutsedge population in untreated control was 83 plants/plot at Oxnard in 2003 only highest rates of Dual Magnum and Define significantly reduced the nutsedge number (70 and 52%, respectively). All other treatments did not control yellow nutsedge.

The major broadleaf weed species were: burning nettle, shepherdspurse, little mallow, black nightshade, nettleleaf goosefoot, redroot pigweed and chickweed. Caparol and Chateau (at all rates) provided the most consistent broadleaf weed control (90-98%) at both locations over the years and also controlled annual bluegrass at Salinas. In 2004 study at Oxnard tank mix of Chateau with Dual Magnum (PRE) and Caparol (POST) following Dual Magnum (PRE) provided near 100% control of all broadleaf weeds. Knowing that Dual Magnum was the best material for yellow nutsedge control, these combinations may provide season-long weed control of all weeds and in case of Dual Magnum +Chateau tank mix it may be achieved with a single PRE application.

Lorox controlled (>90%) little mallow at Oxnard and shepherdspurse at both locations. Goaltender controlled shepherdspurse, chickweed nightshade and nettle. Dual Magnum and Define failed to control broadleaf weeds at lowest rates but provided partial weed control at increased rates (except nightshade that were not controlled by any rate of Define). Shark failed to control any weeds at both locations.

When herbicide injury was recorded 3-5 weeks after transplanting Shark and GoalTender did not cause any visual injury to transplant celery, except in one study in Salinas, where GoalTender caused crinkling of leaves but celery plants later outgrew the injury. Caparol, Chateau and lower rates of Dual Magnum and Define had similar levels of crop injury (1-2 on a 10 point scale, 0=no injury, 10=dead plant). Lorox and highest rate of Dual Magnum caused greater injury (3-3.5 points) than other herbicides. At Oxnard all treatments in all years had similar number of marketable heads to untreated control, indicating that celery outgrew initial herbicide injury at that location. However, in two studies at Salinas Chateau significantly reduced the number of marketable heads.

These studies showed that Chateau can be an excellent replacement for Caparol and Lorox and can provide similar or better broadleaf weed control. Ability to use Chateau PRE still leaves an opportunity to control weeds POST with Caparol if that becomes necessary. Lower label rates of Chateau should be used to avoid crop injury and potential yield reduction. Yellow nutsedge control can be achieved with Dual Magnum and Flufenacet but high densities of nutsedge required maximum rate of Dual Magnum which was injurious to celery transplants. Dual Magnum has indemnification label with Syngenta and is currently available for use in celery, while Chateau is in IR4 process and may potentially be registered in 2007.

Chemigating Kerb® in Lettuce

Jesse M. Richardson, Dow AgroSciences, Hesperia, CA, jmrichardson@dow.com
Barry R. Tickes, Yuma County Cooperative Extension, Yuma, AZ, btickes@ag.arizona.edu
Kurt J. Hembree, UC Cooperative Extension, Fresno, CA, kjhembree@ucdavis.edu
Steven A. Fennimore, UC-Davis, Salinas, CA 93905, safennimore@ucdavis.edu

Applying Kerb® 50-W herbicide through overhead sprinklers has become commonplace during the past few seasons in the low desert lettuce production region of Arizona and southern California, as a result of section 24(c) registrations. Numerous studies were established in Yuma, AZ from 2002 to 2005 and at Five Points, CA in 2004 and 2005. In Yuma County, field trials were conducted in 2002 and 2003 to compare efficacy and crop safety of aerially-applied and sprinkler-applied Kerb. Side-by-side plots were established at five locations. Kerb was applied at rates of 0.6 to 0.85 lb a.i./acre. Individual plots were a minimum of 10 acres in size. Correctly timing the Kerb chemigation to match weed seed germination was one of the most critical factors in obtaining acceptable weed control. To minimize lettuce phytotoxicity and to maximize efficacy, applying the correct amount of water after chemigation was also crucial. In general, applying 0.4-0.6 in of water after chemigating provided optimal results. In 2004, two large-plot replicated studies were conducted in Yuma to determine the optimal chemical injection duration and post-application incorporation water volume necessary to obtain the highest level of weed control. The treatments in both studies were applied four days after sprinkler irrigations were initiated. In the first study, 0.65 lb a.i./A of pronamide was injected into the sprinkler irrigation stream for three different durations; 30-, 60- or 90-min. These durations correspond to 0.05-, 0.1- and 0.15-in water. Following injection, all three treatments received 0.4-in water for incorporation. In the second study, 0.65 lb a.i./A of pronamide was chemigated for 60-min, followed by incorporation water volumes of 0-, 0.4-, 0.8- or 1.2-in. Prior to establishing the two studies, plots were overseeded with giant Indian mustard seeds as an indicator weed. Both experiments included an untreated check. Forty-one days after Kerb application, weed control was determined by removing all weeds in a 10-ft length along the bed top between two lettuce seed lines, and measuring fresh weights. In the injection duration study, the highest level of weed control was achieved with the 90-min injection. The 30-min treatment was no different than the untreated check, while the 60-min duration provided measurable control. In the post-application incorporation study, there were no differences detected in weed control among the various water volumes. However, there was a distinct trend suggesting that weed control decreased with increasing volumes of incorporation water. The best performance came from the 0- and 0.4-in treatments, while the poorest came from the 1.2-in treatment. At Five Points in 2004, Kerb applied by chemigation at 0.75 lb a.i./A was compared to Kerb applied in 5-in bands by ground at 1.5 lb a.i./A in the treated zone. Because the chemigation treatments were broadcast applications of the chemical, those treatments resulted in substantially fewer weeds within the plots than the band treatments. However, comparing 4-in wide zones along the lettuce seed lines, both treatments provided excellent control of common purslane and grass weeds. With pigweeds and shepherdspurse, numerical trends favored the chemigation treatments, but significant differences were not detected. Total savings to the grower in the chemigation treatments would be $139/A, compared to the ground treatments.

® Trademark of Dow AgroSciences LLC
Kerb 50-W is a Federally Restricted Use Pesticide

Table 3. Nutsedge control at Thermal, CA.

Product [1]	Rate	Nutsedge densities (no./A) [2]	
		Mar. 2005	Oct. 2005
EPTC	7 pts	210	6163 b
Metam sodium fb EPTC	60 GPA fb 7 pts	110	11851 a
Telone C35 fb EPTC	20.5 GPA fb 7 pts	14	3661 b
Telone C35 fb EPTC	26 GPA fb 7 pts	45	4986 b

[1] Followed by (fb) means a sequential application.
[2] Data within a column sharing the same letter(s) were not different at P = 0.05.

LITERATURE CITED

Locascio, S. J., J. P. Gilreath, D.W. Dickson, T. A. Kucharek, J. P. Jones and J. W. Noling. 1997. Fumigant alternatives to methyl bromide for polyethylene mulched tomato. HortScience 32(7):1208-1211.

[PMSP] 2003. Pest Management Strategic Plan for California and Arizona Lettuce Production 2003. Available online at http://pestdata.ncsu.edu/pmsp/index.cfm

Syngenta. 2002. Eptam 7E nutsedge suppression label for fallow land. SLN no. CA-900039.

Early Season Weed Control in Onions Prior to 2nd True Leaf Emergence

Grant Poole, UC Farm Advisor, Lancaster California, gjpoole@ucdavis.edu

Recently several post emergent and soil residual pre-emergent herbicides have been developed that could improve weed control prior to second true onion leaf emergence. Traditionally weed control in onions has been dependent on the use of oxyfluorfen (Goal 2XL) and bromoxynil (Buctril 4EC) tank mixes at the second true onion leaf. By this stage weeds are often too large to control without higher rates of these herbicides that can cause excessive crop injury. Several herbicides were evaluated in the Lancaster area for their applications to onions prior to the second true leaf. Most of these herbicides have been on the market for several years and now have new applications in onions.

Of the results from three trials conducted near Lancaster, the outstanding results were the safety and importance of the application of 24 oz. of Prowl H_2O at the onion loop stage. In Trial #3, 4 oz. of GoalTender was tank mixed with 24 oz. of Prowl and applied at the first true leaf that resulted in over 91% filaree control. In Trial #2 the tank mix of Prowl (24 oz) and Outlook (14 oz) at the third true leaf was a very safe and effective applications. From these results the optimal treatment is Prowl H_2O applied at the loop stage followed by 4 or 6 oz. of GoalTender applied at the 1st true leaf.

When 2, 4, 6, and 8 oz./ac. of Prowl H_2O were applied at planting, the 6 and 8 ounce treatments resulted in stunting that would be marginally tolerable. The 2 and 4 oz. rate resulted in a lack of weed control. The issue of crop injury with Prowl H_2O when applied at planting is important because of our sandy soils. Prowl is a growing point inhibitor and soil residual herbicide. Soils have exchange sites that these soil residual chemicals bind to. Sands have less of these exchange sites to tie up the chemical so more is free in the soil to either suppress germinating weeds, or the crop. If the plants are stunted and delayed in their growth, it could possibly result in yield loss. Onion yield was not measured from these treatments but needs to be evaluated. However, since Prowl is a growing point inhibitor, once the onion plant emerges it will not be affected by the herbicide. This is why the onion loop stage is the most favorable stage for the application of Prowl.

Prefar caused too much injury in this trial. GoalTender (4 oz) applied at the loop stage is too early and caused 40% stand loss. Outlook applied at 10 oz. at the first true leaf, 4E, Eptam and Chateau 51WD caused excessive onion injury beyond production standards.

Buctril was applied at a rate of 4 oz and 6 oz./ac. without significant onion injury and good weed control in Trial #2. However these applications were experimental and results may differ when the material is applied through sprinklers.

GoalTender is a new formulation of Goal 2XL that was registered for use in onions in 2004. GoalTender has nearly double the amount of active ingredient (41% oxyfluorfen) than the older formulation, Goal 2XL (23% oxyfluorfen). GoalTender is known to cause much less crop injury than traditional applications of Goal 2XL and Buctril. Research has shown that early applications of GoalTender, at low rates of 4 to 6 oz around when the 1st true leave is ¾ to fully expanded are more effective in controlling weeds with less crop damage. Weed control is often better with earlier GoalTender applications because the weeds at this time are smaller (less than 2 to 3 inches in size) and easier to kill.

Summary:

GoalTender applied at the first true onion leaf stage at 6 oz. provided the best weed control with the least onion injury in this trial. The traditional tank mix combinations of Goal 2XL and Buctril 4EC resulted in greater onion injury with weed control similar or less than that of GoalTender applied at the first true leaf. Although GoalTender applied at 8 oz. at the first true leaf provided the best weed control, this rate causes significant stand loss and injury. These results show the decreased effectiveness on weeds when it is applied at the second true leaf, even at the 8 oz. rate. These results show that GoalTender can provide good weed control with significantly less onion injury when it is applied at the first true onion leaf stage while weeds are small. This effect is due to poor weed tolerance to herbicides and the residual weed control effects of GoalTender following the application. Further research needs to be conducted to assess the effectiveness of GoalTender applied through sprinklers on a larger scale and with certain problematic weeds such as lambsquarters.

Weed Control Studies in Transplanted Bell Peppers with Preemergence Herbicides

Richard F. Smith and, University of California Cooperative Extension, Monterey County, 1432 Abbott Street, Salinas, CA 93901, rifsmith@ucdavis.edu and
Michelle Le Strange University of California Cooperative Extension, Tulare County, 4437 S. Laspina Street, Tulare CA 93274, mlestrange@ucdavis.edu

INTRODUCTION

Peppers are long-season vegetables that have several weed control challenges: They compete weakly with weeds for the first 40 to 60 days following transplanting. They are a long-season crop in many production districts that can be subject to flushes of both winter and summer weeds over the course of their growing cycle. The preemergence herbicides registered for peppers have gaps in the spectrum of weeds that they control (Smith et al., 2003). As a result, growers may spend from $200 to $350/acre (Klonsky et al., 1997) on weed management. Field selection, field sanitation, cultivation and the use of plastic mulches are cultural practices that reduce weed pressure in production fields. Fumigation provides substantial weed control and is frequently used in conjunction with plastic mulches which improves the level of weed control provided by both techniques. Goal Tender was registered in California in 2004 for use with plastic mulch and provides control of Little Mallow (*Malva parviflora*) which is only partially controlled by fumigants and other preemergence herbicides registered for use on peppers. However, many acres of peppers are not grown with plastic mulch, and weed control is a challenge. Devrinol, Prefar and Treflan are registered preemergence herbicides in peppers. Dual Magnum is registered under a 24C and provides good control of hairy nightshade (*Solanum sarrachoides*) and yellow nutsedge *(Cyperus esculentus)* which are not controlled by the other preemergent materials. Late season weed control is also an important issue in this crop. The objective of these studies was to examine at transplant and layby herbicide combinations for peppers that can provide long-term and economical weed control for peppers grown without plastic mulch. The herbicides tested included: Dual Magnum 7.62 (s-metolachlor), Goal Tender 4F (oxyfluorfen), Outlook 6.0 (dimethenamid), flumioxazin (Chateau) impregnated on fertilizer, and Dacthal 75W (DCPA).

METHODS

Field trials were conducted on the Central Coast (Santa Clara County) and Fresno County in 2005 to provide an evaluation of the test herbicides over a wider range of growing conditions and weed spectra.

Central Coast study: The trial was conducted with a cooperating grower in Gilroy. Goal Tender treatments were applied onto shaped beds two weeks prior to transplanting the peppers on April 28. The field was transplanted on May 13. The at-planting treatments were applied over-the-top of the plants immediately following transplanting. Sprinkler irrigation was started 5 hours following transplanting applying 0.38 inch of water. Layby applications were made on June 16 and the material was incorporated with the last sprinkler irrigation before the field was switched to drip irrigation. The plots were hand weeded on June 3 and the July 1 weed evaluations reflect newly sprouted weeds following the layby application. The plots were not cultivated prior to the July 1 weed evaluation. Each plot was one 40-inch bed wide by 25 feet long and replicated four times in a randomized complete block design (RCBD). All spray treatments were applied to the entire bed in 74 gallons of water per acre with two passes of a one nozzle wand with an 8008E teejet nozzle at 30 psi. Flumioxazin on fertilizer granules was spread by hand on the bed top immediately following transplanting. Soil type was Pacheco silt loam and the variety was Baron (planted in greenhouse on March 17).

Fresno County Trial: The field trial was conducted on a Panoche clay loam soil at the UC West Side Research and Extension Center (WSREC) near Five Points. On June 7 the bell pepper variety "Jupiter" was transplanted in single rows into 40" beds. Within row plant spacing was 10". Plot size was two 40-inch beds x 70 feet of row length and replicated 4 times in a RCBD. Preplant applications of Goal Tender were made onto shaped beds on May 10, 28 days prior to transplanting the peppers and incorporated with 0.50 inches of rainfall. The at-planting treatments of Dual Magnum, Outlook and flumioxazin were applied over the top of the plants and the field was sprinkler irrigated applying 0.50 inches of water immediately following transplanting. Sprinkler irrigation continued as needed for a few weeks and then switched to furrow irrigation. On July 25 the field was machine cultivated before layby applications of the herbicides were made as a directed spray to the base of the plants. These applications were incorporated by sprinkler irrigation. All sprayed treatments were applied to the entire plot in 30 gallons of water per acre using a CO_2 backpack sprayer @30 psi and a 2 nozzle boom with 8003evs tips. Flumioxazin on fertilizer granules was hand broadcast over the top of the peppers. There were two untreated checks: one was handweeded twice in addition to layby cultivation and the other was allowed to grow weedy all season.

Plots were evaluated for phytotoxicity to the peppers and weed control on July 1, July 22, and August 12. Pepper stand counts were made on July 13. A portion of each plot (25' row) was hand harvested on August 23 (west bed) and on September 8 (east bed) and the yields were combined for total yield. See tables 2 and 3 for treatments and evaluations.

RESULTS AND DISCUSSION

Central Coast: Hairy Nightshade was the dominant weed at this site. The best weed control was provided by Outlook, then by Dual Magnum and Goal Tender 21 days after treatment (DAT) (Table 1). Flumioxazin impregnated on fertilizer provided good weed control in two treatments, but not in the other. This may be due to problems with obtaining an even distribution of this dry granular material on the top of the bed. Devrinol was at a distinct disadvantage at this site because Hairy Nightshade was the main weed at this site and it does not control this weed. Outlook caused stunting of the plants 21 DAT, and while the stunting was reduced 28 DAT, it was still quite noticeable. There was no difference in the stand among treatments, but there were some instances of burned pepper plants in the flumioxazin treatment, presumably where a prill of the material lodged against the stem of a plant. All herbicides except Devrinol reduce time to weed the plots, but Goal and flumioxazin on fertilizer tended to take more time than Dual Magnum and Outlook. There were no differences in weed control among the layby applications (data not shown) and this test did not provide a good opportunity to evaluate the long-term weed control system for peppers. There were no significant differences in yield among the treatments (data not shown) which indicates that the initial phytotoxicity observed on the Outlook treatments did not translate to reduced yield.

Fresno County Trial: Because of excessive rainfall many weed seeds germinated in the untreated area of the field after the preplant treatments of Goal Tender but before the peppers were transplanted. Goal Tender was extremely effective in controlling all of the weeds (see photo). However, prior to transplanting it was necessary to cultivate and reshape the beds, thus destroying the herbicide layer and the effectiveness of Goal Tender. Weed control ratings on July 1 and July 22 (a few days before layby) showed how Goal Tender was no longer effective (Table 2).

Weeds were vigorous and abundant throughout the season and included several broadleaf species and virtually no grasses except for occasional jungle rice *(Echinochloa colonum)*. The major broadleaf weeds were prostrate, tumble, and redroot pigweeds (*Amaranthus blitoides, A. albus,* and *A. retroflexus*); primarily black nightshade (*Solanum nigrum*), but also some hairy nightshade (*S. sarrachoides*) and lanceleaf groundcherry (*Physalis lanceifolia*); common lambsquarters (*Chenopodium album*); and purslane *(Portulaca oleracea)*. Mustards, shepherds-purse (*Capsella bursa-pastoris*) and London rocket (*Sisymbrium irio*), were initially present prior to layby, but were taken out with the layby cultivation and were not serious competitors. Puncturevine (*Tribulus terrestris*) was also scattered throughout the experimental site but was not included in the weed counts because its populations were too random.

At planting applications: Although weed control was initially excellent, Outlook really hurt the peppers with an over the top application and many plants remained stunted for the entire season. Pepper yields were extremely reduced (Table 3). As the season progressed weeds germinated and the small pepper plants offered little competition. Flumioxazin provided good weed control and only slight pepper phytotoxicity was observed using the dry granular formulation, although some care was given to try to keep the prills off of the pepper plants during the broadcast application. Weed control is probably compromised by this method of application due to the difficulty of obtaining uniform coverage. Dual Magnum provided the best weed control. A little damage was seen on the peppers, but yields were not affected.

Layby applications: After layby there was not a lot of new weeds that germinated however, weeds that were missed by cultivations continued to grow. Dual, Outlook, and Dacthal all provided good to excellent weed control when applied at layby. All of the Goal Tender preplant plots and the flumioxaxin at planting plots were improved with the layby applications. Dual, Outlook, and flumioxazin were effective on nightshades, and reduced pigweeds, purslane, and lambsquarters populations to varying degrees, although none of these products provided complete control of these weeds in this experiment. Still a hand weeding crew would have been able to clean up the field in a relatively short time, if the pepper field had been treated with almost any of these combinations.

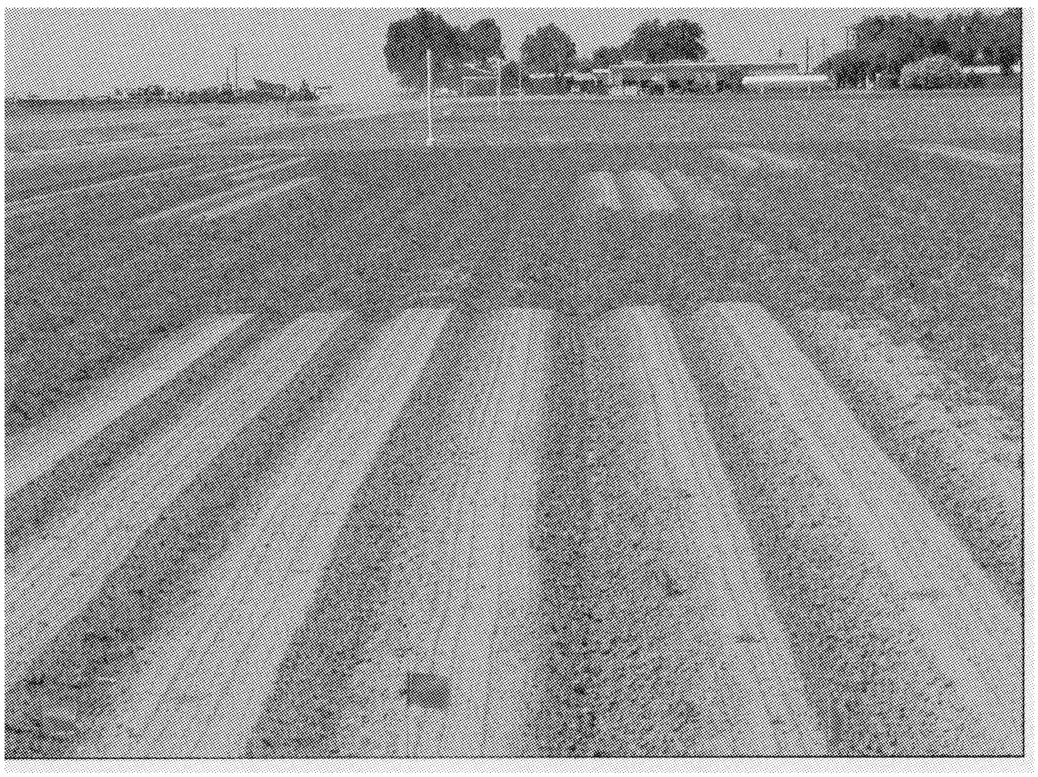
CONCLUSION

The Central Coast trial provided evidence that Goal Tender applied to shaped beds prior to transplanting (and subsequently not worked prior to transplanting) provided acceptable safety to the peppers and good weed control. This use pattern could provide an alternative "at planting" treatment and can provide weed control for the first 30 days following transplanting. Outlook was applied over-the-top in both trials, but was more damaging to the peppers in the Fresno trial. This material did not reduce yields in the Central Coast trial and should be further examined as a pretransplant application. Both trials showed that flumioxazin impregnated on fertilizer has promise as a post transplant application on peppers. The Fresno Trial showed that Dual Magnum, Outlook and Dacthal all provided good layby weed control. Dacthal is already registered for this use, but the Dual Magnum label would need to be adjusted to allow this use. In summary, these trials showed promise for developing a weed control system to provide early and late season weed control for peppers grown without plastic.

LITERATURE CITED
Smith, R. F, W.T. Lanini and C. Bell. 2003. Pepper Pest Management Guidelines – Weeds. University of California Integrated Pest Management Program. ANR Publication 3460. http://www.ipm.ucdavis.edu/PMG/selectnewpest.peppers.html

Klonsky, K., R.F. Smith, and P. Livingston. 1997. Sample costs to produce peppers in San Benito and Santa Clara Counties. University of California, Dept. of Agriculture and Resource Economics Publication. http://coststudies.ucdavis.edu/

ACKNOWLEDGEMENTS
California Pepper Commission
Cooperating growers



Fresno: June 1, 2005 - Goal Tender provided very good weed control prior to transplanting peppers.

Table 1. Central Coast Trial. Post transplant evaluations: Number of weeds (per $6ft^2$), and phytotoxicity (two dates), stand count and time of weed evaluations.

TRT Code	Applications	Lbs a.i./A	Material/A	Nightshade 21 DAT	Total Weeds 21 DAT	Phyto 21 DAT	Phyto 28 DAT	Plants per plot 21 DAT	Time to weed (hrs/A) 21 DAT
1	Dual Magnum 7.62 *Fb* Dual Magnum 7.62*	1.43 *1.43*	1.50 pts *1.50 pts*	0.5	0.5	0.3	0.0	36.8	1.6
2	Dual Magnum 7.62 *Fb Outlook 6.0*	1.43 *0.60*	1.50 pts *0.80 pt*	0.8	0.8	0.8	0.3	35.5	1.3
3	Dual Magnum 7.62 *Fb Dacthal 75W*	1.43 *7.00*	1.50 pts *9.3 lbs*	1.3	1.3	0.3	0.1	36.0	1.3
4	Goal Tender 4F[1] *Fb Dual Magnum 7.62*	0.50 *1.43*	1.00 pt *1.50 pts*	2.3	3.3	0.8	0.4	35.3	3.6
5	Goal Tender 4F[1] *Fb Outlook 6.0*	0.50 *0.60*	1.00 pt *0.80 pt*	2.5	2.8	0.3	0.0	35.0	3.3
6	Goal Tender 4F[1] *Fb Dacthal 75W*	0.50 *7.00*	1.00 pt *9.3 lbs*	2.3	2.3	0.5	0.0	35.8	2.8
7	Outlook 6.0 *Fb Dual Magnum 7.62*	0.60 *1.43*	0.80 pt *1.50 pts*	0.3	0.3	1.0	1.3	34.8	1.2
8	Outlook 6.0 *Fb Outlook 6.0*	0.60 *0.60*	0.80 pt *0.80 pt*	0.3	0.3	1.5	0.8	35.3	1.2
9	Outlook 6.0 *Fb Dacthal 75W*	0.60 *7.00*	0.80 pt *9.3 lbs*	0.5	0.5	1.3	0.8	36.5	1.1
10	Flumioxazin impregnated on fertilizer *Fb Dual Magnum 7.62*	0.094 *1.43*	188 lbs *1.50 pts*	1.0	1.3	1.3	1.0	35.0	2.2
11	Flumioxazin impregnated on fertilizer *Fb Outlook 6.0*	0.094 *0.60*	188 lbs *0.80 pt*	1.0	1.0	1.5	1.0	35.5	2.2
12	Flumioxazin impregnated on fertilizer *Fb Dacthal 75W*	0.094 *7.00*	188 lbs *9.3 lbs*	4.0	4.0	0.8	0.5	36.5	3.4
13	Devrinol *Fb Dacthal 75W*	1.50 *7.00*	3.0 lbs *9.3 lbs*	11.8	12.0	0.0	0.0	35.8	8.4
14	Untreated	---	---	11.8	13.3	0.0	0.0	36.3	7.7
	LSD (0.05)			3.8	3.7	1.4	1.0	NS	2.5

1 – applied 16 days prior to transplanting. * *Fb = Followed by*

Table 2. Fresno Trial. Weed control ratings and Weed counts.

TRT Code	Applications: Preemergence Herbicides	Lbs a.i. per Acre	Material per Acre	Weed CONTROL Ratings * (all broadleaf weeds): 24 DAT	45 DAT	67 DAT	Weed Counts per plot, August 12, 2005* (67 DAT): Pig	Night	Purs	Lamb	TOTAL Brdlvs
1	Dual Magnum 7.62 *Fb Dual Magnum*	1.43 *1.43*	1.5 pt *1.5 pt*	9.8 a	9.2 a	9.6 ab	10.7	0.0	6.7	2.0	19.3 ab
2	Dual Magnum *Fb Outlook*	1.43 *0.60*	1.5 pt *.75 pt*	10.0 a	9.5 a	8.5 bc	15.0	0.3	3.7	3.0	22.0 ab
3	Dual Magnum *Fb Dacthal*	1.43 *7.00*	1.5 pt *9.5 lb*	10.0 a	9.5 a	9.7 a	13.0	0.3	3.7	0.0	17.0 a
4	Goal Tender 4F[1] *Fb Dual Magnum*	0.50 *1.43*	1 pt *1.5 pt*	1.3 c	4.0 c	8.7 abc	13.7	7.0	2.3	0.7	23.7 ab
5	Goal Tender[1] *Fb Outlook*	0.50 *0.60*	1 pt *.75 pt*	1.5 c	6.2 b	9.3 abc	6.0	2.3	2.7	1.7	12.7 a
6	Goal Tender[1] *Fb Dacthal*	0.50 *7.00*	1 pt *9.5 lb*	1.0 c	4.0 c	8.8 abc	13.7	2.7	2.0	0.3	18.7 ab
7	Outlook 6.0 *Fb Dual Magnum*	0.60 *1.43*	.75 pt *1.5 pt*	10.0 a	9.0 a	8.3 c	32.3	0.0	5.3	4.0	41.7 bc
8	Outlook *Fb Outlook*	0.60 *0.60*	.75 pt *.75 pt*	10.0 a	9.6 a	8.5 bc	21.7	0.0	3.7	5.7	31.0 ab
9	Outlook *Fb Dacthal*	0.60 *7.00*	.75 pt *9.5 lb*	9.7 a	9.5 a	7.0 d	37.0	1.0	9.7	8.3	56.0 c
10	Flumioxazin impregnated on fertilizer *Fb Dual Magnum*	0.094 *1.43*	150 lbs *1.5 pt*	7.7 b	8.3 a	9.0 abc	15.0	0.0	3.0	4.7	22.7 ab
11	Flumioxazin *Fb Outlook*	0.094 *0.60*	150 lbs *.75 pt*	9.7 a	8.7 a	8.8 abc	20.7	0.0	3.3	5.0	29.0 ab
12	Flumioxazin *Fb Dacthal*	0.094 *7.00*	150 lbs *9.5 lb*	8.2 b	8.3 a	8.8 abc	18.3	1.3	4.7	2.0	26.3 ab
13	Untreated - *weeded*	--	--	0.7 c	8.3 a	6.7 d	32.3	19.7	3.3	1.7	57.0 c
14	Untreated - *weedy*	--	--	1.0 c	1.7 d	0.7 e	64.3	24.0	24.7	17.0	130.0 d
	LSD (0.05)			1.0	1.5	1.2	20.5	4.0	5.3	6.5	24.4

1- Applied 28 days prior to transplanting. * July 1=24 DAT; July 22=45 DAT; Aug 12=67 DAT. August 12 evaluations are 18 days post layby application.

Table 3. Fresno Trial. Pepper yield, Stand counts, and Phytotoxicity ratings (two dates)*.

TRT Code	Applications	Lbs a.i. per Acre	Material per Acre	Pepper Yield lbs/plot Good	Small	Sunburn	Total	Peppers/plot 36 DAT	Phytotoxicity 24 DAT	Phytotoxicity 67 DAT*
1	Dual Magnum 7.62 *Fb Dual Magnum*	1.43 *1.43*	1.5 pt *1.5 pt*	77.6 ab	18.7	15.9	112.2 ab	186.0 bcd	1.3 b	0.0 d
2	Dual Magnum *Fb Outlook*	1.43 *0.60*	1.5 pt *.75 pt*	71.3 ab	18.4	13.9	103.5 ab	184.5 cd	1.5 b	3.5 bcd
3	Dual Magnum *Fb Dacthal*	1.43 *7.00*	1.5 pt *9.5 lb*	61.0 ab	16.9	11.7	89.5 ab	194.5 abcd	1.0 b	0.0 cd
4	Goal Tender 4F[1] *Fb Dual Magnum*	0.50 *1.43*	1 pt *1.5 pt*	62.6 ab	20.7	14.3	97.6 ab	186.5 bcd	0.2 b	0.3 d
5	Goal Tender[1] *Fb Outlook*	0.50 *0.60*	1 pt *.75 pt*	91.6 a	12.6	11.8	116.0 a	196.5 abc	0.5 b	0.0 d
6	Goal Tender[1] *Fb Dacthal*	0.50 *7.00*	1 pt *9.5 lb*	66.0 ab	12.9	10.2	89.1 ab	200.0 ab	0.2 b	0.0 d
7	Outlook 6.0 *Fb Dual Magnum*	0.60 *1.43*	.75 pt *1.5 pt*	47.2 bc	8.9	9.5	65.5 bc	190.5 abcd	3.7 a	6.0 ab
8	Outlook *Fb Outlook*	0.60 *0.60*	.75 pt *.75 pt*	41.8 bc	10.7	13.7	66.2 bc	187.0 bcd	3.7 a	2.0 abc
9	Outlook *Fb Dacthal*	0.60 *7.00*	.75 pt *9.5 lb*	21.0 c	7.1	3.7	31.9 c	188.0 bcd	5.2 a	6.5 a
10	Flumioxazin impregnated on fertilizer *Fb Dual Magnum*	0.094 *1.43*	150 lbs *1.5 pt*	57.5 abc	15.5	11.3	84.4 ab	182.0 cd	1.0 b	1.0 cd
11	Flumioxazin *Fb Outlook*	0.094 *0.60*	150 lbs *.75 pt*	79.4 ab	15.4	17.6	112.3 ab	194.0 abcd	0.5 b	0.5 d
12	Flumioxazin *Fb Dacthal*	0.094 *7.00*	150 lbs *9.5 lb*	65.3 ab	16.3	7.3	89.0 ab	203.5 a	1.5 b	2.0 bcd
13	Untreated – *weeded*	--	--	78.4 ab	19.2	10.0	107.5 ab	181.5 d	0.3 b	0.3 d
14	Untreated – *weedy*	--	--	20.9 c	6.2	4.5	31.5 c	182.5 cd	0.0 b	0.0 d
	LSD (0.05)			39.8	8.8	9.1	47.4	14.6	1.9	2.8

1- Applied 28 days prior to transplanting. * July 1=24 DAT; July 13=36 DAT; Aug 12=67 DAT. August 12 evaluations are 18 days post layby application.

Intraspecific Variation of *Diorhaba elongata*: implications for classical biological control of invasive *Tamarix* spp. weeds. Hillary Thomas, University of California, Davis

The role of intraspecific variation for improving the success of classical biological control has incited increasing interest in recent years. The Asian leaf beetle, *Diorhaba elongata* (Coleoptera: Chrysomelidae) is a classical biological control agent that has been released against invasive *Tamarix* spp. (Caryophylalles: Tamaricaceae) weeds in the Western United States. *D. elongata* causes observable defoliation and damage to *Tamarix* spp. where it has established, but has failed to establish in California. Both host range testing and field collected data detected significant differences in *D. elongata* host preferences for invasive *Tamarix ramosissima* over *Tamarix parviflora*, while the latter dominates Northern California release sites. I sequenced a portion of the mitochondrial gene CO1 using the primers S1859 and A2590 for newly collected specimens in the beetle's native range to (1) Detect possible differences in allelic frequencies between populations found on *T. parviflora* and *T. smyrnensis*, a *Tamarix ramossisima* synonym, (2) Detect regional population structure that may reflect unexploited phenotypic variation for herbivory on *T. parviflora* present in the beetle's native range, and (3) Compare genetic variation between wild and laboratory populations.

Evaluation of Imazapyr and Aminopyralid for Invasive Plant Management

Joseph M. DiTomaso and Guy B. Kyser. University of California, Davis, California, 95616, jmditomaso@ucdavis.edu

Imazapyr

Imazapyr only recently (2004) received an aquatic registration in California under the trade name Habitat®. While it was previously registered for use in forestry (Arsenal AC®, Chopper®) and non-crop areas (Stalker®), these formulations are not allowed near water. Both Chopper® and Stalker® are emulsiable concentrates formulated at 2 lb ae/gal, whereas Arsensal AC® is a water soluble formulation at 4 lb ae/gal. Habitat® is also a water soluble formulation, but is produced at 2 lb ae/gal.

This new formulation of imazapyr provides an effective tool for the management of very invasive emerged aquatic species, such as the cordgrasses (*Spartina* spp.), or woody invasives along riparian corridors or wetland areas, including perennial pepperweed (*Lepidium latifolium*), saltcedar or tamarisk (*Tamarix* spp.), and tree-of-heaven (*Ailanthus altissima*). In terrestrial environments, imazapyr can be applied foliarly using several techniques, including broadcast applications, directed treatments, rope wick methods, or to woody stems by cut stump, basal bark, or hack-and-squirt (stem injection) techniques. These same applications techniques can also be employed with Habitat® in aquatic areas.

For example, broadcast foliar treatments have now been widely used to control *Spartina alterniflora* in Willapa Bay, Washington, and *Spartina alterniflora* x *S. foliosa* hybrids in the San Francisco Bay. Directed or broadcast foliar treatments of Habitat® are the most common chemical choice for control of *Tamarix* spp. in California and other western states (Brenton 2003). For *Tamarix* seedling control, rope wick applications of Habitat® can also be used with success (Duncan and McDaniel 1998). The aquatic formulation of imazapyr also provides a very valuable option for management of perennial pepperweed in aquatic and riparian areas where other options, such as chlorsulfuron, are not available.

In studies comparing triclopyr, glyphosate, and imazapyr for the management of tree-of-heaven, imazapyr provided the best control using cut stump and hack-and-squirt methods, and also gave control equal to triclopyr using basal bark application technology (DiTomaso and Kyser, unpublished results).

In summary, Habitat® has and will continue to provide a low toxicity and effective tool for difficult to control invasive herbaceous perennial and woody plants in riparian and aquatic (both freshwater and marine) sites.

Aminopyralid

Aminopyralid (Milestone™) is a new picolinic acid (pyridine) herbicide for control of invasive knapweeds and thistles and other species in the sunflower family, as well as legumes, solanaceous weeds (such as tropical soda apple [*Solanum viarum*]), fiddleneck (*Amsinckia* spp.), and a few other problem broadleaf species in wildlands, pastures and rangelands. Aminopyralid received a reduced risk designation by the United States EPA and was registered for use in 2005. It is expected to be registered in California by the end of 2006. The registered use rate of the product will range between 3 oz/A (0.75 oz ae/A) and 7 oz/A (1.75 oz ae/A). Results of studies on the control of several invasive thistles, fiddleneck, and Russian knapweed are presented.

*Yellow starthistle (*Centaurea solstitialis*)*

Results of studies conducted in Oregon, Washington, Idaho and California show that spring treatments of aminopyralid provided excellent control of yellow starthistle, even at rates as low as 2 oz product/A (0.5 oz ae/A) (unpublished results of several researchers). In subsequent studies in Siskiyou County, Steve Orloff (unpublished results) demonstrated complete control of yellow starthistle at 0.75 oz ae/A, and this rate gave comparable to clopyralid (Transline™) at its lowest registered rate of 1.5 oz ae/A.

In more detailed studies conducted at the University of California Davis, DiTomaso and Kyser (unpublished results) demonstrated that, at the rosette stage, aminopyralid was equally effective as clopyralid (1.5 and 3.0 oz ae/A) for control of yellow starthistle at all rates tested between 0.5 and 1.0 oz ae/A. However, aminopyralid was not as effective as clopyralid when plants were treated in the bolting stage. As an additional benefit to early season control, total grass forage in the year after application was nearly twice as great with rosette applications as compared to treatments made to bolting plants. In a subsequent timing study, they showed that the optimal timing for yellow starthistle control at the lowest registered rate of aminopyralid (0.75 oz ae/A [3 oz product/A]) was between December and February. Slightly higher rates were required to obtain complete control in later timings and November applications did not provide season long control. Previously published results by DiTomaso et al. (1999) showed that January to March was the optimal yellow starthistle treatment timing for clopyralid.

*Fiddleneck (*Amsinckia menziesii*)*

Clopyralid treatments for yellow starthistle control in rangelands and pastures can often release fiddleneck, which is unaffected by the herbicide even at high rates. This can create a problem for ranchers or ranchette owners because fiddleneck contains pyrrolizidine alkaloids that are very toxic to livestock. In contrast to clopyralid, aminopyralid provided better that 90% control with a December or January application at all rates, including the lowest registered rate.

*Artichoke thistle (*Cynara cardunculus*)*

Early spring aminopyralid treatments to artichoke thistle in the rosette stage gave excellent control at 1.2 and 1.75 oz ae/A, but only 80% control at 0.75 oz ae/A (DiTomaso and Kyser, unpublished results). Clopyralid also gave excellent control at 3.75 oz ae/A. However, it is important to recognize that injury to plants occurred slowly with both herbicides, generally requiring months to eventually kill the plants. By the end of the growing season, treated plants did not flower. Whether plants were completely killed or not is yet to be determined, as plots will require revisiting in 2006. In addition to flower suppression, aminopyralid and clopyralid also completely prevented the development of new seedlings. In contrast, glyphosate gave excellent control of mature plants and death occurred within two months of treatment. Because glyphosate is non-selective and has no soil activity, it did not control subsequent artichoke thistle germination and, as a result, many new seedlings were present by the end of the growing season.

*Russian knapweed (*Acroptilon repens*)*

Russian knapweed is a widespread invasive weed in the western United States. It is less common in California, but appears to be spreading rapidly. Russian knapweed is one of the more difficult knapweed species to control in California. While picloram is an effective tool in other western states, it is not registered for use in this state. Currently, clopyralid is the only feasible option, but even at the highest registered rate it only provides about 75% control (R. Wilson, pers. comm.). In studies conducted in Lassen and Shasta counties, DiTomaso, Kyser and Wilson (unpublished results) showed that fall applications of aminopyralid were more effective than spring applications at the lowest registered rate, although both gave good control. Thus, it will now be possible to achieve excellent and affordable management of this noxious perennial weed.

*Scotch thistle (*Onopordum acanthium*)*

Scotch thistle is a California Department of Food and Agriculture (CDFA) 'A' listed noxious weed. In 2005 studies conducted in Modoc County, DiTomaso and Kyser (unpublished results) showed that early summer aminopyralid applications to plants in the rosette stage caused significant injury to Scotch thistle and prevented flowering at all rates tested between 0.5 and 1.75 oz ae/A. Since this plant is a biennial, control would be considered complete in this growing season. However, the plots will require revisiting in 2006 to determine whether aminopyralid controlled plants only in their first year of growth, or also provided residual control of new germinants. In this study, clopyralid at 3 oz ae/A and dicamba at 8 oz ai/A also gave excellent control, but these rates were considerably higher than the effective rates of aminopyralid.

In conclusion, aminopyralid will play a key role in the management and eradication of important invasive species in California, particularly the noxious thistles and knapweeds. Its activity on yellow starthistle is about three times that of clopyralid and it also shows good activity at low rates on several other important noxious weeds. Furthermore, it promises to be a more affordable option in the control of some of the states most invasive species.

Literature Cited

Brenton, R.K. 2003. Imazapyr (Stalker or Chopper) herbicide: effective and responsible use of the control of invasive plants. Proc., California Invasive Plant Council Sym. 7:28.

DiTomaso, J. M., G. B. Kyser, S. B. Orloff, S. F. Enloe, and G. A. Nader. 1999b. New growth regulator herbicide provides excellent control of yellow starthistle. California Agriculture 53(2):12-16.

Duncan, K.W. and K.C. McDaniel. 1998. Saltcedar (*Tamarix* spp.) management with imazapyr. Weed Technol. 12:337-344.

Integrated Approach to Managing Herbicide Resistance

Donald A. Bartel – IPM Advisor
Sierra Consulting & IPM
P.O. Box 1971
Nevada City, CA
donald.bartel@sbcglobal.net

"Man's mind stretched by a new idea, never goes back to it's original dimensions." Oliver Wendell Holmes said it so well. Managing herbicide resistance requires not only an integrated approach, but also a whole new perspective on managing unwanted vegetation.

Integrated Vegetation Management (IVM) when properly followed, will in itself, manage herbicide resistance.

The State of California has adopted this definition of IVM:

"A strategic approach to preventing pests from reaching unacceptable levels by selecting and applying the most appropriate combination of available pest control methods (including biological, cultural, mechanical, and chemical) for a given site or pest situation in ways that minimize economic, health and environmental risks." In order to properly follow IVM practices, one must completely understand the above principles. All vegetation management programs must be based on 4 critical elements, the 4 "E's" of IVM. Environment, Effectiveness, Efficiency and Economics are considered equally in all IVM situations.

Biological control is far too basic in California. Australia has us beat down under when it comes to biological programs that are successful. Here in California it's embarrassing to see the insectaries cranking out insects that have not shown to provide economic results by themselves, yet they are selling these while customers are not seeing acceptable levels of control. It is paramount that more research efforts are directed at Biological vegetation management here in California.

Other technologies such as cultural and mechanical are used with increasing costs. Re-vegetation and Habitat Manipulation techniques are increasingly being found to be effective, especially in Invasive Weed Management programs.

IVM works but you must be Actively Involved. Nature is too smart to be ultimately manipulated by your once or twice a year visit. The site must be reviewed and follow-up is critical to the success of any IVM program. Arm Chair PCAs writing recommendations without proper site and environmental review is part of the problem.

Develop Best Management Practices (BMPs) that include elements such as early scouting and proper weed I.D. Water quality, proper calibration, and adequate coverage issues can all lead to failures in weed control programs and preclude resistance potentials.

Rotate your tools; all tools in IVM should be included when possible. Annual rotation of herbicides prevents establishment of resident species populations. Changing herbicides, both foliar and pre-emergent, provides opportunity for changing mode-of-action, another principle in reducing resistance.

Think outside the box...Are you on a treadmill? If you are doing the same thing year in and year out, you may be part of the problem. Look to new ideas, such as mulching, re-vegetation, habitat manipulation, free-space landscaping with selection of desired species, and many other new techniques being applied in IVM and you may be amazed at the increase in effectiveness and decrease in costs.

Effects of Vineyard Floor Management Practices on the Development of Distinct Weed Communities in a California Vineyard

Richard Smith, Tiffany Bensen, Larry Bettiga and Laura Tourte
University of California Cooperative Extension, Monterey County, 1432 Abbott Street, Salinas, CA 93901, rifsmith@ucdavis.edu]

INTRODUCTION

Runoff of pesticides from agricultural land is a key water quality concern on the Central Coast of California. Growers are under increasing pressure to reduce runoff and associated sediment and pesticide loads. 139,299 pounds of simazine were used on 23% of the grape acreage in 2000 (NAPIAP, 2000). This material has been the subject of concern regarding contamination of groundwater. However, it is an exceedingly useful material that provides long-term, economical control of a wide spectrum of weeds in vineyards. It is frequently tank mixed oxyfluorfen to extend the spectrum of weeds; this mixture is commonly used as a strip spray application in the winter in Monterey County. Due to concerns regarding water quality, this project was initiated to examine alternative weed control strategies and vineyard floor management techniques to reduce runoff in vineyards in Monterey County.

METHODS

The study was established in 2000 in a drip-irrigated vineyard in Greenfield. The annual rainfall in Greenfield typically varies from 4 to 8 inches per year. The vineyard was established in 1996 with *Vitis vinifera* L. cv. Chardonnay on Teleki 5C (*V. berlandieri* Planch. x *V. riparia* Michx.) rootstock. Vine spacing was 8 feet between rows and 6 feet within rows. The soil was Elder Loam with gravelly substratum.

Weed control treatments were applied to a 3 foot wide strip in the vine row and included the following treatments: 1) standard preemergence (simazine @ 1.8 lb a.i./A + oxyfluorfen @ 1.0 lbs a.i./A) applied in the winter followed by postemergence herbicides (glyphosate @ 2.0% + oxyfluorfen @ 1.0%) applied in the spring and summer as needed with a Patchen® light activated sprayer; 2) postemergence herbicide treatment (glyphosate @ 2.0% + oxyfluorfen @ 1.0%) and supplemented by applications of glufosinate @ 3%, applied in the spring and summer as needed with a Patchen® light activated sprayer; and 3) cultivation treatment with a Radius Weeder® (Clemens & Co., Wittlich, Germany) cultivator utilized in the spring and summer as needed. The cultivation treatment consisted of a metal bar held perpendicular to the direction of tractor movement. When inserted slightly below the soil surface, it severs weed shoots from their roots. The cultivation treatment was supplemented with had weeding around the base of the vines in the summer. Herbicide applications and cultivations were timed in accordance with grower practices.

Cover crops were planted in the row middles. The cover crop treatments included: 1) no cover crop (bare ground), 2) *Secale cereale* L. cv. Merced rye (rye), and 3) X *Triticosecale* Wittm. ex A. Camus cv.Trios 102 (triticale). Cover crops were planted with a vineyard seed drill in the center 32 inches of the row middles just before the start of the rainy season in the winters of 2000-01, 2001-02, 2002-03, 2003-04 and 2004-05. They were mowed in spring for frost protection and they senesced in summer. Before planting new cover crop seed each November, middles were disced to smooth out dried stubble remaining from the previous winter's cover crop and any weeds that became established during the growing season. Bare ground middles disced during the spring and summer as needed.

Weed control treatments (established in the vinerows) and cover crop treatments (established in the middles) were arranged in a 3 x 3 split-block design with three replicate blocks, covering a total of 23 vineyard rows (7.0 acres). Each block contained six vinerows and six adjacent middles. Weed control treatments, the mainplot treatments, were applied along the entire length of each vine row, which included approximately 300 grapevines. Cover crop treatments, the subplot treatments, were applied along one-third of each middle and were continuous across mainplot treatments in each block. Each replicate mainplot x subplot treatment combination included approximately 100 grapevines and covered an area of 0.11 acre. Data was collected from every other vine row and adjacent middle. Weed evaluations were conducted 4 to 5 times during the spring through fall. Percent vegetative cover and plant diversity were estimated using a line-intercept technique. Plant species intersecting points at 12 inch intervals along a 100 foot transect (18% of the plot) were recorded in each plot. Cash costs for weeding were calculated by collecting information on each weed control operation: quantities and types of materials used, dates and time to complete operations, type of equipment used and time to cultivate or hand weed. Soil compaction was measured in the vine row in the fall of 2003, 2004 and 2005 with a Field Scout Soil Compaction meter SC-900 (Spectrum Technologies, USA).

RESULTS AND DISCUSSION

Percent vegetative cover (weed frequency) over five years indicated that distinct weed communities developed in each weed control treatment. There were more weeds in the cultivation treatment than either the preemergence or post emergent weed control strategies (Figure 1). There were low levels of purslane (*Portulaca oleracea*) and shepherds purse (Capsella bursa-pastoris) at the onset of the trial, presumably due to good control of these two weed species with the combination of cultivation and post emergent weed control strategy that was used in the vineyard prior to the initiation of the trial. However over five years, shepherds purse and purslane have increased dramatically and are the dominant winter and summer weeds in the cultivation treatment (Figures 2 & 3). Shepherds purse and purslane were mostly are at low levels in the preemergence and post emergent treatments. In the postemergence treatment horseweed (*Conyza canadensis*) increased in frequency in 2003 (Figure 4). The increase in population of this weed was stable may be due to the use of glyphosate and oxyfluorfen in 2001 and 2002, both of which provide limited control of this weed. To bring this weed under adequate control it was necessary to apply glufosinate in the 2003, 2004 and 2005 seasons. In 2004 and 2005 the population of this weed was stabilized, but still persistent in the post emergent treatment. Nutsedge (*Cyperus esculentus*) was the dominant weed in the preemergence weed control treatment in all years except 2004 (Figure 5). It is not controlled by the preemergence herbicides, but was partially controlled with post emergent applications of glyphosate. The population was persistent, but evidently the weed control strategy that was employed in the trial significantly reduced the population of this weed in 2003, 2004 and 2005.

The weed populations affected weed control costs in the vineyard. The cultivation treatment evolved into the most expensive weed control treatment over time, principally due to the expense of hand removal of purslane that clumped around the trunk of the vines (Table 1). The post emergent treatment was the least expensive weed control treatment from 2001 to 2004, but in 2005 the preemergence treatment was least expesive. The cultivation treatment also had greater soil compaction than the herbicide treatments (Figure 6), but the compaction did not reduce the yields or quality of the grapes over the course of the trial (data not shown).

The three weed control strategies developed distinct weed control communities. The weeds present in these communities were species that took advantage of the weaknesses of each control strategy.

LITERATURE CITED

[NAPIAP] National Pesticide Impact Assessment Program. 2002. Crop profile for grapes (wine) in California. Available online:
http://www.ipmcenters.org/cropprofiles/docs/cagrapes-wine.html

ACKNOWLEDGEMENTS
Western Sustainable Research and Education Program
Viticulture Consortium Program
Valley Farm Management
Growers: Jason Smith and Darryl Salm

Table 1. Weed control cash costs from 2002 to 2005

Weed Control Strategy	2002	2003	2004	2005
Cultivation	102	137	274	381
Post emergence	94	131	85	196
Preemergence FB post emergence	138	138	115	172

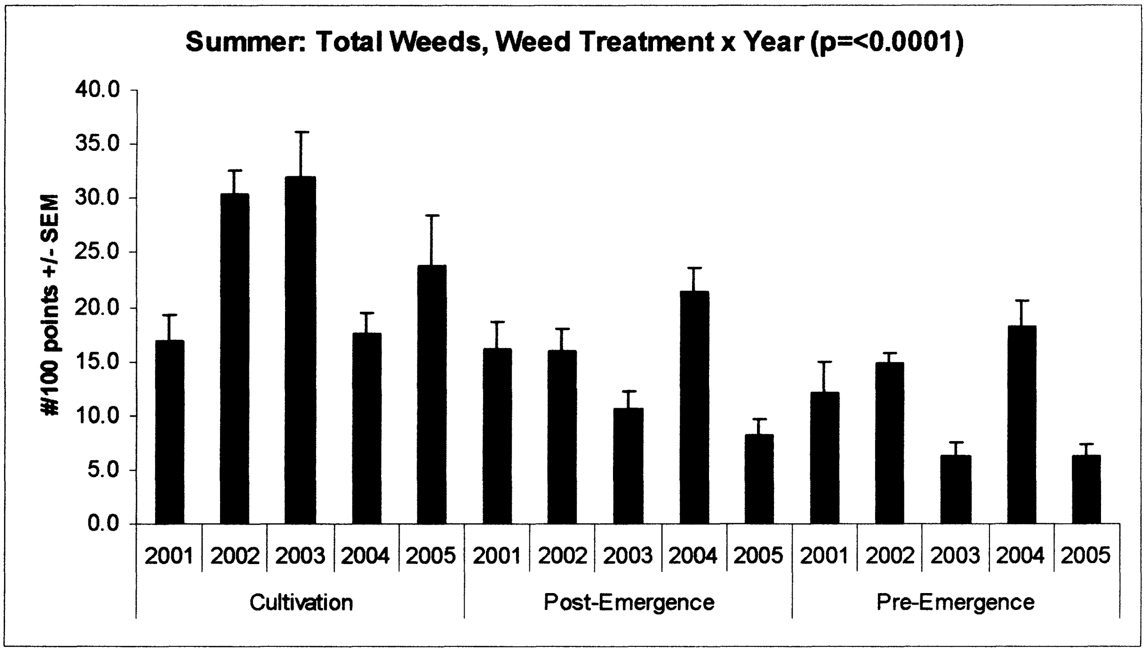


Figure 1. Total weed frequency in the summer in weed control treatment over five years.

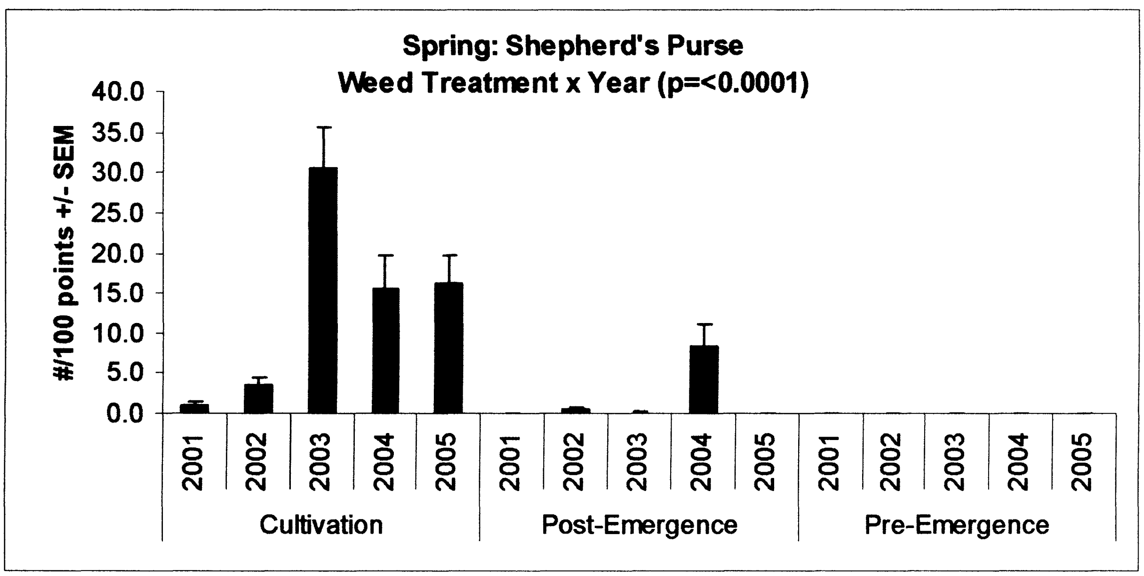


Figure 2. Shepherds purse frequency in all weed control treatments over five years

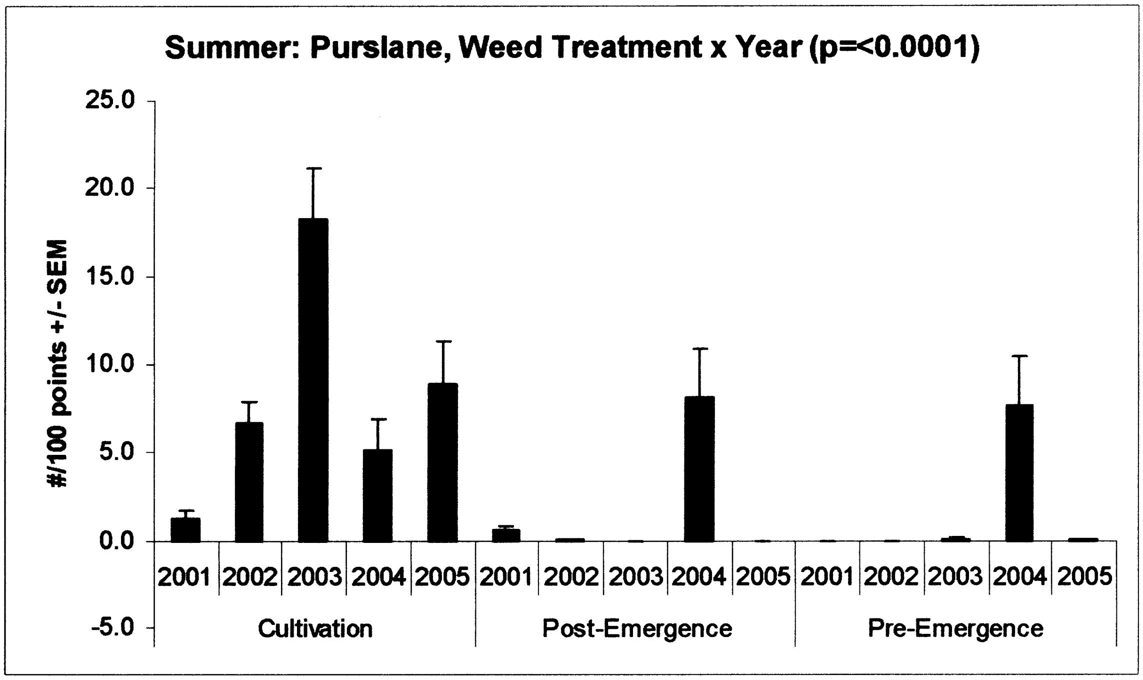


Figure 3. Purslane frequency in all weed control treatments over five years

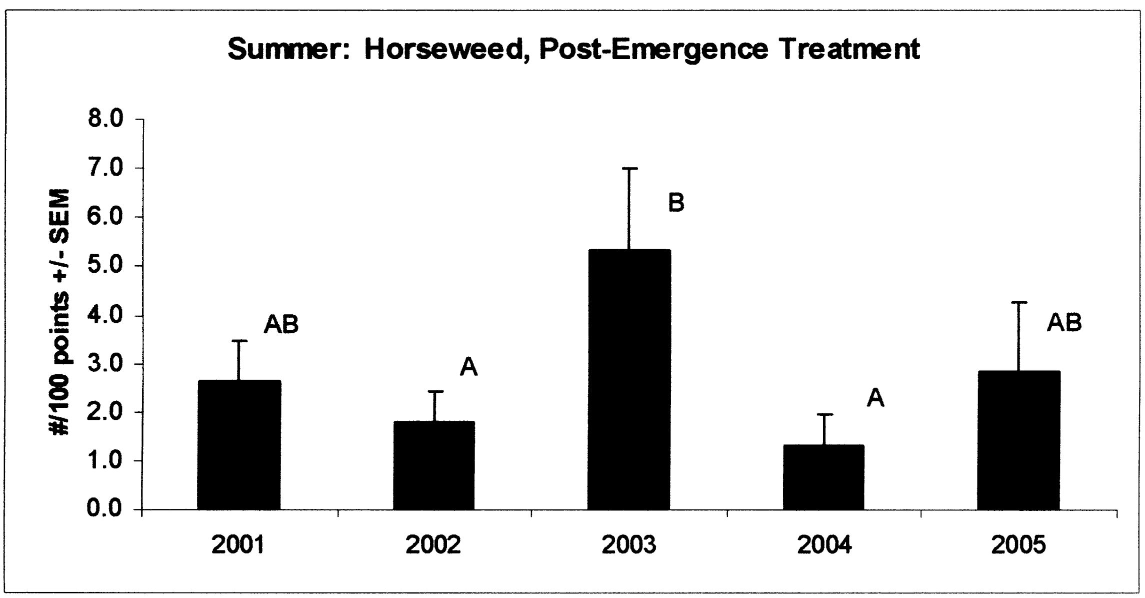


Figure 4. Horseweed frequency in post emergence treatment over five years

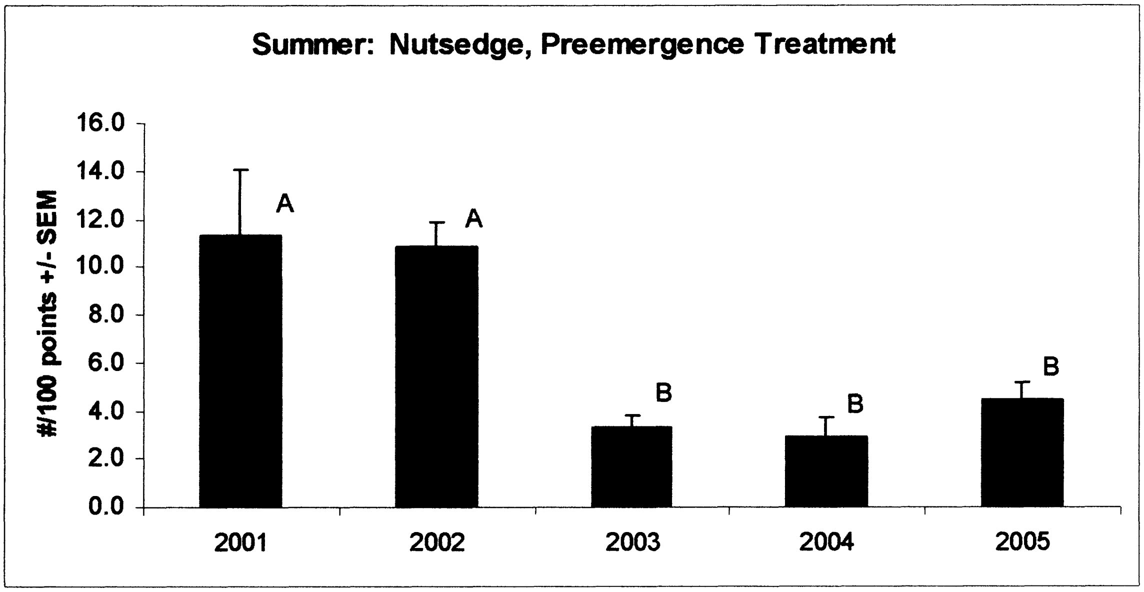


Figure 5. Nutsedge frequency in preemergence treatment over five years

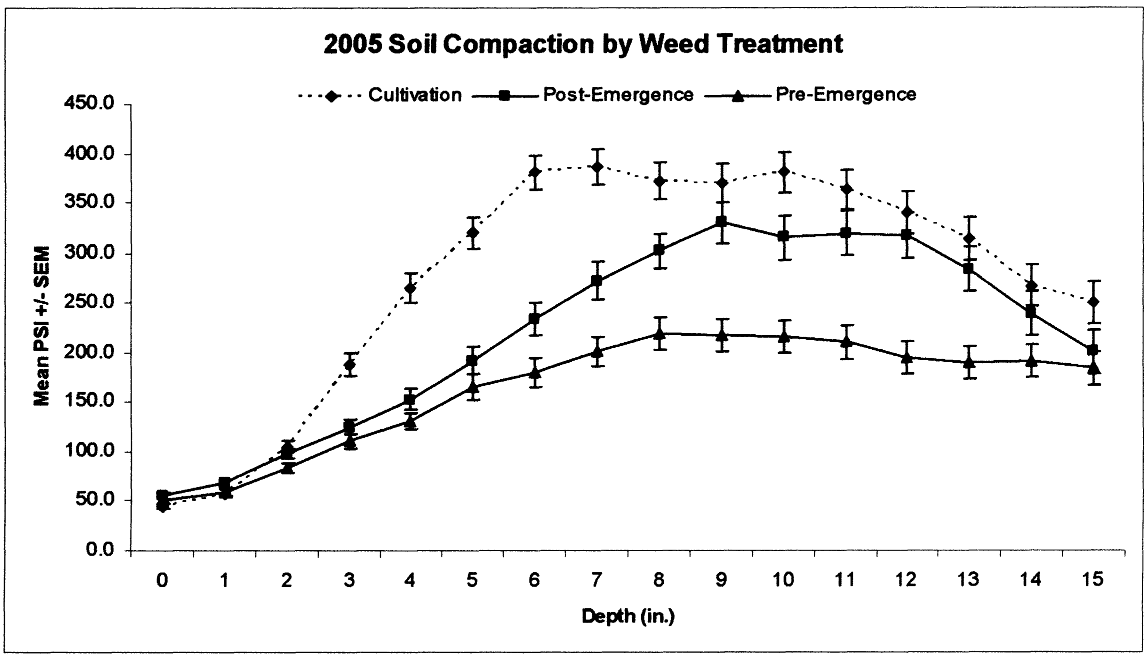


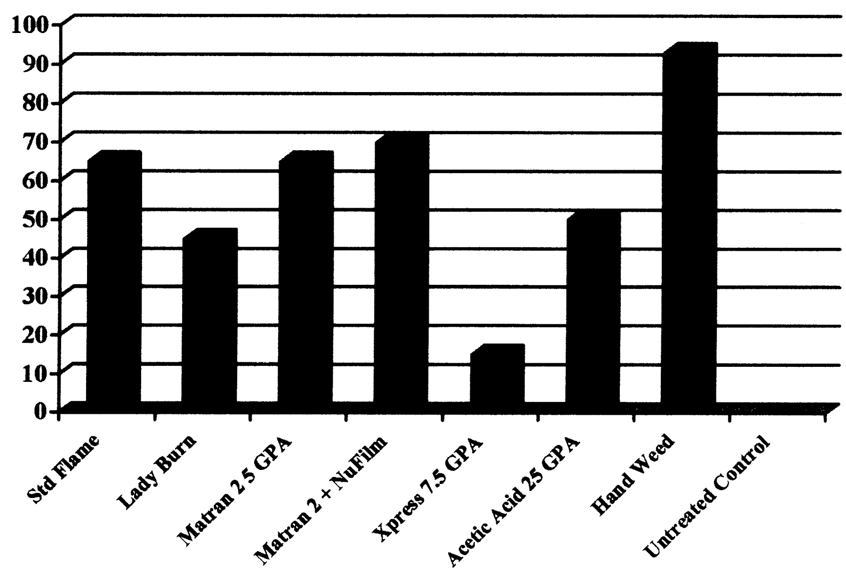
Figure 6. 2005 Soil compaction in weed control treatments

CONTROL OF WEEDS IN CERTIFIED ORGANIC FARMING SYSTEMS

Benny Fouche, University of California Cooperative Extension, Stockton, California.

Two applications of OMRI approved weed control materials and methods were made on certified fava beans, *Vicia faba L.* Vetch. *Luguminosae.* Two types of propane powered flamers, an Eco Weeder radiant burner and a conventional flame burner were compared against Matran-2, Xpress and horticultural vinegar liquid sprays. A hand weeded plot and an untreated control were also included. Weeds present during the trials were annual bluegrass, *Poa annua L. B*luegrass. *Gramineae* and burning nettle, *Urtica urens L.* Nettle. *Urticaeeae*. The first application was made on Nov 25th, 200, when the first true leaves were present on burning nettle, *Urtica urens.* Liquid sprays at 50 GPA volume were applied using an 8003VS Flat Fan Nozzle @ 25 PSI. Materials were as follows: Matran-2 - 45.6% Clove Oil @ 5 GPA Product (10% Product), Matran-2 - 45.6% @ 5 GPA (10% Product) + NuFilm 17@ 16oz/ac, Express - 20.5% Clove & Thyme Oils @7.5 GPA (15% Product), Bradford Horticultural Vinegar - 20% Acetic Acid @15 GPA 7% final concentration. Control of weeds following the first application was most effective using the standard flame burner, Matran-2, and hand weeding. Control of weeds following the second application indicated that the standard flame burner, Matran-2 and the higher rate of the vinegar were effective in controlling weeds.

Percent Control of Weeds Following Spring Applications of Contact Herbicides



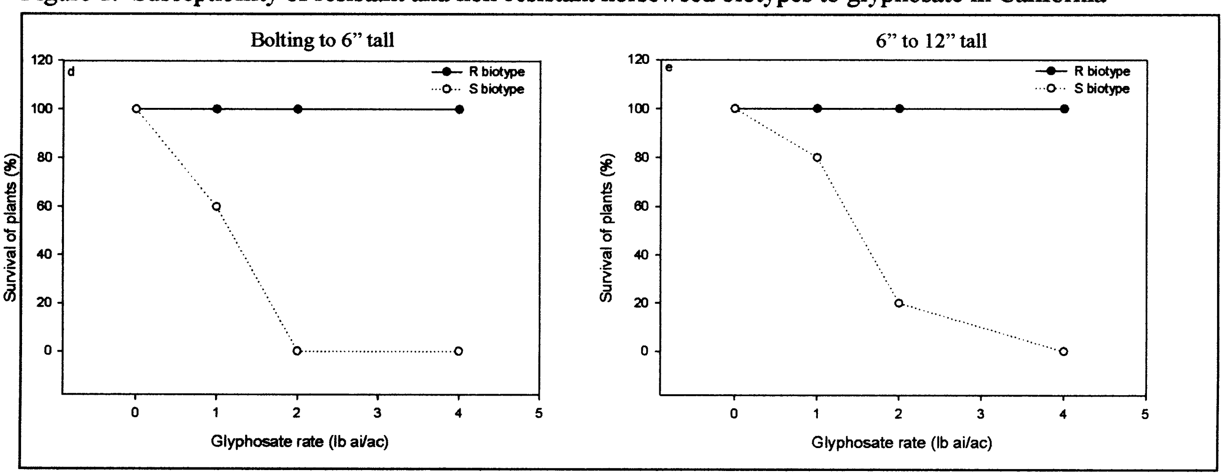
Winning the Battle Against Horseweed and Hairy Fleabane in California

Kurt Hembree and Anil Shrestha
Farm Advisor, UCCE, Fresno County and IPM Weed Ecologist, UC Kearney Ag. Center, Parlier

Horseweed or mare's tail (*Conyza canadensis*) and hairy fleabane (*C. bonariensis*) have become major, wide-spread weed pests for tree and vine growers throughout California. They favor warm, irrigated conditions, but are also common along road sides, irrigation ditches, railroad tracks, and other rights-of-ways where moisture and soil disturbance is limited. Some reasons for their increase in numbers in orchard and vineyard settings include: 1) reduced weed control inputs, especially when crop prices have been depressed, 2) reduced use of effective soil-residual herbicides, particularly in newer regulated ground water protection areas (GWPA), 3) increased degradation of soil-residual herbicides under low-volume irrigation, and 4) poor timing of postemergence sprays.

In 2005, glyphosate-resistant horseweed was found in California along an irrigation canal system in northern Tulare County, which might account for these weeds escaping control in some locations. In our findings, the horseweed biotype was resistant to glyphosate when treated at more than 4X the recommended label rate (Figure 1). Including California, there are now 11 states that have horseweed populations resistant to glyphosate in the USA. Hairy fleabane resistance to glyphosate has only been documented in South Africa and Spain. Studies are currently underway in California to determine if glyphosate-resistant hairy fleabane also exists.

Figure 1. Susceptibility of resistant and non-resistant horseweed biotypes to glyphosate in California

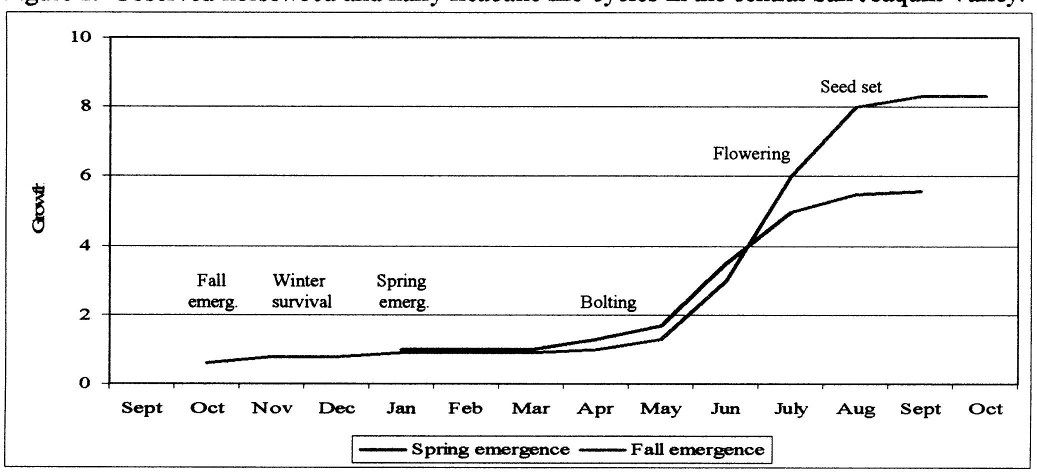


Horseweed and hairy fleabane are summer annual weeds belonging to the Asteraceae (sunflower) family. Unlike most summer annuals, which typically begin germinating in late-winter, these weeds have also been observed emerging in fall (October/November) (Figure 2). Fall-emerging plants appear to go through a vegetative or winter survival stage, similar to biennials. Bolting for spring and fall-emerging plants appears similar, in about April/May. Although these biotypes may look similar in size in the spring, fall-emerging plants may have larger root systems, possibly explaining the poor control with certain postemergent herbicides, like glyphosate. Flowering and seed production seem to vary slightly, with hairy fleabane beginning in June/July and horseweed delayed 30-60 days or more after that.

Both species produce large amounts of seed (horseweed >200,000 and hairy fleabane >10,000) that is dispersed in wind currents. The hairy pappus on the seed, allow the seed to travel distances of ¼ mile or more, much like that of dandelion. Well traveled roadways throughout the state facilitate their spread. Unlike most other weeds, these do not require a period of dormancy to germinate, making it difficult to predict emergence. Mature seed falling to the soil in late-summer can sprout as soon as moisture becomes available. They prefer undisturbed soils, such as tree and vine rows, which are easily warmed during the day. Seed burial and debris on the soil surface seem to discourage germination. Seed survival is about 3 years or less under most conditions.

The physical structure of the two species contributes to their ability to survive postemergence sprays. Horseweed grows upright, 7' tall or more as a single stem, while hairy fleabane grows to about 2-3' tall and has no central stem. Their stems are somewhat woody. Both species have leaves that are fairly narrow, covered with fine hairs. In hairy fleabane, leaves are often <1 cm wide and somewhat crinkled, making spray coverage difficult. Where populations of these weeds are dense, thorough spray coverage of the entire plant is difficult to achieve. Therefore, it is not recommended to wait to treat these plants when they become large.

Figure 2. Observed horseweed and hairy fleabane life-cycles in the central San Joaquin Valley.



In order to control these weeds, it is important to have a good understanding of some of these important growth and development characteristics. Some practices that will aid in their eradication include:

- Do not let these plant produce seed.

- Apply preemergence herbicides emergence in the fall and/or winter. If applying simazine, diuron, bromacil, or norflurazon in a GWPA, obtain a permit from the county agricultural commissioner.
- Apply postemergent herbicides when these weeds have <18-21 leaves (see table). If using glyphosate (Roundup, etc.) it to control these weeds, use at least 2 lb ai/acre for maximum control. Proper surfactants and additives should be used where appropriate according to the label. Tank-mixing certain postemergent herbicide products can also improve control.
- Use appropriate spray nozzles and spray volume to give proper coverage of the target weeds. When weed canopy is dense, consider TwinJet or similar nozzles that will provide wetting of the entire plant, including any stems.
- Never rely on a single herbicide program year-after-year, as this often leads to a shift to troublesome weeds, like horseweed and hairy fleabane; consider herbicide rotation.
- Closely monitor weed escapes and control those missing treatment.
- Repeated mechanical disturbance of the soil discourage these weeds. In-row cultivators are effective on these weeds if treated while they are in the seedling stage. Mowing and flaming do not appear to be effective methods of control and may acerbate the problem.
- Where the population is sparse, use a shovel or other hand equipment for removal, being sure to cut below the soil surface to cut the roots.
- If you suspect herbicide-resistant horseweed or hairy fleabane, contact your local extension agent to help alleviate the problem.

Table. Some herbicides registered in California in orchards and vineyards for horseweed and hair fleabane control.

Preemergence herbicides	Lb ai/A	Horseweed control	Hairy fleabane control
bromacil (Hyvar X®)	3.2	Excellent	Good
bromacil + diuron (Krovar®)	3.2	Excellent	Excellent
diuron (Karmex®, Direx®)	2.5	Good	Good
eptc (Eptam®)	3.0	Excellent	Good
flumioxazin (Chateau®)	0.375	Good	Fair
isoxaben (Gallery T&V®)	1.0	Excellent	Excellent
norflurazon (Solicam®)	2.0	Fair	Fair
oxyfluorfen (Goal 2XL®, Galigan®, etc.)	2.0	Fair	Poor
simazine (Princep®, Caliber 90®, etc.)	2.5	Excellent	Good
simazine + diuron	1.5 + 1.5	Excellent	Excellent
thiazopyr (Visor®)	1.0	Fair	Fair
Postemergence herbicides	Lb ai/A	Horseweed	Hairy fleabane
glufosinate (Rely®) + AMS	1.0 + 10 lb/100 gal	Excellent*	Excellent*
glyphosate (Roundup Weathermax®, Touchdown®, etc.)	2.0	Excellent*	Good to Excellent*
paraquat (Gramoxone Max®, etc.)	2.0	Excellent*	Good to Excellent*
2,4-D (Orchard Master®, Dri Clean®, etc.)	1.4	Excellent*	Excellent*
*Assumes treatment when weeds are small (<21 leaves) with thorough coverage Always read and follow all label recommendations. Other effective products may be available, but not listed in this table.			

There is little doubt that horseweed and hairy fleabane populations are on the increase in California. To help resolve this problem, one needs to become familiar with some of the important characteristics of these weeds and implement an appropriate strategy. To be successful, identify these weeds early and apply appropriate treatments when they are must vulnerable to control and do not let them go to seed. Since these weeds can emerge in the fall and in the spring, it may be necessary to split preemergence treatments to catch the different emergence periods. When using postemergence herbicides, treat when they have fewer than 21 leaves or control will be greatly reduced. Thorough wetting of the weed foliage is necessary for effective control of larger weeds. Disturbing the soil mechanically can impede seed germination and cultivating when weeds are small can give effective control. Additionally, implementing control practices along field margins, fence lines, road sides, and canal banks are essential components for eradication.

Suggested readings

Grower's weed identification handbook. DANR Pub. 4030. Coop. Ext., Univ. of Calif.

Principles of weed control in California. 3rd ed.. CWSS. Thompson Publications.

VanGessel, M.J. 2001. Glyphosate-resistant horseweed from Delaware. Weed Sci. 49:703-705.

Weaver, S. E. 2001. The biology of Canadian weeds. 115. *Conyza canadensis*. Can. J. Plant Sci. 81:867-875.

How the New Ag Waiver Regulations Affect the Cultural Practices of Perennial Crops

Kay L. Mercer, Southern San Luis Obispo and Santa Barbara Counties Agricultural Watershed Coalition, P.O. Box 1440, Santa Maria CA 93456, sbagcoalition@verizon.net

The Southern San Luis Obispo and Santa Barbara County Agricultural Watershed Coalition was formed in 2003 in response to an increasing emphasis on agricultural improvements to water quality. The Coalition is formed by a Memorandum of Understanding between five grower associations: The Central Coast Wine Growers Association, Santa Barbara County Farm Bureau, Santa Barbara County Cattlemen's Association, Flower and Nursery Growers Association of Santa Barbara County and the Grower-Shipper Vegetable Association of San Luis Obispo and Santa Barbara Counties. It is partially funded through an environmental settlement fund that was paid to the Region 3 Regional Water Quality Control Board and administered by the National Fish and Wildlife Association.

The Coalition's purpose is to assist landowners in Southern San Luis Obispo County and Santa Barbara County to: comply with the Conditional Ag Waiver for irrigated agriculture, attend water quality short courses, develop individual management plans, and implement and monitor progress of the plans.

Conditional Ag Waivers for Irrigated Lands are a relatively novel regulatory approach adopted by the California State Water Resource Control Board. The Conditional Waivers waive the requirement that growers obtain a Waste Discharge Requirement which is, in essence, a permit to discharge wastewater. The Intent of the Waivers is to ensure that discharges do not cause or contribute to water quality impairment.

The State Water Resource Control Board has nine Regional Water Quality Control Boards. Each of these has been authorized to implement the Conditional Ag Waivers for Irrigated Lands as best fits their unique region as long as certain conditions are met. Regions 3, 4, and 5 have adopted Conditional Ag Waivers. Other Regions have substituted other programs for the Conditonal Waiver.

Region 5, the Central Valley Region, includes the Sacramento and San Joaquin Valleys. It is composed of more than seven million acres of irrigated cropland and an estimated 25,000+ individual growers and operations. Region 5 was the first RWQCB region to adopt a three –year Conditional Ag Waiver that is currently being renegotiated. Growers may participate as individuals or join various watershed-based Coalitions to address the discharges of wastewater and stormwater from irrigated lands. These Coalitions conduct ambient monitoring as per RWQCB approved phased Monitoring and Reporting Programs. Furthermore, these Coalitions have the potential for identifying and correcting water quality impairments by working with their members to implement relevant Management Practices.

Region 3 adopted the Conditional Ag Waiver in July 2004 for eight counties on the Central Coast. There are about 450,000 irrigated cropland acres and 2500 growers in the Region. The hydrogeology of the Central Coast is very different from the Central Valley and this difference is reflected in the Waiver. Landowners and growers must enroll with the RWQCB, take

Continuing Education water quality classes, write a Farm Water Quality Plan, implement Management Practices and participate in either an eight-county Cooperative Monitoring Program or individually monitoring their discharges. Watershed based Coalitions serve an education and outreach function, but not monitoring function under this Waiver. Very few growers have elected to monitor as individuals: most have selected the Cooperative Monitoring Program.

Region 4, the Ventura/LA County Region, very recently adopted a Waiver in November, 2005. It is a hybrid of the two previously adopted Waivers. Again, growers may participate as individuals or join a Discharger Group.

When one compares the Conditional Waivers one sees many similarities and many differences. For example, Reporting, Planning, Enrollment, Continuing Education, and Monitoring Programs vary dramatically. For example, the Region 3 Waiver addresses groundwater while the other Waivers do not. Region 4 has provided an incentive for proactive growers by reducing monitoring frequency in watersheds that have no detections.

All three Regions require toxicity testing using three aquatic species. The Toxicity Tests are bioassays that provide a more holistic view of water quality when considered together. The species are: *Ceriodaphnia dubia, Pimephales promelas, and Selenastrum capricornutm.* Percent survival (or conversely, percent mortality), growth and reproductive inhibition indicate potential water quality impairments. Significant mortality of *C. dubia*, a water flea, may possibly indicate the potential for the presence of organophosphates and *P. Promelas*, a fat-hear minnow, may indicate the presence of pyrethroids, respectively. Statistically significant, dose-dependent inhibition in the growth of *S. capricornutum* indicates the possibility of the presence of herbicides.

It is important to note that data can be misleading and results should be questioned. Data can be influenced by sampling errors, episodic situations such as an herbicide application errors, Acts of Nature such as 200 year floods, and laboratory errors such as false positives. Other constituents may cloud results. Finally, other sources may be contributing to constituent load.

This information about the Waivers is pertinent because Regional interpretation and reaction to data dictate how quickly growers must respond to data, what types of responses will be required and whether those responses will be mandatory or voluntary. For example, both Region 4 and 5 utilize a trigger approach to additional monitoring and implementation of management practices whereas Region 3 has a weight of evidence approach that prioritizes the watersheds where follow-up monitoring will occur.

Region 5 has been collecting monitoring data over the past three years. There are situations in which various pesticides have been isolated. Typically, herbicide detection are not as frequent as other pesiticide detections. In Stanislaus County, for example, there is one incidence of Trifluralin and Simazine detections. Where analyses indicate pesticide presence, growers must adjust existing or implement new Management Practices to mitigate impacts to water quality impacts . Management Practices enfold a wide variety of practices from highly sophisticated engineered water conveyance and storage projects to very simple and subtle adjustments to fertility, pesticide, irrigation or sediment management practices. Nevertheless, where mitigation efforts fail, regulators will step in.

For example, in Stanislaus County, where herbicides have been detected, the Ag Commissioner is examining the DPR database for crop use and herbicide use patterns in impacted watersheds. Next, he is working with the Watershed Coalitions to determine the best mitigation measures. If implementation of Management Practices does not mitigate the problem, then, the Ag Commissioner may be required to further restrict the use of the herbicides. Non-restricted herbicides may become restricted use materials which will require a Notice of Intent and County approval for use. Restricted Use Materials may be restricted completely from use in the County or in a watershed or localized basis.

Region 4 has initiated its Conditional Waiver Monitoring Program; therefore, data have not been collected to date. Impacts are conjecture at this time.

During the Region 3, 2005 Phase I Cooperative Monitoring Program, no *S. capricornutum* Toxicity Testing "hits" occurred. This could be a result of the crop mix of cool-season vegetables, strawberries, avocados and grapes that are found along the coast and/or the herbicides selected for those particular crops.

For perennial crops, herbicide use in Avocados was significantly lower in Region 3 than in Ventura County in Region 4. In both Regions, applications peaked during the late spring and summer months indicating the use of post-emergent herbicides. This is confirmed by the herbicide mix. Glyphosphate and its generics, Simazine and its generics, and Oxyflurfen comprised 91%, 8% and 1% all herbicides used, respectively.

More than 250,000 acres of grapes were treated in Region 3. Applications occurred during dormancy in the winter to prevent the potential for herbicide drift onto succulent new growth. There is a second application peak in May. Sixty-six percent of all herbicides used in grapes are used by the largest 25 growers in the Region. It could be interpreted that larger growers use more herbicides; or it could be that smaller growers do not accurately report herbicide usage. The composition of herbicides used were Glyphosate and its generics, Oxyflurfen, Paraquat, Simazine and its generics, Surflan and its generics and Diuron at 43%, 25%, 13%, 8%,8% and 1% respectively. This information does not reflect the introduction of new herbicides that have proven to be effective on some resistant weeds.

In reality, to make sense of the Conditional Waivers, landowners and growers must put aside concerns about escalating regulation, disgust with increased paperwork, and arguments about the data. Growers and the resource agencies that support the growers must concentrate on what they can control! *The real goal of the Conditional Waivers is for growers to improve water quality through the Management Practice implementation.*

At present, growers have choices about what management practices they may employ. The regulators are not prescribing Management Practices. Instead, growers must be aware of the impacts of their cultural practices and make decisions about how they use management practices.

Examples of the impacts to herbicide use are:

- To avoid the use of herbicides known to cause water quality issues when alternative products are available

- To avoid the use of herbicides that bind to soil in areas where sediment movement may occur
- To eliminate the use of a herbicide if monitoring data indicates it is causing water toxicity
- To avoid the use of a formulation such as granules or crystals in areas where there is the potential for off-site movement in to waterways
- To plant crops that are appropriate for the growing conditions
- To rotate crops and herbicides to avoid the development of resistant weeds
- To avoid spraying during high winds to prevent herbicide drift into adjacent waterways
- To use drift control agents; and
- To avoid high-risk herbicide applications techniques such as aerial spraying near waterways

Most of these choices are not novel! Nevertheless, they will receive increasing emphasis as data are collected and herbicide impacts are better characterized. These will direct what and how herbicides are used in the future! Failure to improve water quality will only lead to greater regulation, greater restrictions on available herbicides and prescriptive management practices.

A Pattern of Root Distribution by Yellow Starthistle

Steve Young
University of California, Davis

Abstract. Yellow starthistle is a late season non-native annual forb that is common throughout much of California. The roots of yellow starthistle begin growth in late fall and continue until late spring or early summer. The soil moisture use pattern of yellow starthistle may inhibit native perennial bunchgrasses and other deep-rooted native perennial species from establishing in mesic regions of California. Field studies were conducted near Davis, California to determine the annual rooting and soil moisture use pattern of yellow starthistle. Roots of yellow starthistle were monitored in the field using a rhizotron chamber with a viewing window covering about a two-meter square area below the soil surface. Root numbers were counted bi-weekly beginning in spring following the installation of the root chamber and the appearance of roots on the glass window and ending in mid-summer with senescence of yellow starthistle. Soil moisture was monitored with a neutron probe at 30, 60, 90, 120, 150 and 180 cm depths. The total number of roots (new and old) continued to increase from late April to early May, which coincided with rosette and bolting stages for yellow starthistle. As yellow starthistle plants went from bolting to flowering in late May to mid July, total number of roots declined from 827 roots/cm^2 to 636 roots/cm^2. Total root numbers in the 0 to 60 cm and greater than 60 cm depth declined after April and peaked in May, respectively. Soil moisture content declined at all depths from April to July. From April to May, the greatest decline in soil moisture content occurred between 60 to 150 cm, at the same time that a spike in root growth occurred. Soil moisture decline continued less dramatically at depths greater than 150 cm and after June. In this study, yellow starthistle is using a greater amount of water from deep in the soil profile during the short period between late spring and early summer when plants are bolting. The short period of high soil moisture use by yellow starthistle maybe a mechanism for quick re-generation when cut or grazed and faster use of available soil moisture compared to a slower absorbing native perennial bunchgrass.

Effective Fennel Control with Herbicides

Carl E. Bell
Regional Advisor – Invasive Plants
University of California Cooperative Extension
5555 Overland Ave., suite 4101
San Diego, CA 92123
cebell@ucdavis.edu

Fennel (*Foeniculum vulgare* Miller) is a perennial plant that is grown commercially and in home gardens for the edible young stems, the enlarged base of the stem, and the seed that are used in cooking. It is a member of the Apiaceae, a large family with 43 native and non-native genera listed as occurring in natural habitats throughout California. There are 24 genera in this family cultivated for food, herbs, and medicinal purposes in the US. Fennel was likely introduced into California for food uses over 150 years ago, and now has become a common invasive plant of roadsides and disturbed sites in lower elevation areas of the state.

Fennel is a tall herbaceous plant, typically about 2-2.5 m tall in southern California. The plant has finely dissected leaves with long clasping petioles and upright solid stems. Stems and leaves have a strong anise (licorice) odor when crushed. Flowers are yellow in compound umbels typically 5-8 cm across. Seed are small, compressed, and ribbed. Disturbance is regarded as an important factor favoring the establishment and spread of fennel. Once introduced, it spreads by seed and persists throughout the winter as a root crown. In many locations, it has developed a nearly monotypic stand.

Three field experiments were conducted in southern California over a three year period (2004 to 2006).Two experiments were conducted at Marine Base Camp Pendleton in San Diego County, CA. The third experiment was at Sepulveda Basin Park in Los Angeles CA. Each experiment consisted of the same ten treatments, shown in the Table. Herbicide rates were based upon manufacturer's printed label information and from available literature. All three experiments utilized a completely randomized design with four replications. All locations had high populations of perennial fennel plants. The MBCP 04 experiment used an area that had been burnt in a wildfire in the fall of 2003. The fennel was re-growing from root crowns following winter rains. Neither experiment in 2005 was on a site that had burned prior to treatment.

Treatments 1 –7 were applied in a broadcast spray which delivered the desired amount of herbicide spray solution evenly over each experimental plot. Treatments 8 and 9 were applied as a spot spray targeted to all fennel plants within a plot using a hand-pump pressured backpack sprayer with a single cone pattern nozzle. These two treatments used percent solutions of herbicide in water based upon herbicide label recommendations. Data collected included cover estimates, biomass estimates, and visual evaluations.

Visual evaluations of fennel control taken approximately six weeks after treatment were similar in all three experiments (Table 5). Control was good to excellent (> 85%) for all treatments except treatment 1 (Glyphosate at 1 lbai/A) at one of the Marine Base Camp Pendleton sites and the Los Angeles site. All sites were evaluated again approximately 12 to 14 months after treatment. Fennel control remained high for all broadcast treatments including triclopyr. In all three experiments, fennel biomass was statistically lower in all herbicide treatments compared to the untreated control. Fennel cover at the two MBCP sites was not different between treatment plots prior to herbicide treatment. Similar to the biomass data, fennel cover was significantly reduced by all herbicide treatments compared to the untreated control.

Effective herbicide treatments for fennel were verified in these experiments. Results are similar and confirm experiments at other locations in southern California. Overall, treatments including triclopyr worked very well, even when evaluated 14 months after treatment (MAT). The higher rate of glyphosate worked well, but not when evaluated 14 MAT. The lower rate of glyphosate is not sufficient for consistent control of fennel. Purple needlegrass (*Nasella pulchra)*, a native perennial bunchgrass, was present in both the Marine Base Camp Pendleton sites. It survived most of these herbicide treatments well, even glyphosate. This was likely because herbicide treatments were made in early spring while the grass was emerging from winter dormancy and the plants translocation stream was upward, not down to the root system.

Table. Herbicide treatments for fennel control experiments.

Herbicide	Rate (kg active ingredient per ha)	Surfactant
1. Glyphosate	1 - broadcast	none
2. Glyphosate	2- broadcast	none
3. Triclopyr	1- broadcast	Non-ionic 1% by volume
4. Triclopyr	2- broadcast	Non-ionic 1% by volume
5. Glyphosate plus triclopyr	1 + 1- broadcast	None
6. Glyphosate plus triclopyr	1 + 2- broadcast	None
7. Glyphosate plus triclopyr	2 + 1- broadcast	None
8. Glyphosate	2% by volume, spot spray	
9. Triclopyr	1% by volume, spot spray	Non-ionic 1% by volume
10. Untreated control		

Literature:

Klinger, R. 2000. *Foeniculum vulgare* Miller, pp 198-202, *in* Bossard, C.C., J. M. Randall, and M.C. Hoshovsky. 2000. Invasive Plants of California's Wildlands. University of California Press, Berkeley.

GLYPHOSATE-RESISTANT HORSEWEED: AN EMERGING PROBLEM IN THE SOUTH CENTRAL VALLEY

Anil Shrestha, Univ. of California, Statewide IPM Program Kearney Ag. Center, Parlier
Kurt J. Hembree, Univ. of California Cooperative Extension, Fresno County, Fresno

Glyphosate-resistant horseweed biotypes have been reported in 10 states in the U.S., mainly in annual row-crop systems. However, we found that glyphosate-resistant (R biotype) horseweed also exists on canal banks in the southern San Joaquin Valley (SJV) and California is now the 11th state to report glyphosate-resistant horseweed. Our study showed that horseweed plants were resistant to at least four times the labeled rate of glyphosate. The level of resistance to glyphosate, however, was influenced by the stage of growth of horseweed at the time of glyphosate application. There was a probability of controlling some of the 'R' biotype horseweeds at the 5-8 leaf stage with a 2 or 4 lb ai/ac rate of glyphosate. After the 18-21 leaf stage, the horseweed plants were able to survive glyphosate application rates up to 4 lb ai/ac. At later stages, even some plants of the susceptible (S) biotype escaped the lower rates of glyphosate. Therefore, it is important to control horseweed at an early stage of growth. This is the first case of a glyphosate-resistant horseweed population in a non-crop situation. The irrigation canal borders numerous orchards and vineyards and growers have reported difficulties in controlling horseweed with recommended rates of glyphosate in these perennial cropping systems. Although, existence of glyphosate-resistant horseweed has not been tested in these orchards and vineyards, glyphosate escapes of horseweed have shown similar injury symptoms as the resistant populations along the canal banks. Therefore, it is suspected that these orchards and vineyards may contain glyphosate-resistant populations of horseweed. Growers who solely rely on postemergence products, such as glyphosate, for weed control in environmentally-sensitive areas may have to modify their weed control strategy to prevent the spread of these resistant horseweed populations. Close monitoring and an integrated weed management program will have to be implemented to manage glyphosate-resistant horseweed biotypes in the SJV.

Distribution and Relative Glyphosate Resistance of Ryegrass in California

W. Thomas Lanini, University of California, Davis
One Shields Ave, Department of Plant Sciences, Davis, CA 95616, wtlanini@ucdavis.edu

Ryegrass (*Lolium* spp.) is a winter annual, common throughout California. In 1998, two orchard sites were identified as possibly having glyphosate resistant ryegrass populations. These populations were confirmed as being resistant to glyphosate (Simarmata et al. 2003). At least one orchard in the San Joaquin Valley has also been reported to contain glyphosate resistant ryegrass (R. Vargas, personal communication). The species of ryegrass, although reported to be rigid ryegrass (*Lolium rigidum*) (http://www.weedscience.org/in.asp), appears to be *L. multiflorum* or possibly a hybrid of *L. rigidum* and L. multiflorum.

Although it has only been confirmed in two or three orchards, many other non-confirmed reports have indicated that glyphosate resistant ryegrass may be more common in California than originally reported. If resistance to glyphosate is confirmed, alternative weed management programs would need to be developed. The objective of this study was to screen ryegrass populations collected throughout California for resistance to glyphosate and to determine the level of resistance among populations.

Materials and Methods

1. Seed Collection

Seed from mature annual ryegrass was collected in May, July, and August, 2004, from roadsides and agricultural fields and orchards throughout the Sacramento and San Joaquin Valleys (Table 1). A description of each collection site was noted, including collection date, and the GPS coordinates. At each site, seed from at least 15 plants was collected and combined into a single sample. Attempts were made to collect at least 1000 mature seed for each sample site. A total of 60 sites ryegrass sites were sampled in 2004. Seed was cleaned and dry seed stored at room temperature (70°F) until use. At least four months of dry storage was required to overcome dormancy and begin the experiments.

2. Preliminary sensitivity experiment

Seed from a known susceptible ryegrass population were planted into pots and grown in the greenhouse. Pots, 4-inch diameter X 4-inch deep, were filled with UC modified soil mix http://greenhouse.ucdavis.edu/materials/nutrients_soil.htm), and at least 10 seed planted 0.25 to 0.5 inches deep. Pots were placed in a temperature controlled greenhouse, 75°F day and 55°F night, with supplemental lighting (12 hr day length). Plants were thinned to 2 to 3 plants per pot at one week after emergence and allowed to grow until 4-6 inches in height. Once plants reached the desired height, they were treated with 8 glyphosate rates: 0, 0.031, 0.062, 0.125, 0.25, 0.50, 1.0, and 2.0 lbs acid equivalent (ae)/ac. Four replicate pots per treatment were used. Glyphosate applications were made using a track sprayer, with a final spray volume of 16 gal/acre. Distilled water was used for all applications, in order to avoid confounding effects of hard water. Twenty one to 25 days after treatment, plants were harvested and fresh weight determined. Percent control was calculated as the fresh weight of the treated plant divided by the fresh weight of the untreated plant. The rate that resulted in a 50% reduction in fresh weight (I_{50}) was calculated.

3. Screening experiment

Seed from each individual ryegrass population was planted into 12-inch X 18-inch flats to provide at least 20 plants in each flat. Application of glyphosate was made to each flat at 0.062 lbs ae/ac, the I_{50} rate determined in the preliminary sensitivity experiment. Plants were grown in the same greenhouse, under similar conditions as used in the preliminary sensitivity experiment. Ryegrass was cut at ground level and shoot fresh weight was measured for each individual flat at 21 days after treatment. Samples were then placed in a forced air dryer (120°F) and dried, and weighed. The distribution of responses within and between populations was compared.

4. Rate response experiment

In addition to comparing all populations at a low application rate, we also wanted to determine the rate of glyphosate necessary to kill all ryegrass from a population. Following cutting for biomass measurement, ryegrass was able to produce new shoot growth. Once plants reached 6 inches in height, they were once again treated with glyphosate, but at double the previous rate – 0.125 lbs ae/ac. At 21 days after treatment, plants were again cut at ground level for biomass measurement as done in the screening experiment. This was repeated with glyphosate rate doubling [0.25, 0.75 (triple rate), 1.5, 3.1, 6.1, and 12.2 lbs ae/ac] at each successive treatment, until all plants in a flat were killed.

Results and Discussion

Seed were collected by driving until a mature ryegrass was seen, stopping and collecting a sample. Thus, many samples were collected on the roadside, but in all cases adjacent to agricultural fields. Ryegrass was a common along roadsides and in fields in the Sacramento Valley. While driving in the San Joaquin Valley, ryegrass was less common on roadsides and fields, particularly further south in the Valley.

Treating the 60 ryegrass populations with glyphosate at 0.062 lbs/ac resulted in minimal growth reductions in all the populations (data not shown). The susceptible population was a population collected about 20 years ago from a location with no known glyphosate use. Thus, all the ryegrass populations appeared resistant relative to the susceptible ryegrass.

Of the 60 ryegrass populations evaluated, only five populations were killed by the recommended glyphosate rate of 0.75 lb/a (Table 1). At double the recommended rate of glyphosate (1.5 lbs/ac), less than 15% of the sampled ryegrass populations were killed. The observation that many populations are resistant to glyphosate is not surprising, since seed samples were collected from areas where it is likely they would have been treated with glyphosate, in many cases repeatedly, and thus only resistant plants would remain. Ten populations have not been completely killed by over 12 lbs of glyphosate per acre, and a few populations show less than 50% control from the 12.2 lb/ac rate, indicating a very high level of resistance.

The ryegrass populations in the northern Counties, near the locations of the original observations of resistance, required a high rate of glyphosate for control. It is likely that most populations in California contain some glyphosate resistant individuals and that once susceptible individuals are removed by treatment with glyphosate, resistant individuals breed with other resistant individuals, creating a highly resistant population.

The abundance of glyphosate resistant ryegrass along roadsides has likely allowed the rapid spread throughout the state, as mud picked up in tires could carry the seed. The high level of glyphosate resistance in roadside ryegrass may be a reflection of repeated use of glyphosate by road crews, particularly in programs where residual herbicides are not used.

The data on glyphosate resistant ryegrass distribution and rate sensitivity will serve as a baseline, allowing other populations to be tested and compared in the future. Now that glyphosate resistant ryegrass has been confirmed in many areas of California, alternative management options will need to be implemented.

Table 1. Site description and coordinates for annual ryegrass seed collected in 2004 (60 sites), going from south to north, and the rate of glyphosate[1] (lbs/acre) needed to kill ryegrass.

Site description	County	Date collected	North Coordinate	West Coordinate	Glyphosate rate (lbs ae/acre) required for 100% ryegrass control
Roadside	Fresno	Aug-2004	36°35.277	119°29.693	1.5
Roadside - Aromas	Monterey	Aug-2004	36°52.669	121°38.234	3.1
Almonds Ave 18 1/2	Madera	1-Jul-04	37°01.106	120°16.165	6.1
Cotton Gin yard	Madera	9-Jul-04	37°02.531	120°35.504	12.2 +
Roadside Hwy 165	Merced	9-Jul-04	37°08.804	120°49.451	3.1
Roadside Hwy 59	Merced	9-Jul-04	37°14.296	120°29.275	3.1
Almond orchard	Merced	1-Jul-04	37°14.443	120°22.747	6.1
Almond orchard	Merced	1-Jul-04	37°15.503	120°22.787	3.1
Almond orchard	Merced	9-Jul-04	37°22.9726	120°53.176	3.1
Roadside	Stanislaus	9-Jul-04	37°25.193	120°59.100	0.75
Almond orchard	Stanislaus	1-Jul-04	37°32.198	121°14.313	3.1
Roadside near Keyes	Stanislaus	9-Jul-04	37°33.151	120°55.774	0.75
Next to RR tracks	San Joaquin	9-Jul-04	37°51.601	121°13.184	3.1
Abandoned orchard	San Joaquin	8-Jul-04	37°54.803	121°40.686	0.75
Tomato field	San Joaquin	8-Jul-04	37°55.743	121°23.844	1.5
Vacant lot near Rd 8 in Stockton	San Joaquin	9-Jul-04	38°04.102	121°14.715	3.1
Edge of corn field	San Joaquin	8-Jul-04	38°04.177	121°44.163	3.1
Vineyard near Stockton	San Joaquin	8-Jul-04	38°06.439	121°23.449	0.75
Roadside near Pear orchard	Solano	8-Jul-04	38°09.246	121°40.730	1.5
Hwy 113 & Jepson Prairie	Solano	7-Jul-04	38°16.991	121°49.431	3.1
Roadside	Solano	7-Jul-04	38°20.194	121°48.291	0.75
Hwy 99 and Grant Line rd	Sacramento	9-Jul-04	38°22.657	121°21.860	3.1
Roadside Pedrick rd.	Solano	11-Jul-04	38°24.545	121°48.276	3.1
Roadside near Pedrick road	Solano	8-Jul-04	38°28.904	121°48.326	3.1
Roadside Rd 98	Yolo	12-Jul-04	38°32.565	121°48.188	12.2+
Roadside north or Winters	Yolo	12-Jul-04	38°32.836	121°58.265	6.1
Roadside near Winters	Yolo	12-Jul-04	38°32.894	121°53.074	12.2+
Roadside	Yolo	2-Jul-04	38°33.722	121°57.023	6.1
Roadside near Turkovich Farm	Yolo	2-Jul-04	38°34.834	121°56.045	12.2+
Roadside	Yolo	2-Jul-04	38°36.518	121°58.275	3.1

Site description	County	Date collected	North Coordinate	West Coordinate	Glyphosate rate (lbs ae/acre) required for 100% ryegrass control
Roadside	Yolo	2-Jul-04	38°37.188	121°46.159	3.1
Roadside	Yolo	2-Jul-04	38°37.214	121°57.012	3.1
Roadside	Yolo	12-Jul-04	38°38.106	122°00.488	6.1
Roadside Capay Valley	Yolo	12-Jul-04	38°42.346	122°03.791	3.1
Almond orchard County Line rd	Yolo	12-Jul-04	38°55.550	122°00.706	12.2
Almond orchard	Colusa	14May04	38°55.934	122°03.641	3.1
Roadside	Colusa	12-Jul-04	38°57.095	122°22.874	3.1
Almond orchard	Colusa	14May04	38°57.296	122°03.643	3.1
Roadside	Colusa	12-Jul-04	39°04.969	122°04.737	12.2+
Roadside south of Willows	Colusa	12-Jul-04	39°06.356	122°09.111	3.1
Walnut orchard	Sutter	11-Jul-04	39°06.598	121°40.296	3.1
Roadside near Willows	Colusa	12-Jul-04	39°07.189	122°13.445	6.1
Roadside	Colusa	Aug.2004	39°11.944	122°00.487	6.1
Roadside	Colusa	Aug.2004	39°12.616	122°02.278	6.1
Abandoned orchard	Sutter	11-Jul-04	39°15.011	121°40.326	3.1
Roadside	Colusa	Aug.2004	39°15.32590	122°03.34777	12.2+
Roadside with rice all around	Butte	11-Jul-04	39°29.584	121°50.547	3.1
Roadside	Butte	20May04	39°34.844	121°56.044	3.1
Prune orchard	Butte	11-Jul-04	39°35.994	121°51.436	6.1
Almond orchard	Butte	11-Jul-04	39°36.804	121°51.463	3.1
Corn field	Glenn	Aug.2004	39°39.209	122°00.059	6.1
Roadside next to almond orchard	Glenn	11-Jul-04	39°41.081	121°52.745	12.2+
Young almond orchard	Glenn	11-Jul-04	39°42.541	122°04.460	6.1
Walnut orchard	Glenn	11-Jul-04	39°44.092	121°57.741	12.2+
Prune orchard	Glenn	11-Jul-04	39°47.382	122°04.009	12.2+
Roadside	Glenn	11-Jul-04	39°48.253	122°04.001	3.1
Prune orchard	Tehama	11-Jul-04	39°49.545	122°07.375	12.2+
Prune orchard near Corning	Glenn	11-Jul-04	39°49.555	122°08.028	6.1
Roadside	Glenn	11-Jul-04	39°51.435	122°09.185	3.1
Olive orchard near Corning	Tehama	11-Jul-04	39°54.850	122°07.530	3.1

[1] The glyphosate rate listed on the Roundup WeatherMax label for control of ryegrass is 0.75 lb ae/acre.

Literature Cited

Simarmata, M., J.E. Kaufmann, D. Penner. 2003. Potential basis of glyphosate resistance in California rigid ryegrass (*Lolium rigidum*). Weed Sci. 51: 678-682.

Lessons on Managing Glyphosate Resistance from Australia: When on a Good Thing, Don't Stick With It

Richard T. Roush,
UC Statewide IPM Program, University of California
One Shields Ave., Davis, CA 95616-8621
rtroush@ucdavis.edu

Flexibility and diversity in crops and weed management strategies are needed to slow or deter the evolution of herbicide resistant weeds. As described in this paper, avoiding use of glyphosate at least one year every few years may be crucial to maintaining its effectiveness, especially for horseweed (*Conyza*) and ryegrass.

The first cases of resistance in weeds to glyphosate documented anywhere in the world were in ryegrass from under orchards in Australia in 1996 (Powles, et al. 1998, Lorraine-Colwill, et al. 1999). Resistance has since been found in goosegrass (*Eleusine indica*) in oil palm plantations in Malaysia (1997), ryegrass in California in 1998 with Brazil and Chile following in 2001-03, horseweed (*Conyza canadensis*) in connection with Roundup Ready soy production in 2000, and other *Conyza* species in Spain and South Africa in 2003-04. Buckhorn plantain (*Plantago lanceolata*) was also documented as showing resistance in South Africa in 2003 (www.weedscience.com). Resistance cases encountered thus far in several of these species lower glyphosate's effectiveness in the cropping, and it is an herbicide that is not easily replaced. Glyphosate is a key herbicide with an excellent profile for human health and the environment. In California, glyphosate can be especially important for the adoption of reduced tillage, thereby helping to reduce dust in our air, which is a looming regulatory issue.

Resistance to glyphosate has attracted considerable attention outside agriculture because of its use in transgenic Roundup Ready crops, especially soybeans, corn, and cotton. There is a great deal of concern that such crops will further intensify the use of glyphosate and result in more resistance in weeds to glyphosate. Resistance in horseweed, for example, has been associated with Roundup Ready soybeans in eastern states, but appeared so quickly that much of the selection had probably occurred earlier due to previous pre-season applications of glyphosate. Further, many other cases of resistance to glyphosate have not involved the use of transgenic crops, which serves to emphasize that conventional use of glyphosate products is also sufficient to select for resistance. Resistance management for glyphosate is thus needed independent of GM crops. However, glyphosate resistant corn and cotton are already grown commercially in California, with alfalfa soon to follow, and Roundup Ready rice under investigation at least elsewhere in the US, so we should be careful in these systems. Given the history of resistance to glyphosate in horseweed and ryegrass in California and elsewhere, these are key weeds for which we should adopt strategies to avoid glyphosate resistance, including avoiding glyphosate as their sole means of control.

Given the importance of glyphosate (the active ingredient of Roundup) for weed management systems around the world and especially with the detection of resistance to glyphosate in California (as described in the previous presentations by Shrestha, Lanini, and Jasieniuk), it is important to consider what lessons can be learned from Australia and applied elsewhere to slow resistance to this important and popular herbicide. Most of what I can tell you about resistance to glyphosate in Australia is due to the work of my colleague Dr. Chris Preston at the University of Adelaide in South Australia, who also visited Davis in late 2005.

There are now more than 44 populations documented with resistance to glyphosate in Australia, scattered across four states in the southern part of the continent. There has been a rapid increase in the number of populations found since 2000, almost all of them from reports by growers that glyphosate seemed to be working more poorly than in the past. First were two from orchards receiving quarterly applications of glyphosate, but there were ten populations by 2001 and 34 by 2002. The good news is that resistance to glyphosate is still confined to intensive uses. Of the 34 confirmed populations, the majority are in fallows or horticulture (Table 1).

Table 1. Confirmed glyphosate-resistant annual ryegrass populations in Australia.

Situation	Number of resistant populations	States
Orchard, vineyard	9	NSW,SA, WA
No-till grain cropping	6	NSW,Vic, SA, WA
Chemical fallow	18	NSW
Fencelines, firebreak, irrigation ditches, etc.	11	NSW, SA, WA

Where the herbicide history is known, these populations are characterised by persistent use of glyphosate for many years, the use of few or no other effective herbicides, and little or no tillage. Although it is tempting to assume that tillage delays resistance by killing any weeds that survive the glyphosate application, modelling results suggest that the absence of tillage also accelerates resistance by not turning susceptible weeds seeds into the soil as part of the "seed bank" that can sprout in later years and breed with resistant plants (especially obligate outcrossers like ryegrass), thereby slowing resistance.

Glyphosate resistance genetics and resistance management

Research by Chris Preston and colleagues shows that resistance to glyphosate in Australian annual ryegrass is probably due mostly to one gene and is relatively low, about 3 fold in the heterozygotes (weeds carrying one copy of the resistance gene) and 7 fold in the resistant homozygotes (carriers of 2 copies of the resistance allele) (Lorraine-Colwill et al. 2001). This resistance seems to have something to do with the translocation of glyphosate (Lorraine-Colwill et al. 2003). By "relatively low", I mean by comparison to resistance for most other kinds of herbicides, where resistance is generally on the order of

10-40 fold. Preston has also found a few cases of resistance by an altered (mutated) target enzyme EPSPS (discussed by Jasieniuk), which can "stack" by crossing with the other gene to provide resistance more like 15 fold, which would become much more serious.

From research at Monsanto, the genetics of resistance to glyphosate in *Conyza* associated with Roundup Ready soybeans seem similar to those in ryegrass. Even before the commercial introduction of glyphosate, *Conyza* was naturally somewhat tolerant to it, so even a relatively low resistance of 3-7 fold resistance can make a difference, in contrast to weed species that are much more sensitive. Resistance evolved very soon after the introduction of Roundup Ready soybeans, starting in about 4 years. As in the several other cases of resistance that have nothing to do with GM crops, resistance to glyphosate in *Conyza* was probably was building to conventional use of glyphosate over many years prior to the commercial release of GM soy.

Given that resistance to other herbicides has evolved resistance in as little as 4 years in Australia, it seemed odd that resistance had taken so long to evolve to glyphosate, even after adjusting for the relatively low advantage of resistance to glyphosate sprays. Simulation models that Chris Preston and I developed, which matched resistance evolution quite well for other herbicides, indicated that resistance should be evolving much faster to glyphosate.

This led Chris and I to suspect that there are strong fitness costs to glyphosate resistance, that is, in the absence of glyphosate treatment, resistant weeds are poorly fit (e.g., could have lower seed set, poorer pollen production, etc.) compared to susceptible plants in the same field. This fitness penalty will slow the evolution of herbicide resistance and also decrease the number of resistant individuals in the population when the herbicide is not used. Preston's subsequent research showed that the fitness disadvantages depend on circumstances and are enhanced in competition with other plants, but the frequency of resistance in a population declines quite rapidly, from 45% to about 11% in three years The fitness penalty is at least 40%. It has also been noted that glyphosate resistance does not seem to spread as rapidly in the field as do other resistances in Australia, which also supports the idea of a fitness cost.

It should be possible to exploit the fitness penalty associated with glyphosate resistance. This is likely to be achieved best by employing a rotation that does not require glyphosate to be applied to a field in every year, perhaps skipping at least one year out of every three. In the years when glyphosate is not used, the frequency of resistant individuals will decrease due to selection against them. This will delay the onset of resistance, especially if undertaken before resistance becomes common, and will be especially important to avoid the accumulation and spread of both resistance genes. This conclusion is consistent with the field observation in Australia that resistance has not evolved in populations where glyphosate has not been persistently used, but where there has instead been more variety in weed management practices.

It's probably also important to avoid spraying large weeds, but rather to spray them when they are small. Spraying weeds when they are smaller may be less likely to select for weeds that have the small resistance advantage conferred by a glyphosate resistance allele. If weeds are sufficiently large and tolerant that a few will survive even when susceptible, plants with a 3 fold advantage in resistance are more likely to survive and increase the frequency of resistance. On the other hand, more general work in resistance management suggests that altering the rates or concentrations of herbicides is unlikely to make much difference to the selection for resistance (Preston and Roush. 1999).

In California, we need to avoid excessive use of glyphosate. especially for Roundup Ready alfalfa. Alfalfa is grown on a large acreage in California, so selection pressures could be extensive. Alfalfa is also a perennial crop that won't be rotated with another crop (and other weed management practices) for 3-4 years. It will be tempting to use glyphosate often, and indeed labels will allow glyphosate apoplications 3-4 times a year in Roundup Ready alfalfa. I want to emphasize that it was similar circumstances, 3-4 uses per year under orchards, which generated the very first cases of glyphosate resistance anywhere in the world. We need to be especially careful in California with management practices for *Conyza* and ryegrass, which have already shown a facility for evolving resistance to this important herbicide. Monsanto has accepted the need for resistance management and offers very useful information on a new website, **http://www.weedresistancemanagement.com/.**

In Australia, playing off a popular commercial advertisement for fly spray, advice given for resistance management is "When on a Good Thing, Don't Stick With It". Glyphosate is a good thing, but we have to be careful not to use it too much. Resistance can be managed, but we need to vary herbicides and other weed control practices to keep weeds "off balance", and thereby make it harder for weeds to adapt to any particular control tactics. With care and restricted use, resistance to glyphosate can be delayed, perhaps indefinitely.

References Cited

Lorraine-Colwill, DF., Hawkes, TR., Williams, PH., Warner, SJ., Sutton, PB., Powles, SB., Preston, C. (1999) Resistance to glyphosate in *Lolium rigidum*. Pesticide Sci, 55, 486-503.

Lorraine-Colwill, D.F., Powles, S.B., Hawkes T.T., Preston, C. (2001) Inheritance of evolved glyphosate resistance in *Lolium rigidum*. Theo. & Appl. Genetics. 102, 545-550.

Lorraine-Colwill, D.F., Powles, S.B., Hawkes, T.R., Hollinshead, P.H., Warner, S.A.J., Preston, C. (2003) Differential glyphosate translocation in a resistant *Lolium rigidum* population. Pesticide Biochemistry and Physiology, 74, 62-72.

Preston, C. and R.T. Roush. 1999. Variation in herbicide dose rates: risks associated with herbicide resistance, pp. 128-137, in "Precision Weed Management in Crops and Pastures", eds., R. W. Medd and J. E. Pratley. Proceedings of a workshop, 5-6 May 1998, Wagga Wagga, NSW. CRC for Weed Management Systems, Adelaide. 154 pp.

Powles, S.B., Lorraine-Colwill, D.F., Dellow, J.J., Preston, C. (1998) Evolved Resistance to glyphosate in rigid ryegrass (*Lolium rigidum*) in Australia. Weed Sci. 46, 604-607.

Interactions among Weeds, Ants and Obscure Mealybug in Central Coast Vineyards

Mark D. Welch, Michael J. Costello, and Scott J.Steinmaus
Horticulture and Crop Science Dept. and Department of Biology Cal Poly San Luis Obispo, CA

Obscure mealybug (OMB), *Pseudococcus viburni* (Signoret), is a major insect pest of grapes on the Central Coast. It makes use of weeds as alternate hosts during the growing season as well as in the winter. Mealybug infestations are exacerbated by the presence of ants, which protect the mealybugs from natural enemies and distribute mealybugs among host plants. In 2004 we undertook a two year field study to observe the association of OMB with the Argentine ant, *Linepithema humile,* and the effect of eliminating alternate weed hosts for OMB on grape infestation in Central Coast vineyards. The experimental design was a split plot where the presence or absence of weeds was the main plot factor and the presence or absence of ants was the subplot factor. Ant density was measured weekly. The presence or absence of OMB on common spring and summer weed roots was recorded, and grape cluster infestation by OMB at harvest was analyzed. A greenhouse study confirmed the broad host range of OMB on a variety of weed and cover crop species. Most vineyard weed species were found to be hosts for OMB. Results indicate that weed control had no impact on OMB infestation of grape clusters, but that ant exclusion played a significant role. We conclude that weed management is not a viable cultural control for OMB.

Critical period of weed control in cotton in Muzarabani- The Zambezi valley

Z.Mavunganidze (Mavudzi)[1], A. B Mashingaidze[2], O. A Chivinge[2], C. Riches[3], J. Ellis-Jones[4],

1.Bindura University of Science Education, Department of Agriculture P.O Box 1020 Bindura.Email:zmavunganidze@buse.ac.zw Fax: 071-7534

2. *University of Zimbabwe, Department of Crop Science, P.O Box MP 167, Mt Pleasant, Harare, Zimbabwe.*

3.*Natural Resources Institute, University of Greenwich, Central Avenue, Chatham Maritime, Kent, ME4 4TB, UK.*

4.Silsoe Research Institute, Wrest Park, Silsoe, Berdford, MK 45 4HS, UK.

A field trial was conducted in Muzarabani to determine the critical period of weed interference in cotton in 2000-2001 and 2001-2002 seasons. There was an increase in the cotton yield, boll mass and plant height as the period of weed competition was reduced. In 2000-2001 season in the treatments that were kept weed free and then weedy throughout the season the highest cotton yield (2527 kg ha^{-1}) was obtained in the treatment that was kept weed free throughout the season and the lowest (524 kg ha^{-1}) in the treatment that was weed free for 2 weeks after crop emergence and then weedy rest of the season. The highest cotton seed yield (2727 kg ha^{-1}) for the treatments that were kept weedy and then weed free for the rest of the season was obtained in the treatments that were kept weedy for 2 weeks after crop emergence and the weed free for the rest of the season while the lowest yield (432 kg ha^{-1}) was obtained in the treatment that was kept weedy throughout the season for 2 weeks after crop emergence. To avoid significant yield loss farmers in Muzarabani need to begin weeding cotton at east 2 weeks after crop emergence leaving weeds beyond 2 weeks will result in a significantly drop in yield and additional weeding will be required up to 11 weeks after crop emergence, in order to attain maximum yields in a dry season. The critical period for a wet season was observed to be between 3 weeks after crop emergence up to 8 weeks after crop emergence, weeding thereafter will not result in any significant yield increase, according to results in 2001-2002 season.

Evaluation of Plantback Intervals on Vegetable Crop Yield Following Application of Chateau and V-10142

John S. Rachuy (Staff Research Associate) and Steve Fennimore (UC Weed Specialist)
University of California – Davis, Salinas, CA, 93905

Objective

Evaluation of the safest time interval for vegetable replanting following application of Chateau and V-10142.

Methods

The trial was conducted at the USDA-ARS/UCCE Spence research farm near Salinas, CA; on a loamy sand soil with a pH of 7.2 and with 1.0 % organic matter. The test plot was established using a randomized complete block design, with all treatments replicated four times. Each replicate plot consisted of three 40" wide beds by 20' long. Pre-emergence (PRE) herbicide applications of Chateau 51WG at 0.094 and 0.188 lb ai/A and V-10142 3.3FL at 0.2 and 0.4 lb ai/A were applied on March 15, April 14 and May 16 & 17, 2005, at 4, 3 and 2 months before seeding (MBS), respectively. In addition, pre-emergence applications of Chateau 51WG at 0.094 lb ai/A and V-10142 3.3FL at 0.2 lb ai/A were applied on June 15, 2005, at 1 MBS. All treatments were applied manually as a broadcast spray at 40 gpa over the tops of the peaked beds, using a handheld, single-nozzle boom attached to a CO_2 backpack sprayer. On the day following each application, the entire plot was irrigated by overhead sprinklers for 3 to 4 hours, to incorporate the treatments. Roundup Ultra was applied at 2% v/v in 22 gpa on April 26, 2005, as a spot treatment to control volunteer weeds.

On July 14, 2005, iceberg lettuce cv. 'Sniper', romaine lettuce cv. 'Green Towers', Broccoli cv. 'Marathon', spinach cv. 'Whale', and green onion cv. 'Whitespear' were mechanically planted in single lines (two separate crop lines per bed), using a tractor operated Stanhay planter. On the same day, carrot cv. 'Navajo' was mechanically planted in a single line using a manually operated Earthway seeder.

Crop stand counts were taken on August 3, 2005 (20 days after seeding (DAS)) and on each biomass sampling date (Table 1). Crop injury (foliar phytotoxicity / plant stunting) ratings, with a scale of 0-10 (0 = no injury, $\leq$2 = acceptable injury, 10 = dead plant) were assessed on August 3 (20 DAS) and 24 (41 DAS), 2005 (Table 2). Crop biomass samples (fresh) were collected on September 2 (50 DAS) for iceberg and romaine lettuce, September 7 (55 DAS) for spinach, September 9 (57 DAS) for broccoli and September 12 (60 DAS) for green onion and carrot. Fresh samples were placed in drying ovens for 3 – 7 days and dry weights determined (Table 3). All crop assessment data were subjected to analysis of variance, and mean separation was performed using LSD (P=0.05).

Results

Chateau:

Head Lettuce, Leaf Lettuce and Spinach – No significant plant stand reduction at either rate at any of the four plantback intervals. Found to be safe at 0.094 lb ai/ac at either 3 or 2 MBS and at 0.188 lb ai/ac at either 4 or 3 MBS. No significant biomass reduction at either rate at any of the four plantback intervals. (Tables 1, 2 & 3)

Broccoli – No significant plant stand reduction at either rate at any of the four plantback intervals. Found to be safe at 0.094 lb ai/ac at 3 MBS and at 0.188 lb ai/ac at either 4 or 3 MBS. Significantly increased biomass at 0.094 lb ai/ac at 1 MBS; otherwise, no significant biomass reduction at any other rate / plantback interval combination. (Tables 1, 2 & 3)

Green Onion and Carrot – No significant plant stand reduction at either rate at any of the four plantback intervals. Found to be safe at either rate at any of the four plantback intervals. No significant biomass reduction at either rate at any of the four plantback intervals.

V-10142:

Head and Leaf Lettuce – No significant plant stand reduction at either rate at any of the four plantback intervals. Found to be unsafe at either rate at any of the four plantback intervals, due to moderate to severe phytotoxicity and stunting. Caused significant biomass reduction in all rate / plantback interval combinations, with the exception of 0.2 lb ai/ac at 4 MBS. (Tables 1, 2 & 3)

Broccoli, Spinach, Green Onion and Carrot – Caused significant plant stand reduction in all rate / plantback interval combinations. Found to be unsafe at either rate at any of the four plantback intervals, due to moderate to severe phytotoxicity and stunting. Caused significant biomass reduction in all rate / plantback interval combinations. (Tables 1, 2 & 3)

Conclusions

Chateau at both 0.094 and 0.188 lb ai/ac appears to be safe for use within 3-4 months of planting any of these crops. Due to the severity of its phytotoxic effects, V-10142 appears to be unsafe for use on iceberg lettuce, romaine lettuce, broccoli, spinach, green onion or carrot at intervals up to four months prior to planting.

Table 1. Crop stand evaluations.

Treatment	Timing (Preplant)	Iceberg Lettuce # / 20ft	Iceberg Lettuce # / 3ft	Romaine Lettuce # / 20ft	Romaine Lettuce # / 3ft	Broccoli # / 20ft	Broccoli # / 3ft	Spinach # / 20ft	Spinach # / 3ft	Green Onion # / 20ft	Green Onion # / 3ft	Carrot # / 20ft	Carrot # / 3ft
		8/3	9/2	8/3	9/2	8/3	9/9	8/3	9/7	8/3	9/12	8/3	9/12
Chateau 0.094	- 4 months	61 a	11.5 a	82 a	15.3 a	68 a	10.8 ab	173 a	30.0 a	125 a	53.3 ab	66 a	27.3 a
Chateau 0.094	- 3 months	78 a	12.3 a	91 a	13.8 a	74 a	11.0 ab	170 a	31.0 a	141 a	39.8 b	66 a	16.0 ab
Chateau 0.094	- 2 months	85 a	13.0 a	94 a	15.3 a	68 a	11.8 ab	157 a	28.3 a	108 a	49.8 ab	64 a	28.8 a
Chateau 0.094	- 1 month	62 a	9.0 a	65 a	10.0 a	60 a	9.5 ab	155 a	25.5 a	104 a	46.8 ab	71 a	24.5 a
Chateau 0.188	- 4 months	68 a	10.0 a	94 a	13.3 a	54 a	11.8 ab	180 a	28.3 a	124 a	41.5 ab	65 a	21.8 a
Chateau 0.188	- 3 months	66 a	8.8 a	69 a	10.8 a	65 a	11.5 ab	158 a	30.3 a	125 a	55.0 a	73 a	23.3 a
Chateau 0.188	- 2 months	59 a	8.0 a	85 a	14.8 a	61 a	8.5 b	129 a	26.0 a	102 a	42.3 ab	61 a	20.0 a
V-10142 0.2	- 4 months	57 a	10.5 a	75 a	11.5 a	54 a	2.3 c	173 a	7.8 b	114 a	13.3 c	69 a	3.3 bc
V-10142 0.2	- 3 months	84 a	14.3 a	85 a	11.8 a	46 a	0.0 c	140 a	0.0 c	98 a	0.0 c	69 a	0.0 c
V-10142 0.2	- 2 months	71 a	13.3 a	61 a	12.3 a	67 a	0.0 c	162 a	0.0 c	109 a	0.0 c	67 a	0.0 c
V-10142 0.2	- 1 month	76 a	12.3 a	91 a	9.8 a	59 a	0.0 c	137 a	0.0 c	97 a	0.0 c	74 a	0.0 c
V-10142 0.4	- 4 months	71 a	14.5 a	80 a	11.0 a	60 a	0.0 c	144 a	0.0 c	124 a	0.0 c	65 a	0.0 c
V-10142 0.4	- 3 months	64 a	9.8 a	76 a	10.3 a	47 a	0.0 c	146 a	0.0 c	84 a	0.0 c	73 a	0.0 c
V-10142 0.4	- 2 months	84 a	13.5 a	98 a	11.8 a	60 a	0.0 c	152 a	0.0 c	95 a	0.0 c	68 a	0.0 c
Untreated	NA	82 a	13.5 a	82 a	14.0 a	68 a	12.0 a	163 a	27.3 a	110 a	46.0 ab	78 a	24.8 a
LSD 0.05		25.9	5.6	34.5	6.3	24.8	3.5	44.4	6.9	33.2	14.1	15.4	13.4

Table 2. Crop injury evaluations.

Treatment	Timing (Preplant)	Iceberg Lettuce 8/3	Iceberg Lettuce 8/24	Romaine Lettuce 8/3	Romaine Lettuce 8/24	Broccoli 8/3	Broccoli 8/24	Spinach 8/3	Spinach 8/24	Green Onion 8/3	Green Onion 8/24	Carrot 8/3	Carrot 8/24
		0 – 10 [A]											
Chateau 0.094	- 4 months	1.6 ef	2.3 cd	2.0 d-g	2.3 de	0.4 d	2.8 bcd	0.4 c	2.4 b	0.3 d	0.5 b	0.5 b	1.1 cd
Chateau 0.094	- 3 months	1.4 ef	1.1 de	1.5 fg	1.3 ef	0.0 d	0.9 de	0.0 c	0.8 bc	0.8 cd	0.5 b	2.3 b	1.0 cd
Chateau 0.094	- 2 months	1.0 ef	2.0 cd	1.0 fg	1.3 ef	0.3 d	2.1 cd	1.3 c	1.4 bc	1.6 cd	0.9 b	0.8 b	1.0 cd
Chateau 0.094	- 1 month	4.0 c	3.4 c	3.9 cde	3.5 cd	2.4 c	3.5 bc	0.6 c	2.8 b	2.4 c	1.5 b	1.4 b	1.4 cd
Chateau 0.188	- 4 months	1.9 e	1.9 cd	1.8 efg	1.8 def	0.0 d	1.1 de	0.0 c	1.3 bc	0.9 cd	1.1 b	0.6 b	1.3 cd
Chateau 0.188	- 3 months	2.3 de	1.9 cd	2.4 def	1.9 def	0.3 d	1.8 cde	0.0 c	1.6 bc	0.8 cd	0.5 b	0.5 b	0.3 d
Chateau 0.188	- 2 months	3.6 cd	3.5 c	2.5 def	2.1 de	3.1 c	4.6 b	1.3 c	2.1 b	2.4 c	1.8 b	1.3 b	2.0 c
V-10142 0.2	- 4 months	4.5 bc	5.3 b	4.1 bcd	5.1 bc	5.3 b	8.2 a	4.6 b	8.1 a	4.5 b	8.0 a	4.9 a	7.9 b
V-10142 0.2	- 3 months	6.3 a	5.8 b	5.9 abc	5.6 b	6.8 ab	9.4 a	6.8 a	9.4 a	6.1 ab	10.0 a	6.4 a	9.5 a
V-10142 0.2	- 2 months	6.0 ab	5.9 b	6.3 ab	6.1 b	6.8 ab	9.4 a	6.6 a	9.4 a	5.9 ab	10.0 a	6.4 a	9.6 a
V-10142 0.2	- 1 month	7.0 a	6.3 b	6.1 ab	5.4 bc	7.0 a	9.6 a	7.0 a	9.6 a	6.4 a	7.8 a	6.6 a	9.6 a
V-10142 0.4	- 4 months	6.5 a	8.5 a	6.6 a	8.6 a	7.0 a	9.6 a	7.0 a	9.5 a	6.4 a	10.0 a	5.4 a	9.7 a
V-10142 0.4	- 3 months	7.6 a	9.3 a	7.5 a	8.9 a	7.8 a	9.7 a	6.8 a	9.5 a	6.4 a	10.0 a	6.8 a	9.7 a
V-10142 0.4	- 2 months	7.4 a	8.7 a	7.1 a	8.1 a	7.3 a	9.6 a	7.0 a	9.4 a	6.5 a	10.0 a	7.0 a	9.7 a
Untreated	NA	0.0 f	0.0 e	0.0 g	0.0 f	0.0 d	0.0 e	0.0 c	0.0 c	0.0 d	0.0 b	0.0 b	0.0 d
LSD 0.05		1.7	1.7	2.3	2.0	1.6	1.9	1.6	2.1	1.7	2.4	2.3	1.5

[A] Rating scale: 0 = no injury; ≤2 = commercially acceptable; 10 = dead plants

Table 3. Crop biomass (dry weight / plant) evaluations.

Treatment	Timing (Preplant)	Iceberg Lettuce 9/6	Romaine Lettuce 9/6	Broccoli 9/13	Spinach 9/12	Green Onion 9/15	Carrot 9/16
		grams / plant					
Chateau 0.094	- 4 months	3.4 ab	3.2 bc	41.1 ab	12.1 ab	6.2 b	19.3 a
Chateau 0.094	- 3 months	4.1 a	3.8 abc	39.8 b	11.8 b	8.7 a	27.8 a
Chateau 0.094	- 2 months	2.9 ab	3.3 bc	38.3 b	13.3 ab	6.8 ab	20.9 a
Chateau 0.094	- 1 month	3.4 ab	4.5 ab	54.8 a	14.7 a	7.0 ab	22.3 a
Chateau 0.188	- 4 months	4.5 a	5.0 a	38.7 b	13.2 ab	7.9 ab	22.9 a
Chateau 0.188	- 3 months	4.1 a	4.1 abc	37.4 b	12.3 ab	6.3 b	20.5 a
Chateau 0.188	- 2 months	3.7 ab	4.3 ab	46.0 ab	14.3 ab	7.7 ab	24.5 a
V-10142 0.2	- 4 months	2.3 bc	2.6 cd	10.6 c	3.0 c	1.6 c	7.5 b
V-10142 0.2	- 3 months	1.2 cd	1.4 de	0.0 c	0.0 d	0.0 c	0.0 b
V-10142 0.2	- 2 months	1.2 cd	1.4 de	0.0 c	0.0 d	0.0 c	0.0 b
V-10142 0.2	- 1 month	0.7 cd	1.4 de	0.0 c	0.0 d	0.0 c	0.0 b
V-10142 0.4	- 4 months	0.5 d	0.4 e	0.0 c	0.0 d	0.0 c	0.0 b
V-10142 0.4	- 3 months	0.2 d	0.4 e	0.0 c	0.0 d	0.0 c	0.0 b
V-10142 0.4	- 2 months	0.3 d	0.9 e	0.0 c	0.0 d	0.0 c	0.0 b
Untreated	NA	3.5 ab	3.5 abc	36.8 b	13.3 ab	7.4 ab	20.9 a
LSD 0.05		1.7	1.5	14.1	2.8	1.8	9.3

Herbicides for Controlling Problem Weeds in Wine Grapes

Mick Canevari, Paul Verdegaal, Don Colbert, Randall Wittie, Scott Whitely
University of California, Cooperative Extension, San Joaquin County

Introduction

New herbicides are needed to address weed control issues in vineyards and to offset the rapid development of herbicide resistant marestail (Horseweed) occurring in other San Joaquin valley locations. In addition, some current herbicides are a risk to move into groundwater sensitive areas. New groundwater protection regulations have limited the use of selected herbicides; diuron, simazine and norflurazone.

Weeds also compete with grapevines for water, soil nutrients and sometimes light, interfere with harvest and can harbor insects that vector Pierce's disease. Well-established vines are less affected than new vines, but heavy populations of annual or perennial weeds can still reduce growth, yield and quality. Vineyards with dense weed growth are inefficient users of water and nitrogen fertilizer.
Weed management is part of an overall vineyard management system because weeds:

- influence other pests such as insects, mites, nematodes and diseases
- reduce vine growth and yields
- provide habitat for mice and voles
- disrupt the application pattern of water from low-volume spray emitters
- require frequent cultivation close to the trunks which can damage vine roots or the base of the vine trunk.

Choosing the right herbicide and with proper timing most weed species can be controlled. In some situations, combinations or sequential applications of herbicides will be required to provide long term effective, economical control.

Objective

A research trial was conducted in Lodi California to evaluate:
(1) Herbicide performance on tough to control weeds such as marestail (*Conyza canadensis*) and turkey mullein (*Eremocarpus setigerus*).
(2) New post herbicides for broad spectrum weed control.
(3) The effect of herbicide tank mixes; Chateau, Surflan, Goal, Roundup, Rely and Matrix.

Method

The following herbicides were applied to the berms of dormant grape vines on an established Sangiovese vineyard located near Woodbridge, California on 2/24/05:

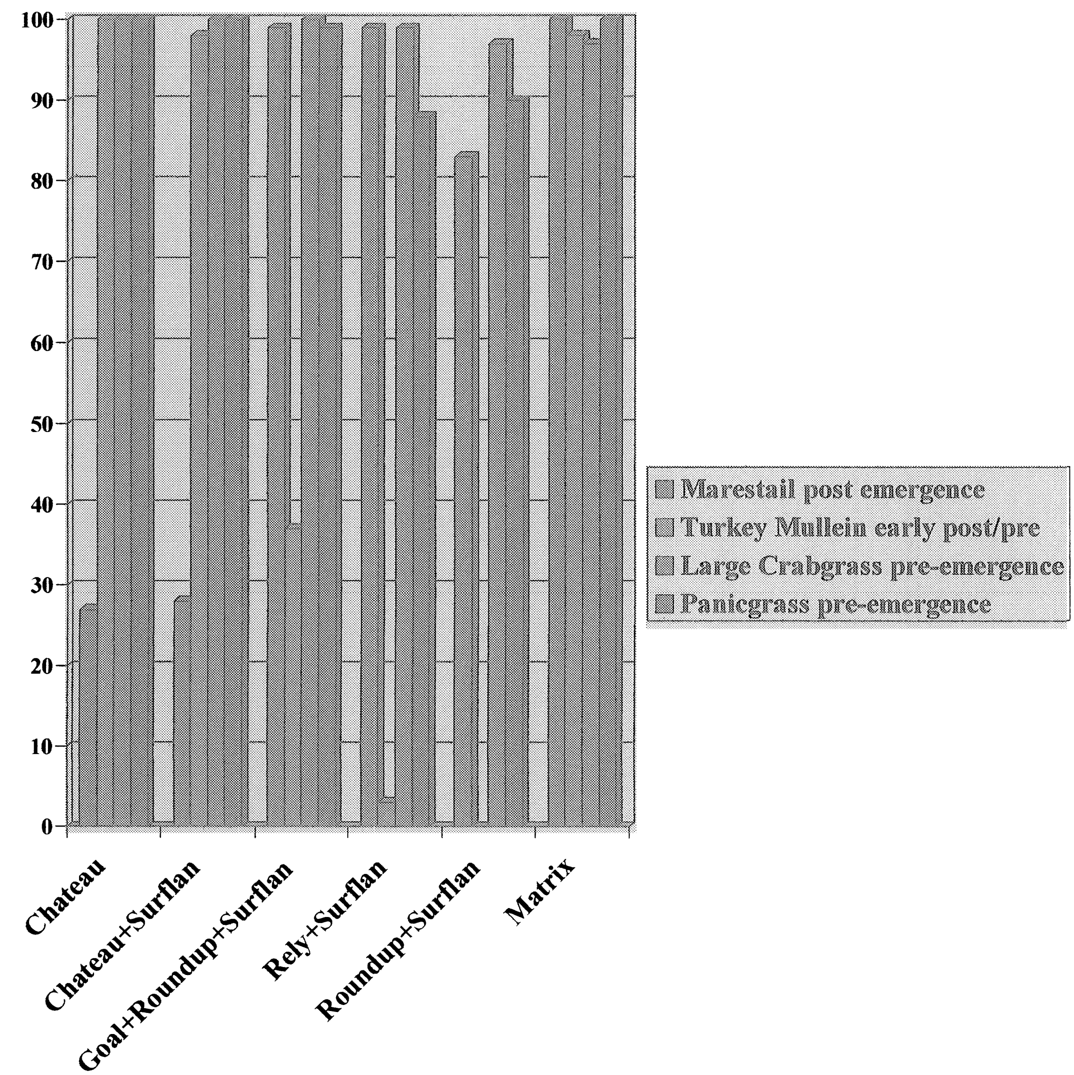
(1) Chateau 51WG 0.375 lb ai/A, (2)Chateau 51WG 0.375 lb ai/A + Surflan 4F 3.0 lb ai/A, (3)Goal 2EC 1.0 lb ai/A + Roundup Weathermax 1.0 lb ai/A, (4) Rely 1EC 1.0 lb ai/A + Surflan 4F 3.0 lb ai/A, (5) Roundup Weathermax 1.0 lb ai/A +
(2) Surflan 4F 3.0 lb ai/A (6) Matrix 25WG 0.125 lb ai/A and (7) Untreated Check.

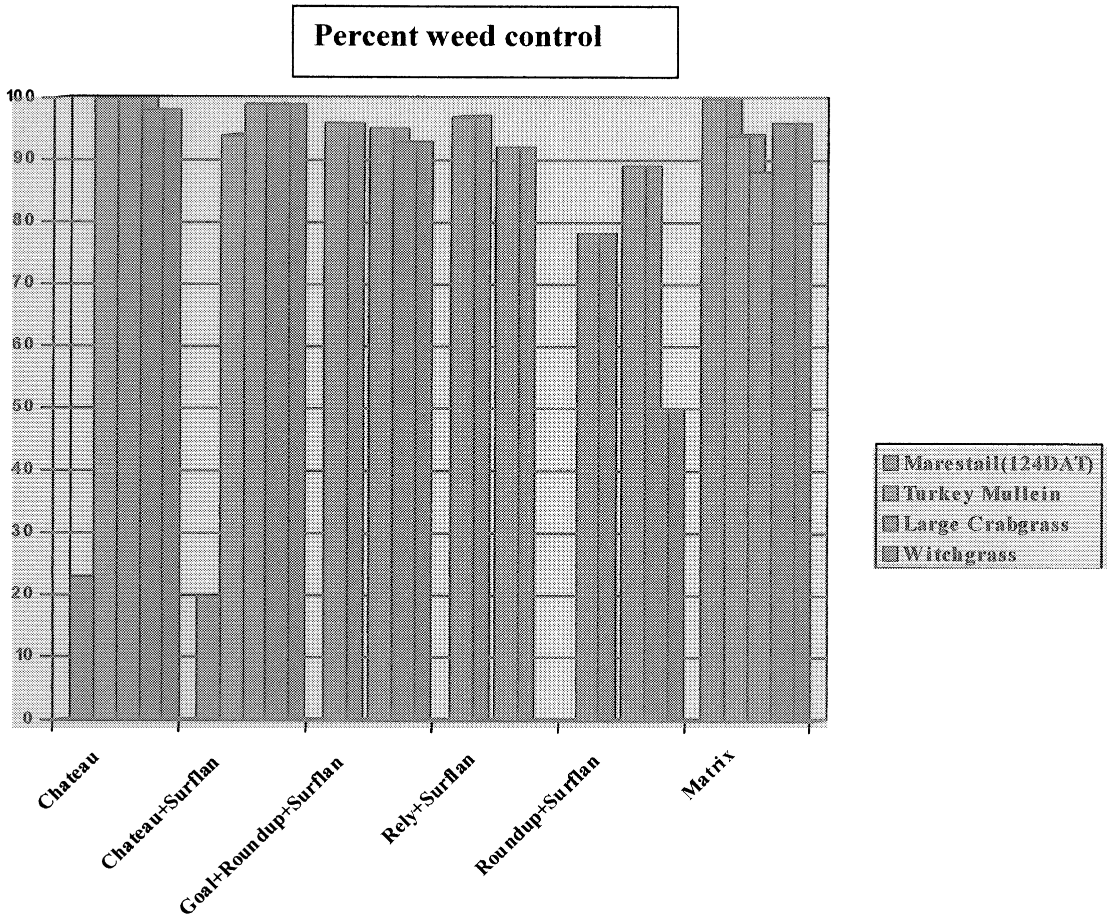
Treatments were arranged in a randomized complete block design with three replicates. Plot size was 6' X 21'. Materials were applied with a CO2 backpack sprayer, 35 psi in 40 gpa of water and Unifilm 707 surfactant added to all treatments.
Weeds emerged prior to herbicide application were as follows: common chickweed (*Stellaria media*) = 5-7" Ht. and flowering; marestail [horseweed] (*Conyza canadensis*) = 0.5-3.0" diameter, 8-16 leaves and turkey mullein (*Eremocarpus setigerus*) = preemergence to cotyledon, 0.25" diameter.
Treatments were applied preemergence to witchgrass (*Panicum capillare*) and large crabgrass (*Digitaria sanguinalis*).

Conclusion

All weeds had emerged prior to applications except for large crabgrass and witchgrass. Matrix showed post and pre-emergence activity on marestail and turkey mullein and gave pre-emergence control of large crabgrass and witchgrass. Chateau was weak on emerged marestail with good control of turkey mullein pre and post emergence. Chateau provided excellent preemergence controlled of large crabgrass and witchgrass. Goal + Roundup + Surflan resulted in excellent control of the grasses with poor control of mullein. Rely + Surflan was excellent on marestail, crabgrass, witchgrass and poor on turkey mullein. Roundup + Surflan treatments gave excellent control of large crabgrass, fair on marestail with poor activity on mullein and witchgrass.
In many vineyards because of the numerous weed species, herbicide tank mix combinations will be needed to obtain complete weed control. Applying herbicides early when weeds are small will allow for less herbicide use, better performance, a cleaner berm and lower cost.
Chateau and Matrix are new herbicides that are not included on DPR's 6800 list of ground water restricted herbicides.

Percent weed control




Percent weed control
100
90
80
70
60
50
40
30
20
10
0
Marestail(124DAT)
Turkey Mullein
Large Crabgrass
Witchgrass
Chateau
Chateau+Surflan
Goal+Roundup+Surflan
Rely+Surflan
Roundup+Surflan
Matrix

The Impacts of Weeds and Control in Newly Planted Alfalfa

Mick Canevari, Don Colbert, Randall Wittie, Scott Whiteley
University of California, Cooperative Extension, San Joaquin County

Introduction

Weed control is generally the first major decision that has to be made after the alfalfa germinates. It is common for multiple weed species to germinate in a new alfalfa stand. One herbicide alone may not provide acceptable control of all species allowing the uncontrolled weeds to flourish and reduce alfalfa yield, stand and hay quality. Identifying weed populations at the two-leaf stage of alfalfa growth will allow a better herbicide choice or combination of herbicides to increase the spectrum of control. A delayed and uninformed decision will result in poor weed control, alfalfa injury and a economic.

Excessive weed competition in new alfalfa plantings can cause irreversible damage to the productivity of the stand. Weeds compete with alfalfa seedlings for water, nutrients and light. They retard alfalfa growth, impede root development and reduce yield and stand. Keeping alfalfa weed free from planting through harvest improves harvest efficiency, expands marketing opportunities and produces hay that commands a higher sales price. The presence of poisonous weeds such as common groundsel (*Senecio vulgaris*), coast fiddleneck (*Amsinckia intermedia)* and hemlock (*Conium maculatum*) further reduces the hay's value and makes it unmarketable, since these poisonous weeds can cause various sicknesses or even death in livestock.

Objective

The research trial was conducted to: (1) evaluate several postemergence herbicides for broad spectrum weed controlin seedling alfalfa; (2) evaluate weed control combining herbicides; Raptor, Pursuit, Buctril, Butyrac and Prowl; (3) evaluate crop tolerance to herbicides, alfalfa yield and stand loss due to weed competition.

Alfalfa Tolerance All herbicide treatments were very safe to alfalfa except for Gramoxone Max which resulted in severe leaf burn.
Weed Control Overall, herbicide combinations provided better weed control than herbicides used alone (Figure 1& 2).
Alfalfa and Weed Yields (Dry Weights)
First Cutting 4/14/05. The highest alfalfa yields were the two or three way herbicide combinations (Table 1).
Second Cutting 6/10/05. The highest yielding (Lb/A) treatments were treatments which included Raptor and/or Pursuit in combination with other herbicides.

Table1. Alfalfa and weed yield with various postemergence herbicides and tank mixtures in seedling alfalfa.

Treatment[1]	Rate lb ai/A	Alfalfa and Weed Yield – Lbs/A ....First Cutting...... Alfalfa	Weeds	....Second Cutting... Alfalfa	Weeds	Plant Stand /ft[2] 151Days[3]
Weed Pharma[2]	20 gpa	60	6660	200	700	3
Pursuit + Buctril	0.094 + 0.375	3100	1040	2220	120	9
Pursuit + Butyrac	0.094 + 0.75	3720	700	2640	40	13
Pursuit + Prowl	0.094 + 1.0	1800	2380	2540	140	10
Raptor	0.047	3380	2120	2480	0	10
Raptor + Pursuit	0.024 + 0.024	3180	2000	2640	0	10
Raptor + Pursuit	0.032 + 0.032	3660	960	2700	20	11
Raptor+ Pursuit + Prowl	0.032 + 0.032 + 1.0	3780	520	2980	20	12
Raptor + Buctril	0.047 + 0.375	3540	200	3220	0	10
Raptor + Buctril + Prowl	0.047 + 0.375 + 1.0	3240	100	3340	40	12
Raptor + Butyrac	0.047 + 0.75	3600	120	2540	0	10
Raptor + Butyrac + Prowl	0.047 + 0.75 + 1.0	3280	140	3000	0	11
Raptor + Prowl	0.047 + 1.0	2620	440	2740	0	11
Pursuit	0.094	2580	2800	2280	40	9
Buctril	0.375	340	4800	520	400	5
Gramoxone	0.188	180	5260	1240	420	10
Butyrac	1.0	1600	2640	2400	20	8
Untreated check	-	180	5120	380	880	2
LSD (0.05)		600	940	420	280	1.9

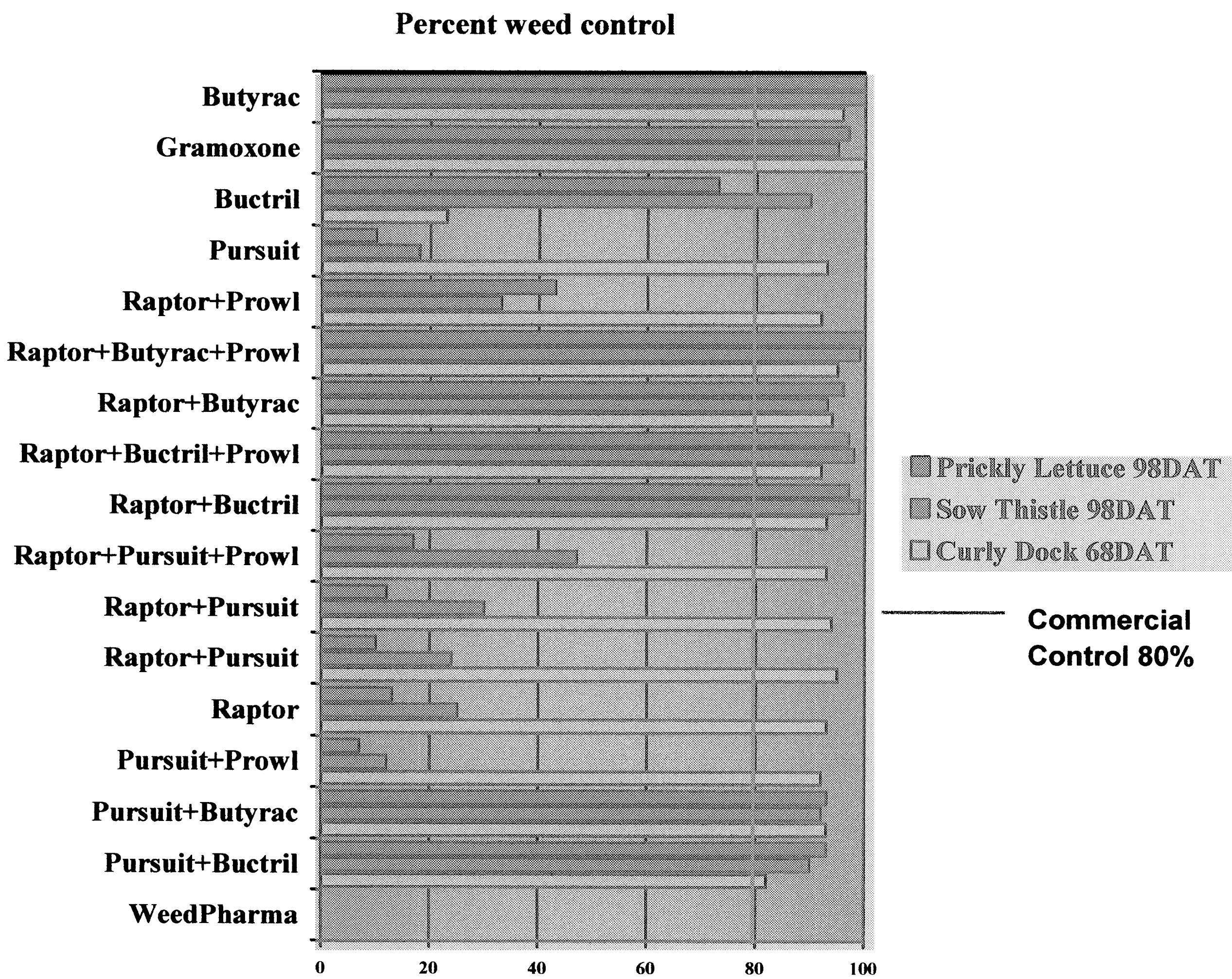
[1]Unifilm 707 (NIS) added to paraquat at 0.125% V/V. All other treatments Unifilm 707 0.25% V/V + UN32 1.25% V/V.
[2]Applied at 20 gallons of product/acre; no adjuvant added.
[3] 151 days following herbicide applications

Summary
All herbicide treatments showed good alfalfa tolerance except for Gramoxone which resulted in some severe necrosis with recovery prior to the 1st cutting. Buctril and Weed Pharma treatments reduced the alfalfa populations similar to the untreated check. Plant loss was due to severe weed competition which shaded and killed alfalfa seedlings.
In general, the best herbicide treatments for overall weed control were tank mixtures which broaden control of weed species; (1) Raptor + Buctril + Prowl, (2) Raptor + Buctril, (3) Raptor + Butyrac, (4) Raptor + Butyrac + Prowl, (5) Pursuit + Buctril, (6) Pursuit + Butyrac and (7) Gramoxone.
Treatments with the highest alfalfa yields were Raptor + Pursuit + Prowl, Pursuit + Buctril, Raptor + Pursuit, Raptor + Butyrac and Raptor + Buctril. Alfalfa to weed ratio was very low for Buctril, Gramoxone and Acetic Acid and similar to the Untreated Check. All herbicide treatments with Pursuit and Raptor combinations resulted in the highest alfalfa yields and populations at both harvest.

Conclusion
Due to the selective nature of today's herbicides, combining one or more into the same application should be considered when a broad diversity of weeds are present. Using a single selective herbicide may not control all weeds allowing the uncontrolled to flourish.

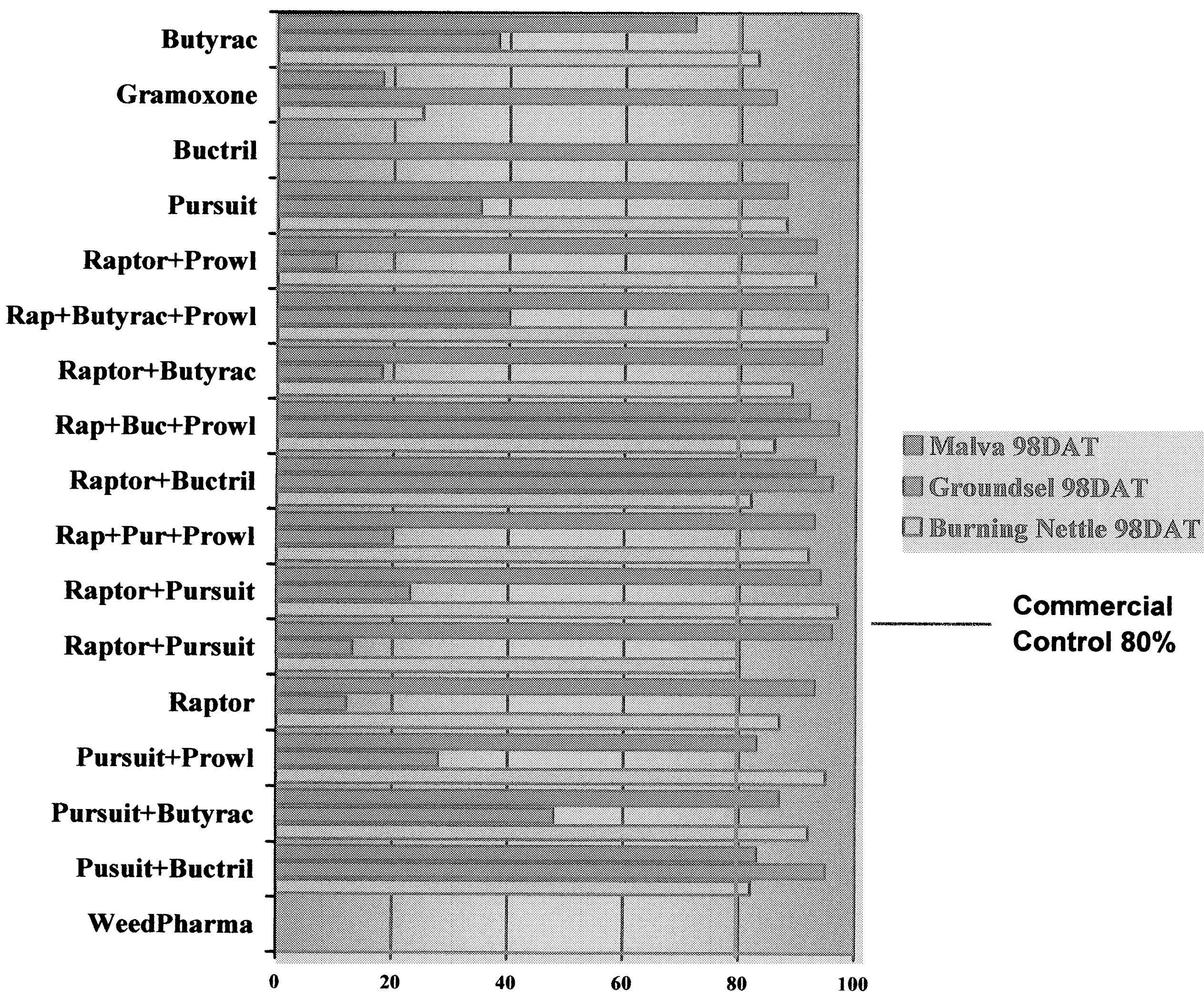
Herbicide combinations will improve broad spectrum weed control and result in improved economic performance. By enhancing a broader control spectrum the yield of hay will increase as will hay quality. Removing weed competition from a new seedling stand will result in a higher alfalfa population to establish.

Acknowledgements
Appreciation and many thanks are extended to John Spaletta (Alpine Farms) for his assistance, interest and patience.



Percent weed control
Butyrac
Gramoxone
Buctril
Pursuit
Raptor+Prowl
Raptor+Butyrac+Prowl
Raptor+Butyrac
Raptor+Buctril+Prowl
Raptor+Buctril
Raptor+Pursuit+Prowl
Raptor+Pursuit
Raptor+Pursuit
Raptor
Pursuit+Prowl
Pursuit+Butyrac
Pursuit+Buctril
WeedPharma
0
20
40
60
80
100
Prickly Lettuce 98DAT
Sow Thistle 98DAT
Curly Dock 68DAT
Commercial Control 80%

Percent weed control



SOLAR INACTIVATION OF SOILBORNE WEED PROPAGULES AS A TOOL FOR PRESERVING AND RESTORING NATIVE PLANT COMMUNITIES

James J. Stapleton, Statewide Integrated Pest Management Program, University of California Kearney Agricultural Center, Parlier (email: jim@uckac.edu)

Introduction

The preservation of native flora is desired in many settings, including wildlands, various types of managed or semi-managed landscapes, and nurseries. In many cases, weedy, invasive plant species threaten or encroach on the native flora, causing unwanted competition, poor aesthetics, environmental stress or toxicity, and other undesirable effects, and restoration efforts are undertaken. There are many weed control strategies available for use in ecological restoration; in warmer climates, one or more of the solar inactivation (solarization) techniques for nonchemical destruction of soilborne weed propagules may be useful.

Materials and Methods

To inactivate weed propagules in open ground settings, solarization using a single layer of clear plastic film may be used. This method is particularly effective for control of winter annual grasses (Elmore et al., 1997). At the Fay's Wildflower Meadow area at the Rancho Santa Ana Botanic Garden (RSABG) in Claremont, CA, winter annual grasses were destroying the aesthetic beauty of the California native annuals planted there each year. As a method of restoring the native species, solarization of open ground was done using transparent UV-inhibited polyethylene film. Ground was prepared by raking and sprinkler irrigation. The plastic film was then laid by hand in strips with sand placed on the seams to create a solid barrier during the solarization process, which was conducted in late summer-early fall 2004. Film was then removed and native species were seeded.

For weed control in nurseries or for small soil volumes, the double-tent method of solarization using two layers of clear plastic film is capable of providing eradication of all weed propagules within a few hours of treatment, rather than the weeks of treatment preferable for disinfestation of open ground (Stapleton et al., 2002). In remote areas or for small volumes of soil, solarization can be done simply in large plastic trash bags which are filled with moist soil, sealed, and left in the sun (unpublished data).

Results

Observations indicated that the solarization was successful at controlling the winter annual weed species and greatly improving the desired ambience of Fay's Wildflower Meadow at the RSABG (Jett, 2005). With regard to the double-tent method of solarization for production of container-grown nursery plants, in addition to being an excellent, low-cost method of eradicating weed propagules (Stapleton et al., 2002), it has been approved as a method of producing nematode-free nursery plants by the California Department of Food and Agriculture (CDFA, 2002). The double-tent method may also be used to disinfest pots, flats, etc. for reuse or to prevent dissemination of propagules in discarded materials (unpublished data).

Discussion

The effective heat dosage for weed propagule destruction during solarization is a relationship of [temperature x time], and will vary among species (Elmore et al., 1997). Advantages of solarization include ease of application and use, low cost, nonhazardous, and no synthetic pesticides necessary. Limitations include climatic, weather, shading, soil depth constraints, resistant weed propagules, possible mechanical damage to film and need for plastic disposal, and requirement for moist soil for best treatment effect (Stapleton, 2000; Stapleton et al., 2005). For resistant or deeply-distributed weed propagules, the solar techniques can be augmented by combining with other biological or chemical treatments.

Conclusions

In warmer climates, solar inactivation (solarization) techniques for soilborne weed propagules may be useful in preservation or restoration of native plant communities. In open ground settings, solarization using a single layer of plastic film may be used, while for weed control in nurseries, the double-tent method for container or small volume production is capable of providing eradication of all weed propagules. Advantages of solarization include ease of application and use, low cost, nonhazardous, and no synthetic pesticides necessary. Limitations include climatic, weather, and soil depth constraints, resistant weed propagules, plastic disposal, and requirement for moist soil for best treatment effect. For resistant or deeply-distributed weed propagules, the solar techniques can be augmented by combining with other biological or chemical treatments.

References

California Department of Food and Agriculture. 2002. Approved treatment and handling procedures to ensure against nematode pest infestation of nursery stock. Nursery Inspection Procedures Manual, NIPM Item 7. Plant Health and Pest Prevention Services, Pest Exclusion Branch, Sacramento. Available at: http://www.cdfa.ca.gov/phpps/pe/nipm.pdfs.nipm_7.pdf

Elmore, C.L., Stapleton, J.J., Bell, C.E., and DeVay, J.E. 1997. Soil solarization: A nonpesticidal method for controlling diseases, nematodes, and weeds. DANR Publication 21377, University of California, Oakland. 14 pages.

Jett, S. 2005. Solar power brings meadow blooms. Friends of the Rancho Santa Ana Botanic Garden Newsletter 20(2):5 (Spring 2005).

Stapleton, J.J. 2000. Soil solarization in various agricultural production systems. Crop Protection 19:837-841.

Stapleton, J.J., Prather, T.S., Mallek, S.B., and Ruiz, T.S. 2002. High temperature solarization for production of weed-free container soils and potting mixes. HortTechnology 12:697-700.

Stapleton, J.J., Molinar, R.H., Lynn-Patterson, K., McFeeters, S.K., and Shrestha, A. 2005. Soil solarization provides weed control for limited-resource and organic growers in warmer climates. California Agriculture 59(2):84-89. Available at: http://californiaagriculture.ucop.edu/0502AMJ/pdfs/Solarization.pdf

WEED POPULATIONS IN PERENNIAL CROP NURSERIES TREATED WITH METHYL BROMIDE AND ALTERNATIVE FUMIGANTS

Anil Shrestha, Univ. of California, Kearney Agricultural Center, Parlier
Greg T. Browne, USDA-ARS, Davis
Bruce D. Lampinen, Dept. of Plant Science, Univ. of California, Davis
Sally Schneider and Tom Trout, USDA-ARS, Parlier
Leo Simon, Univ. of California, Berkeley

Failure to control weeds with pre-plant fumigation results in high labor costs for weeding in perennial crop nurseries where PRE and POST herbicides cannot be used around the young, developing tree seedlings and cuttings. Studies were conducted at four locations in California in almond and walnut nurseries to test the effect of methyl bromide (MB) and alternative fumigants and their method of application on weed population. Treatments varied by locations and included MB + chloropicrin, iodomethane + chloropicrin (IM:PIC), Telone II, Telone C35 with HDPE, and Telone C35 with a virtually impermeable film (VIF), Inline, and a non-fumigated control. The alternative fumigants and application methods were generally effective as MB but results varied by location and were influenced by the dominant weed species present. For example, the dominant weed in Yuba City was volunteer oats and the most effective treatment was MB. All the fumigants were less effective against harder seeded weed species such as burr clover (*Medicago* sp.) and mallows (*Malva* sp.). Therefore, fumigants alone (whether MB or alternatives) will not be effective against these species unless supplemental measures are applied or developed. The alternate fumigants may provide similar weed control as MB. VIF and HDPE had similar results in these nurseries. Inline showed some benefit in the control of mallows.

Arun The Magnificent

Arun the Magnificent has performed for 36 years.
His high wire walking can make your heart stop.
He has dazzled audiences with his daredevil deeds.
His act is the best under the Cal/EPA big top.

The cable is strung between two legislative poles.
Pesticides must be beneficial for their intended use.
And walking the efficacy policy is a balancing act,
Between scientific judgment and bureaucratic abuse.

The balancing pole is the secret to the high wire act.
It's the data's weight and breadth that holds him on the wire.
Controls and replications and analysis of variation,
Provide the rotational inertia that walkers require.

But the circus wants him to perform for every show.
And to walk the wire with any kind of pole.
And sometimes all he gets is a green painted stick.
From a registrant looking for a data loophole.

Arun doesn't always trust the surly Ringmaster.
He has had run-ins with the man before.
Once he had the elephants bump the cable poles,
When Arun was walking high above the center ring floor.

When he steps out to cross the treacherous wire,
Some folks in the audience begin to cheer.
Step over step he crosses the hundred feet of cable.
And pretends he doesn't hear the crowd if it starts to jeer.

Arun has walked the wire a thousand times,
But reaching the other side you just never know.
He remembers what happened to the Flying Chemistry Brothers,
Someone cut the ropes in the middle of a show.

But now the walking cable is starting to stretch,
The efficacy policy strands are starting to fray.
And the Ringmaster thinks his act has lost its thrill.
But the high wire act may not have seen its very last day.

Old Man Leverage

A deal is made, the check is signed.
The new owner has paid a reasonable price.
But the tractor isn't sold till it's on the truck.
It's the last roll of the horse traders dice.

Now the buyer seems to be a savvy fellow,
An apple grower from over on the coast.
And his truck and trailer look study enough,
And the new winch he talks about the most.

The crawler tractor hasn't run for a few years,
And now the pony motor refuses to start.
And with those tracks and three tons of inertia,
Loading her is going to half work and half art.

She faces us off like a stubborn old bull,
You're not taking me without a fight.
And with tracks to magnify her resistance,
We might have to convince her with a stick of dynamite.

We try to drag her to a better loading site,
But the spring grass sets the truck wheels a spinning.
And now we have the truck stuck in the mud.
Something tells me, "this is only the beginning".

We finally get the truck moved to a better spot,
And we use the winch to drag her uphill.
It's better to have gravity on our side.
We'll need every ally in this test of will.

With the truck wheels spinning and grass flyin.
He backs the trailer down the narrow dirt lane.
And with the truck and trailer finally in position.
I got a little whiff of victory champagne.

With a jumper cable assist from my pickup,
The farm show winch has got her on the roll.
But then she stalled half way up on the trailer.
Her tracks have locked up in a rebar hole.

Now the morning has turned into the afternoon,
And my buyer looks like he's ready to break.
And my sweat is smearing the ink on his check.
This sale could be lost with one more mistake.

But there was an ally waiting to help us,
Do you recall college physics 1A?
The fulcrum, the plank and applied force.
This simple machine helped me save the day.

Old Man Leverage doesn't care who you are,
And he doesn't care about where you are from.
He is the simplest of the "five machines",
Old Man Leverage will work for anyone.

I grabbed two poles from a broken fence,
And blocks of wood from the back of my truck.
And we pried those tracks up the loading ramp.
She flopped on the trailer like a wounded buck.

Forty-Mile An Hour Alfalfa

I still wonder what the old man was thinking.
Why he bought this ground at the bottom of a crease.
With the Sierra Nevadas to the west,
And five hundred miles of desert to the east.

The down sloping wind really owns this land.
She's a cruel landlord always asking for more.
And you know it's her coming to collect the rent,
She starts banging on the back porch screen door.

She stampeded my wheel lines late yesterday,
One mile of sprinkler pipe was on the roll.
She ran them till they jumped all of my fences.
I found them wrapped around their favorite power pole.

Now I own one mile of "hippe" pipe art,
with a big "wowie" in every piece.
I guess I call "Scrape Iron Eddie".
He might pay extra for a nice mantle piece.

And my bales are FOB[1] at the neighbors again.
I can't help it if he's downwind from my ranch.
And I know he gets tired of selling my hay.
I'll return the favor if I ever get the chance.

Why I keep farming,
I just don't even know.
Because 40 mile an hour alfalfa,
It is the toughest hay to grow.

Now some storm clouds are moving up from the south,
A little moisture would help settle the dust.
But the promise of rain was just a joke.
She swept it away with a 50 mph gust.

And she lets the dust devils, play on the ranch.
Her juvenile nephews are rotten to the core.
And when they get done running in my windrows,
I've got nothing but an alfalfa eyesore.

Now the harvest ants and the horned toads,
They've got it figured, no doubt.
Just let her blow till she's tired,
And then you can just dig yourself out.

And I wish I could join those lucky horned lizards.
At least they've got somewhere to go!
Because I'm trapped up here in my pickup,
Till the landlord collects the rent that I owe.

Now I just loaded 20 tons of discounted hay,
As more TDN[2] disappeared in the wind.
And now my eyeballs need a good washing out.
And my brain just wishes it would end.

How can one place have, this much wind?
Isn't there somewhere else it needs to blow?
Because this 40 mile an hour alfalfa.
It's gotta be the toughest hay to grow!

Now the roof on the hay barn left last night.
And tumbleweeds are pushin my fences down.
I think the landlord is trying to tell me something!
I think it's finally time to move into town!

---

1 FOB –Freight On Board, the price of hay at the ranch.
2 TDN –Total Digestible Nutrients, A grading system for hay. Most of the digestible nutrients are present in the leaves.

YOU CAN'T FARM WITH AN AEROSTAR

Well, I bought this piece of ground ten years ago,
To build some city boy dreams.
I cleared the sage and planted the seeds.
This farming, it can't be as hard as it seems.
And I got the name of a local farmer,
Someone I might try to befriend.
To answer all my crazy questions,
And the things I couldn't comprehend.

Now he always acts surprised,
Every time that I drive up.
Because everybody he knows,
Drives a pickup truck.
So he hides out in his shop,
Hoping I will just drive away.
Until he realizes it's me,
And not some tourist from the highway.

When he finally offered me some neighborly advice,
He didn't mean me any harm.
"David, buy the pickup first!
Then start the farm".

Well, I prayed for the snow and the spring rain.
I learned that water is precious indeed.
And I learned that a farmer has to experiment,
If he is ever going to succeed.
But after four years of worry and sweat,
I am going to have to concede.
The only crop I can seem to grow,
Is a new kind of jackrabbit feed.

So I asked him, "What am I doin wrong?
Is there something I cannot see?"
He stared at the ground, took a deep breath,
And then he told me.
"IT'S THE CAR!
YOU CAN'T FARM WITH AN AEROSTAR!"

"Now you better stay off the highways,
When those cold winds start to blow.
Because that's a California car.
It doesn't like the snow.
Or always carry your tire chains,
Flashlight and poncho.
Unless you like driving sideways,
Where ever you try to go."

"And I know that sliding door opens wide,
And those seats, they do come out.
And you can just fit a pair of calves inside,
From the tail to the snout.
But if you desecrate the family car,
Your wife is going to shout.
And you better not drive in the carpool,
Until all that poop dries out."

"And when you take those rear seats out,
There is plenty of room in back.
For your tools, pesticide cans,
And your handyman jack.
But, you better pray the Lord is with you,
If you ever get in a wreck.
Because that load you have been a carryin,
You will be wearing around your neck!"

"So you had better hire a good lawyer.
And write a brand new will.

Because if your tools don't getcha,
That 2,4-D will!"

"Ah tell ya, IT'S THE CAR!
YOU CAN'T FARM WITH AN AEROSTAR!"