California Weed Science Society

Journal

Information on Weeds and Weed Control from the California Weed Science Society

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IN THIS ISSUE

Introduction

This issue of the California Weed Science Society Journal focuses on weed control issues in trees and vines. There are several newly registered materials for use in these crops and they are discussed in this issue. These new materials are a welcome addition to the weed control options already available for these crops. In addition, is an article on reducing drift of herbicides in vine crops and the development of distinct weed communities under various weed control strategies. To round out this issue there is a research report on medusa head control, as well as a summary of the scholarship awards given to deserving students at the CWSS annual meeting in January in Monterey.

Be sure to mark your calendars for the CWSS annual meeting in Santa Barbara on January 23-25, 2012 (for information visit the website at http://www.cwss.org).

Maximizing Herbicide Performance in Tree, Nut, and Vine Crops

Kurt Hembree, Farm Advisor, UC Cooperative Extension, Fresno County

Herbicides play a vital role in weed management efforts in tree fruit, nut, and vine crops throughout California. When herbicides are used correctly, they provide growers with effective weed control at an affordable price. However, when herbicides are not applied according to label directions, or are used in a careless manner, weed control may suffer and crops and/or other desired vegetation may be damaged. Many factors must be considered before selecting and applying herbicides. Some of the important ones include correctly identifying specific weeds being targeted, achieving uniform spray coverage, making sure the spray equipment is calibrated and working correctly, and employing an applicator who demonstrates the care, attitude, and skills necessary for getting the job done right the first time. Herbicides won't perform properly if any of these or other important factors are neglected. *The goal of applying herbicides* should be to deliver the proper dose of spray carrier, herbicide(s), and spray additive(s) (if required) to the target area accurately, uniformly, and efficiently. By doing so, one should expect to achieve reliable herbicide performance and crop safety.

Fortunately, many pre- and postemergent herbicides are available for use in tree fruit, nut, and vine crops in California, all of which can provide safe and reliable weed control at an affordable price, that is, if the treatment reaches the target area (soil and/or weeds). It's important to understand that when a portion of the spray mix does not make it to the target area, but lands somewhere else, the actual dose of herbicide reaching the target area will be lower than calculated. This can result in weed escapes or erratic control, plant injury, and a waste of herbicide and time. In some cases, a misapplication may be simply due to plugged, worn, or damaged spray nozzle tips, resulting in poor coverage and reduced weed control. In other cases, spray drift leaving the application site, can deposit herbicides onto the foliage and/or fruit of desired plants, potentially causing significant damage, as shown in chart 1.

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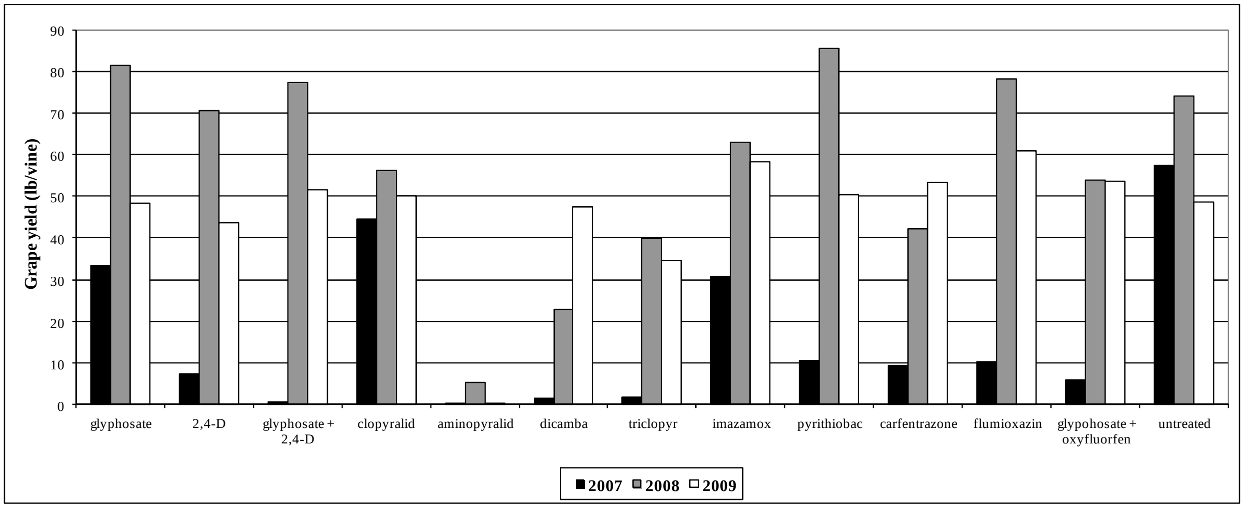
Chart 1. Yield of grapevines when four-inch shoots were exposed to postemergent herbicide spray drift



Once herbicides and rates have been selected for a particular spray job, consideration needs to be given to several application techniques to ensure the herbicide treatment performs according to expectations: select appropriate spray nozzles, pressures, and spray volumes for the different herbicide types; make good herbicide-soil contact; treat emerged weeds when they are young; and spray when conditions are favorable.

First, select appropriate spray nozzles, an operating pressure, and a spray volume intended for the herbicide type(s) used. This will help ensure the spray solution reaches the target area as uniformly as possible. While spray nozzles are the cheapest part of any spray operation, they are often the most overlooked component. Spray nozzles are highly engineered and designed to deliver a given droplet size in a uniform spray distribution pattern at a given spray pressure. Spray nozzle choice *directly affects* droplet size, application uniformity, spray coverage, and drift potential, which *directly impacts* weed control, economics, and environmental quality.

Since spray droplet size directly affects spray drift potential, selecting spray nozzles and an operating pressure that minimizes off-target drift is necessary. Spray droplets <200 microns in diameter are light, remain airborne a long time, and are the most susceptible to drift. Spray droplets <200 microns in size are referred to as "fine" or "very fine" (table 1). While droplets of this size aid spray coverage, they are readily affected by wind speed, travel speed, and sprayer pressure, so are discouraged for use in most weed sprays. "Medium" and larger-sized spray droplets are heavier and less likely to drift, so are recommended for herbicide sprays. Figure 1 illustrates the difference in drift potential between fine and medium-sized spray droplets. Other factors influencing spray drift include environmental conditions, spray height, and herbicide volatility.

Spray droplet diameter (µm)	Spray droplet category	Example
10	---	Dry fog
<145	Very fine (VF)	Wet fog
145 – 225	Fine (F)	Fine mist/ drizzle
226 – 325	Medium (M)	Very fine rain
326 – 400	Coarse (C)	Fine rain
401 – 500	Very coarse (VC)	Light rain
>500	Extremely coarse (XC)	Medium rain
1000	---	Heavy rain

Table 1. Spray droplet size by category.

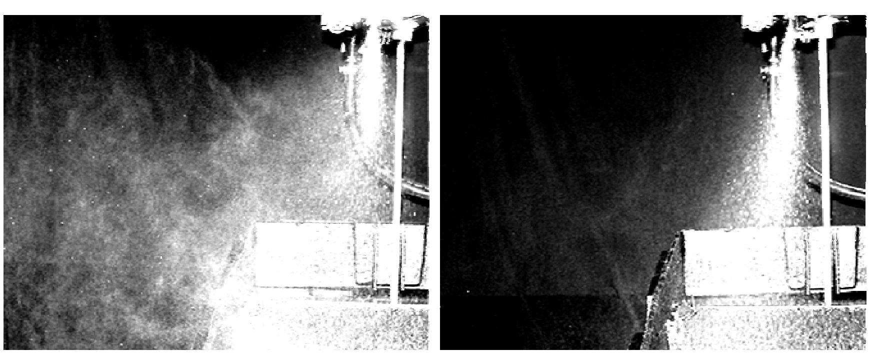


Fig. 1. Spray drift from fine-sized droplets (left) and medium-sized droplets (right).

To help maximize on-target spray delivery, nozzles and an operating pressure should be selected to produce spray droplets that are small enough to provide enough coverage, but large enough to reduce spray drift. For contact herbicides, nozzles and a pressure that produce medium-sized droplets are usually ideal, while coarse and larger sized droplets are more practical for systemic and

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preemergent materials. While the extended range (XR) flat fan spray nozzle is a fairly old design, it has been the standard for ground applications for years, but they are probably the least efficient (>80%) when it comes to reducing spray drift potential, particularly when operated at a pressure of 30 psi and higher. To help reduce spray drift, XR flat fan nozzles should be operated at a spray pressure of 15 to 20 psi. More recent spray nozzle designs (including chamber or turbo and venturi or air induction) have led to reduced spray drift without sacrificing herbicide performance. Several spray nozzle types are listed in table 2, comparing their abilities to aid spray drift management and be used with different herbicide types. As a general rule, use spray nozzles and an operating pressure that produce medium to very coarse spray droplets.

Spray nozzles that have an orifice size larger than 02 (0.2 gpm flow rate) should be used to minimize plug-ups and keep droplets at 200 microns or larger in size. Additionally, keeping the spray volume at 30 gpa and higher is helpful for maintaining adequate wetting of the soil and/or weed foliage. The time and money spent choosing appropriate spray nozzles is cheap compared to the investment in herbicide product, application equipment, and problems arising from a poor spray job. Also, plugged, worn, or damaged spray nozzles should be replaced, as they can greatly hinder the uniformity in spray coverage. Water-sensitive spray cards can be helpful in determining whether or not the nozzles are delivering a uniform pattern of spray droplets.

Table 2. Spray nozzle type comparisons.

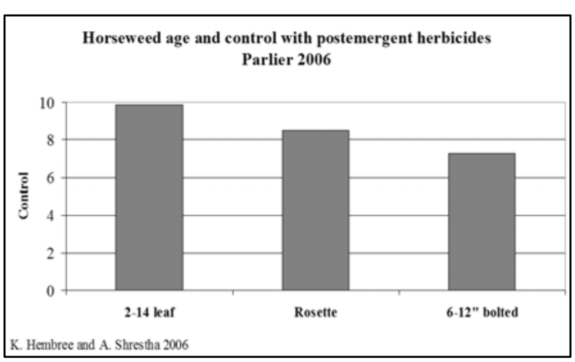
Spray nozzle design	PSI	Spray droplet size*	Drift management rating	Herbicide type (preemergent)	Herbicide type (systemic)	Herbicide type (contact)
Extended Range (XR)	15 - 60	F - C (15 psi) VF - M (50 psi)	Very good (15-20 psi) Good (>30 psi)	Excellent	Good to very good	Good to excellent
Off-center	30 - 60	M - VC	No information	Very good	Good	Poor
Turbo TeeJet	15 - 90	M - XC	Excellent (<30 psi) Very good (>30 psi)	Very good	Very good to excellent	Good to very good
Drift Guard TeeJet	30 - 60	F - C	Very good	Very good	Very good	Good
Air Induction	30 - 100	C - XC	Excellent	Very good	Excellent	Good
Air Induction XR	15 - 90	M - XC	Excellent (<30 psi) Very good (>30 psi)	Very good	Excellent	Very good
Turbo TeeJet Induction	15 - 100	XC	Excellent	Good	Excellent	Poor
TwinJet	30 - 60	VF - C	Poor	Good	Good	Excellent
Drift Guard TwinJet	30 - 60	F - C	Very good	Very good	Excellent	Very good
Turbo TwinJet	20 - 90	M - XC	Excellent (<30 psi) Very good (>30 psi)	Very good to excellent	Excellent	Very good to excellent

*VF = very fine, F = fine, M = medium, C = coarse, XC = extremely coarse

Information presented here was obtained from Spraying Systems Company TeeJet Technologies catalog No. 50 and test plot observations. For additional information regarding spray nozzle selection and use, refer to the manufacturer's website (www.teejet.com) or other places where spray nozzles are sold.

Second, preemergent herbicides require good soil contact to perform properly. Any barriers on the soil surface, such as leaves, dried weeds, or other debris, that prevent the herbicide from reaching the soil surface can result in erratic weed control. Some preemergent products, like flumioxazin, oxyfluorfen, and oryzalin, adhere tightly to weeds and other organic matter debris and may not be washed into the soil surface adequately, resulting in spotty weed control. In other cases, windy conditions may blow soil surface debris that are covered with the herbicide from the site before a rainfall event can adequately wash the herbicide into the soil and activate it. Mechanically blowing off tree and vine rows before preeemergents are applied can help resolve this issue. Once the soil has been treated with preemergent herbicides, foot traffic should be minimized to enhance the integrity of the treatment. Pruning trees or vines and removing the cuttings should be performed prior to herbicide treatment.

Third, emerged weeds are easier to kill when they are small and tender, so postemergent materials should be applied as soon after emergence as practical. If a prolonged period of dry weather or lack of soil moisture occurs after weed emergence, weeds may become droughty or stressed and become more difficult to kill. Treating shortly after emergence helps resolve this issue. Older weeds will have dense foliage and generally woodier stems, requiring a higher spray volume and herbicide rate. Additionally, larger weeds may re-grow after treatment, often requiring a follow-up treatment for complete control. Treating large weeds also increases the risk of spray drift because the spray nozzles and/or spray boom needs to be raised to compensate for the taller weeds.



Finally, herbicides should only be applied when conditions favor maximum performance. Consideration needs to be given to both equipment and environmental factors. Spraying during optimal conditions will help reduce the likelihood of spray drift so more of the carrier and herbicide

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reaches the target site. Table 3 shows various application and environmental factors that affect spray drift and herbicide performance. Before spraying, one should always follow the spray nozzle manufacturer's recommended height, spacing, and operating pressure, then apply in accordance with the herbicide label.

Table 3. Factors that influence spray drift and herbicide performance.

Factor	Favors more drift and reduced herbicide performance	Favors less drift and desired herbicide performance
Spray equipment factors		
Nozzle type (droplet size)	Fine and smaller-sized droplets	Medium and larger-sized droplets
Nozzle orifice size	02 and less	03 and larger
Nozzle height	Higher	Lower
Spray pressure	>40 psi	<40 psi
Travel speed	>6 mph	3-6 mph
Environmental factors		
Wind speed	0 to 3 mph and >7 mph	3 to 7 mph
Air temperature	>85 °F	<85 °F
Relative humidity	Lower	Higher
Air stability	Vertically stable	Vertical movement
Herbicide volatility	Volatile chemistry	Non-volatile chemistry

Alion™: A New Pre-Emergent Herbicide for the TNV Market

Ryan Allen, Bayer CropScience

Alion™ is a newly-registered herbicide from Bayer CropScience that provides long-lasting residual weed control when applied prior to weed emergence. Indaziflam, the active ingredient of Alion, is a new and unique chemistry that is effective against both broadleaf and grass weed species alike. Alion is currently registered and available for use in California tree nuts and pistachios, pome fruit, stone fruit, and citrus.

Mode of Action: Indaziflam belongs to the alkylazine chemical class, and is classified by HRAC and WSSA as a Group L and Group 29 herbicide, respectively. Group 29 was recently created by WSSA for the alkylazine class specifically, and indaziflam is the only active ingredient currently available in this class. Indaziflam is a cellulose biosynthesis inhibitor (CBI) and prevents the emergence of weeds from seed. Alion is primarily effective when applied pre-emergent, as effect on developed leaves and tissue is minimal.

Weeds Controlled: Alion is effective against a wide range of broadleaf and grass weed species. Additionally, it is also effective against ACCase-, ALS-, triazine-, and glyphosate-resistant weeds, as no cross-resistance has been observed with Alion. The list of controlled weeds is constantly being updated as data becomes available on Alion's effectiveness against additional species. Below is the current EPA-approved list of weeds controlled by Alion (Please note that not all listed weeds are on the current California-approved container label as of yet):

GRASS WEEDS CONTROLLED

• Barley, mouse	• Crabgrass, large	• Goosegrass	• Panicum, Texas
• Barnyardgrass, common	• Crabgrass, smooth	• Guineagrass	• Ryegrass, annual
• Bluegrass, annual	• Crowfootgrass	• Junglerice	• Ryegrass, Italian
• Brome, downy	• Cupgrass, southwestern	• Lovegrass, tufted	• Sandbur, southern
• Brome, foxtail	• Foxtail, giant	• Millet, wild proso	• Signalgrass, broadleaf
• Brome, rigid	• Foxtail, green	• Oat, wild	• Sprangletop, bearded
• Cheat	• Foxtail, yellow	• Panicum, fall	• Sprangletop, Mexican

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BROADLEAF WEEDS CONTROLLED

- Amaranth, spiny
- Buckwheat, wild[1]
- Burclover, California[1]
- Buttercup, corn
- Carpetweed
- Catsear, spotted
- Celery, wild[1]
- Chickweed, common
- Chickweed, mouse-ear
- Clover, crimson[1]
- Clover, red[1]
- Clover, white[1]
- Cudweed, purple
- Dandelion, common (seedling)
- Eveningprimrose, cutleaf[1]
- Fiddleneck, coast
- Filaree, redstem
- Filaree, whitestem
- Fleabane, hairy
- Geranium, Carolina
- Groundsel, common
- Henbit[1]
- Horseweed (Marestail)
- Knotweed, prostrate[1]
- Kochia
- Lambsquarters, common[1]
- Lettuce, prickly[1]
- Mallow, common (Cheeseweed)
- Mallow, little (Cheeseweed)
- Melon, smell
- Morningglory, ivyleaf
- Morningglory, pitted[1]
- Mustard, black
- Mustard, wild
- Nettle, stinging
- Nightshade, American black
- Nightshade, black
- Nightshade, hairy
- Pigweed, prostrate
- Pigweed, redroot
- Pigweed, smooth
- Plantain, buckhorn
- Prickly sida (Teaweed)
- Purslane, common
- Purslane, horse
- Pusley, Florida
- Ragweed, common[1]
- Redmaids
- Rocket, London
- Sesbania, hemp
- Shepherdspurse
- Smartweed, Pennsylvania
- Sorrel, red
- Sowthistle, annual
- Sowthistle, spiny
- Spanishneedles
- Spurge, prostrate
- Spurge, spotted
- Spurry, corn
- Sunflower, common[1]
- Swinecress
- Thistle, Russian
- Velvetleaf
- Vetch, purple
- Willowweed, panicle
- Woodsorrel, common yellow[1]
- Woodsorrel, Florida yellow

[1] Indicates suppression

Application Information: The use rate of Alion is 5.0 – 6.5 fl oz/A, with an annual maximum rate of 10.3 fl oz/A. Alion is an SC formulation that tankmixes readily with other commonly-used labeled products. Since Alion offers minimal post-activity, a tankmix with a foliar herbicide such as Rely® 280 is needed for control of emerged weeds. Alion requires 0.25 inches or more of rainfall or irrigation within 3 weeks after application for proper incorporation. Thus, ideal application timing in California is during the fall when rainfall can be expected. Spray volume should be at least 10 GPA, with adjuvant selection determined by the tankmix partner requirements. Alion can be used in tree crops that have been established for at least 3 years after transplanting, and citrus trees that have been established for at least one year after transplanting. Crop tolerance has been excellent with Alion, as no phytotoxicity has been observed in any of the labeled crops when the product has been applied according to labeled directions.

Performance: Alion has been proven in numerous field trials to provide at least 6 months of residual grass and broadleaf weed control when applied at 5 oz/A. Control lasting much longer than 6 months has been observed in some instances, although it should not be expected under typical conditions. Figs. 1 & 2 below illustrate Alion's effectiveness in comparison with Matrix® and Chateau® against both grass and broadleaf weeds. This data is a compilation of 49 trials conducted over 3 years by both Bayer CropScience and independent researchers.

Fig. 1

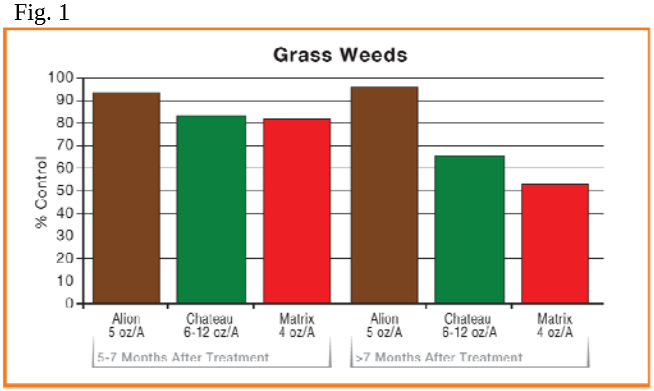
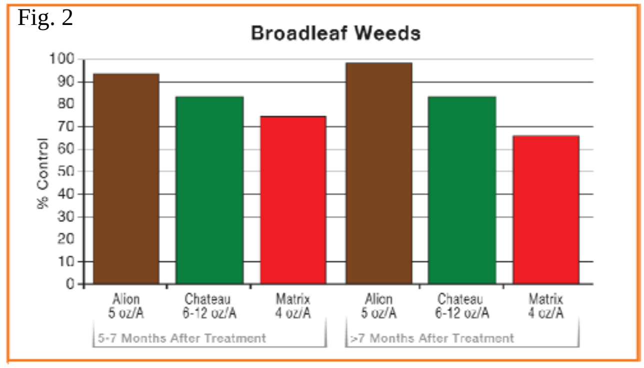


Fig. 2



Summary: Alion is newly-registered for use in California tree nuts (including pistachio), stone fruit, pome fruit, and citrus. One application of Alion at 5 oz/A prior to weed emergence can be expected to provide at least 6 months of residual control of both grass and broadleaf weeds. Alion is effective against tough weeds such as hairy fleabane and marestail, including biotypes resistant to other herbicide modes of action. Alion has excellent crop tolerance and can be readily tankmixed with other products labeled on the respective crops.

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Treevix Herbicide for Post Emergent Weed Control in Tree

Curtis R. Rainbolt, BASF Corporation, Fresno, CA, curtis.rainbolt@basf.com

In fall of 2010, Treevix® Herbicide was registered in California for weed control in tree nuts, citrus, and pome fruit. The active ingredient in Treevix is Kixor® (saflufenacil). Kixor is a protoporphyrinogen-IX-oxidase (PPO) inhibitor belonging to the pyrimidinedione class of chemistry. Kixor has activity on a very broad spectrum of broadleaf weeds but does not effectively control grasses or sedges. Although Kixor has both pre-emergence and post-emergence activity, Treevix is used only for post-emergence burndown weed control. The Kixor family of herbicides also includes Sharpen®, Verdict®, and Optill® (these products are not currently registered in California) which have both pre- and post-emergence uses in corn, soybeans, cereals, and many other crops.

An over reliance on glyphosate for weed control in tree crops has led to the selection of weed populations and species that are resistant or tolerant to glyphosate. Battling glyphosate resistant weeds such as marestail and fleabane has become the main challenge of weed control programs for many growers and pest control advisors. Because it provides effective postemergence burndown control of many difficult weeds including marestail, hairy fleabane, and willowherb, Treevix is an excellent tool for use in tree crop weed control programs. Due to a lack of activity on grasses, Treevix should be tank-mixed with a herbicide that has grass activity. In most commercial applications, Treevix has been tank mixed with glyphosate at a rate of 1 lb/A. Tank-mix combinations of Treevix and glyphosate provide excellent postemergence control of many broadleaf and grass weeds. In situations where growers do not want to apply glyphosate around young trees, Treevix has been successfully tank-mixed with paraquat or glufosinate.

Key factors for maximizing performance of Treevix in the field include weed size, carrier volume, and adjuvant selection. Similar to most burndown herbicides, Treevix herbicide works best on small weeds. Field trials have shown that 3 to 6 weeks after application, control of hairy fleabane that is less than 6 inches tall is 97% compared to only 82% when the fleabane is taller than 6 inches. When applying Treevix, increasing the carrier volume from 5 to 20 gallons per acre (GPA) also improved efficacy. Increasing carrier volume from 20 to 40 GPA did not decrease efficacy, but did not improve it in all situations. Adjuvant trials over multiple years indicate that Treevix efficacy is greatest when combined with methylated seed oil (MSO) compared to crop oil concentrates (COC) and non-ionic surfactants (NIS). Regardless of water quality the addition of ammonium sulfate (AMS) has also been shown to increase efficacy.

In summary, Treevix herbicide can provide excellent burndown control of broadleaf weeds such as marestail and hairy fleabane. Efficacy is greatest when weeds are smaller than 6 inches, carrier volume is 20 GPA or greater, and MSO and AMS are used as adjuvants.

Pindar® GT Herbicide for Weed Control in Tree Crops

J. P. Mueller[1], B. Bisabri[2], M. L. Fisher[3], M. Sorribas[4], R. K. Mann[4],
D. G. Shatley[5], J. Yerneni[4]. Dow AgroSciences

Pindar GT Herbicide (oxyfluorfen plus penoxsulam) combines two herbicidal modes of action into one product. Oxyfluorfen is a PPO (protoporphyrinogen oxidase) inhibitor in mode of action group E (Herbicide Resistance Action Committee; HRAC) and mechanism of action group 14 (Weed Science Society of America; WSSA). For many years, it has been the standard for residual weed control in tree crops. Penoxsulam is an ALS (acetolactate synthase) inhibitor in HRAC group B and WSSA group 2. It provides extended residual weed control for tree crop orchards at 2 to 3 pints/acre (0.016 to 0.032 lb a.i./acre). This combination provides broad spectrum and long lasting pre-emergence and post-emergence control of difficult to control broadleaf weeds and some major grass species. Pindar GT controls weeds which are resistant to other herbicide classes, and is now registered for use in US tree nut orchards.

More than 100 weed control efficacy trials were conducted with Pindar GT from 2004 through 2010 in US tree nuts and in open fields. These replicated experiments involved pre-emergence and early post-emergence application during tree dormancy (December through February). Based on this extensive research under a wide range of conditions, Pindar GT is known to control the most difficult broadleaf weeds infesting tree nuts: hairy fleabane (*Conyza bonariensis*), horseweed (*Conyza canadensis*), filarees (*Erodium* species) and mallows (*Malva* species). Pindar GT also controls at least 60 other weed species, including most broadleaf weeds of importance to tree nut growers. It also controls some of the major grass weeds, such as barnyardgrass (*Echinochloa crus-galli*), bromegrasses (*Bromus* species), large crabgrass (*Digitaria sanguinalis*), wild barley (*Hordeum leporinum*), wild oat (*Avena fatua*), annual bluegrass (*Poa annua*) and witchgrass (*Panicum capillare*).

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From 2004 through 2010, a large and thorough research project was conducted to document the safety of Pindar GT to tree nut crops. In addition to the efficacy trials described above, Pindar GT was tested in 37 crop safety trials in all major tree nut production areas. Many of these sites received three years of consecutive applications at up to four times the maximum label rate, which is 3 pints/acre. Tree growth, tree vigor and crop yield were assessed. Pindar GT was shown to be safe to bearing and non-bearing tree nuts when used according to label directions.

To validate these research results under commercial use conditions, Pindar GT was compared to grower standard programs in 23 large scale demonstration trials in tree nuts. Treatments were applied in the winter 2009 – 2010 dormant period in the San Joaquin and Sacramento Valleys of California. Demonstration trial participants used Pindar GT in one spray tank load and treated the rest of the orchard with flumioxazin (Chateau®) and/or rimsulfuron (Matrix® FNV) herbicides. Demonstration trial participants chose the spray adjuvant, a contact ("burndown") herbicide and a grass control product. Data collected were percent control compared to a nearby untreated area within the orchard.

The relatively high rainfall amounts which occurred in 2010 provided a challenge for residual herbicide programs. Pindar GT was shown to deliver consistent weed control across a wide range of weed species, soil types and rainfall levels. In most trials, Pindar GT performed better than the standard residual herbicide program used by the growers. Pindar GT provided four to six months control of the major broadleaf weed species infesting tree nut orchards in California, including glyphosate - tolerant populations of *Conyza* (fleabane, horseweed). No crop safety, tank mixing or tank clean out issues occurred with Pindar GT during this commercial validation project.

Based on over 100 replicated research trials and 23 large scale demonstration trials, Pindar GT performance is consistent across soil types, geography and weather conditions. The high rate provides four to six months of residual weed control. The broad weed control spectrum and pre- and post-emergence activity of Pindar GT was illustrated in these research projects. The two modes of herbicidal action in Pindar GT will be valuable for weed resistance management. An extensive crop safety research program illustrated that Pindar GT has excellent crop safety when used according to label directions.

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1. Brentwood, CA. 2. Orinda, CA. 3. Lantana, TX. 4. Indianapolis, IN. 5. Lincoln, CA.
® Pindar GT is a registered trademark of Dow AgroSciences LLC.
® Chateau is a registered trademark of Valent U.S.A. Corporation.
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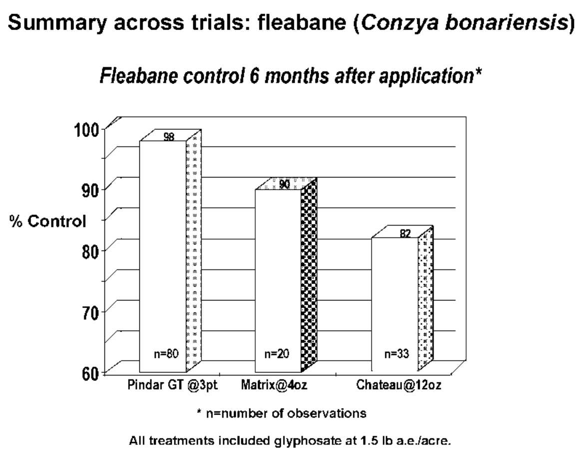

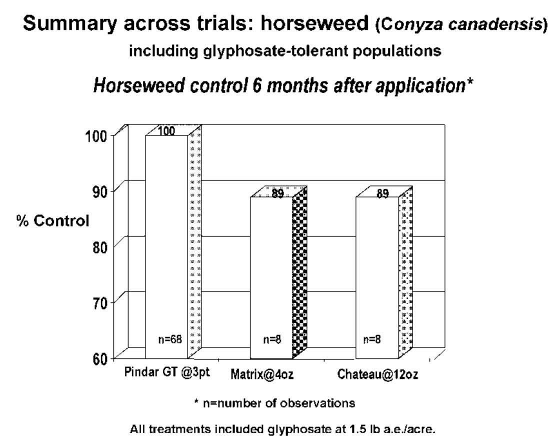

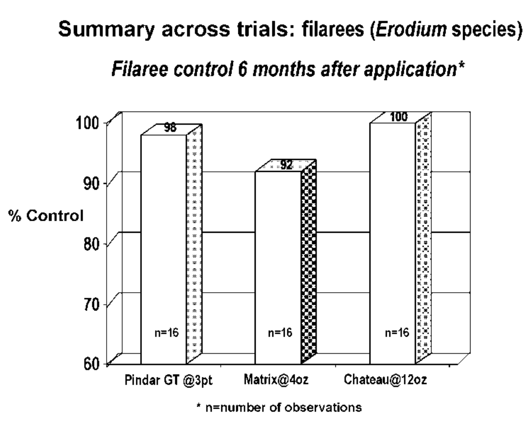

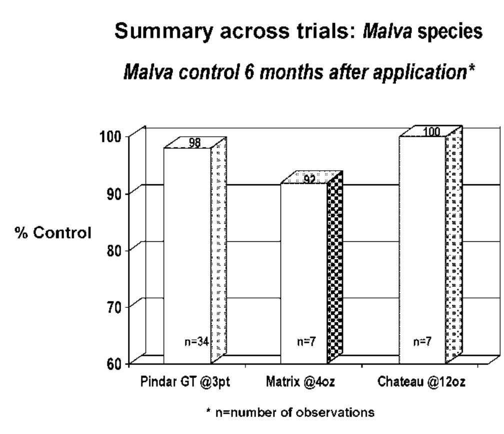

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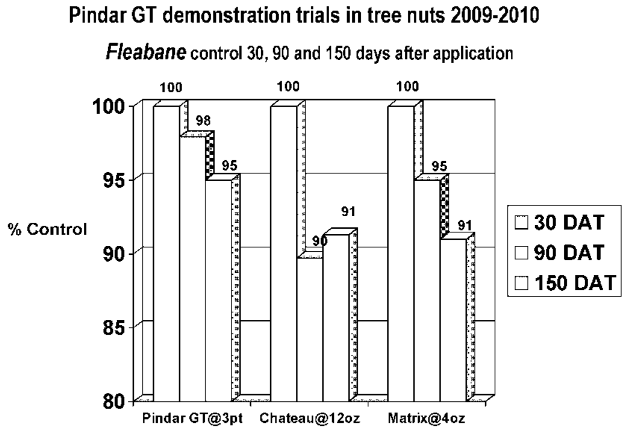
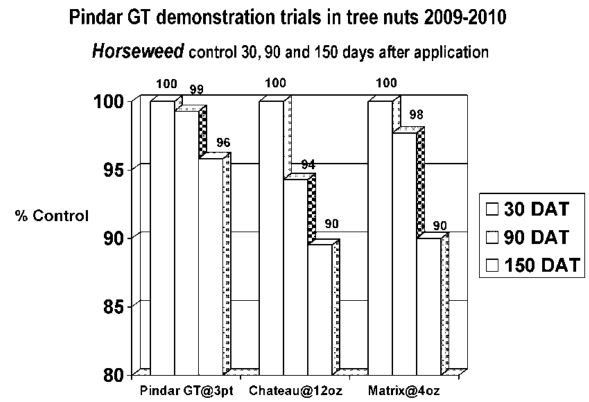
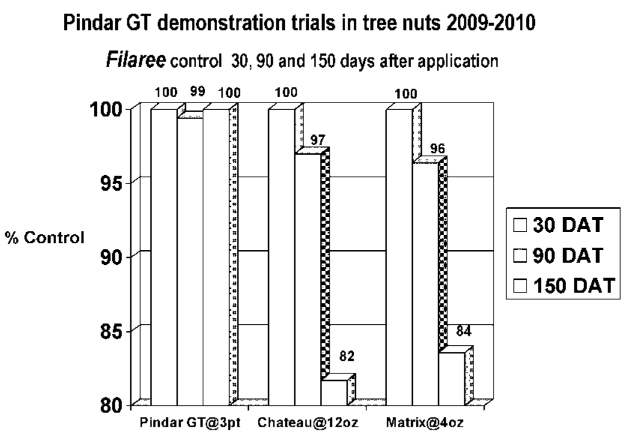
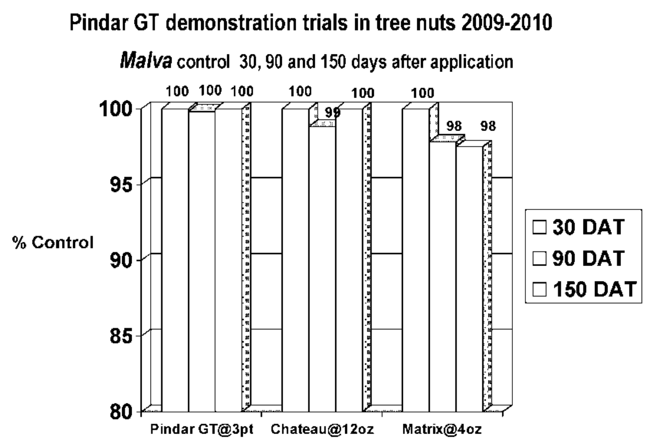
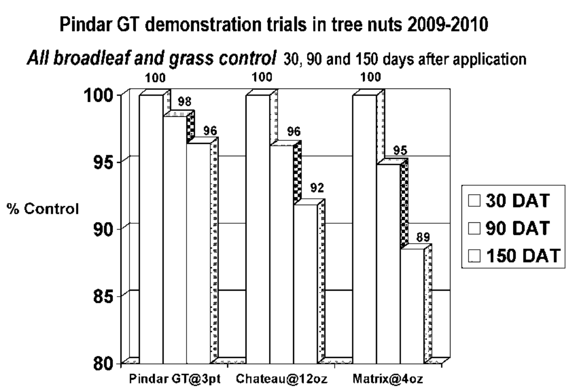


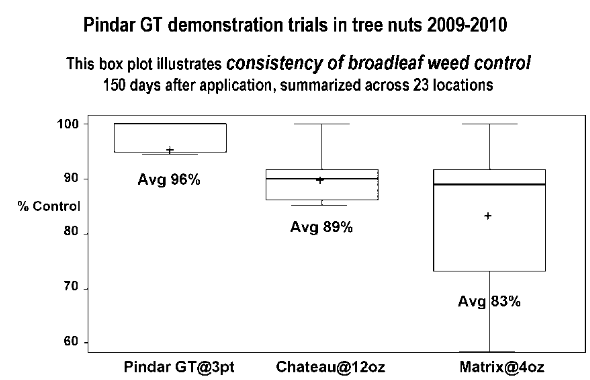








[A grass herbicide tank-mix partner was not included.]



[A grass herbicide tank-mix partner was not included.]

Weed Communities in a Wine Grape Vineyard Shift Under Three Weed Control Strategies

Richard Smith and Larry Bettiga, Farm Advisors, Monterey County

Weed control in wine grape production is an important and fundamental part of crop production. Growers manage weeds in rows to reduce competition for water, nutrients and light (Hembree et al. 2006), and to prevent tall-statured weeds such as horseweed (*Conyza canadensis* L. Cronq.) (Shrestha et al. 2007) from growing or climbing into the canopy, where they interfere with harvest. Monterey County is a low rainfall production district and controlling weeds under the vine row, where most of the root system is concentrated, is particularly important given that weeds compete with the vines for water, which is a critical and costly crop production input.

Weed control in the vineyard is primarily conducted in a 4-foot-wide swath underneath the vines. Weeds are managed

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with herbicide applications, cultural practices (e.g., mechanical cultivation and hand weeding), or a combination of the two. The row middles are vegetated by cover crops or resident vegetation in the dormant season, and are tilled or mowed in spring. The choice of weed control program depends primarily on the cost of the weed control practice, the type of production (e.g. organic vs conventional), weed spectrum and rainfall pattern.

In 2000 to 2005 we conducted a trial evaluating the impact of three weed control strategies on many aspects of vineyard floor management. In this article, we will just focus on the impact of the weed control strategies on shifts in the weed communities in each treatment over the five years of the trial.

Methods

Research site: The trial was initiated in late fall 2000 in a drip-irrigated vineyard near Greenfield, Calif., and continued through the 2005 harvest. 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. Annual rainfall normally ranges from 4 to 10 inches. Soil is elder loam with gravelly substratum. The vineyard was drip-irrigated from April to October. The site was in vegetable production prior to the establishment of the vineyard and therefore had a good population of common vegetable weeds such as shepherd's purse and purslane. The weed control strategy in the vineyard prior to the initiation of the trial was a combination of cultivation followed by post emergence applications of glyphosate and oxyfluorfen.

Experimental design: Vine row weed-control treatments were: (1) cultivation, (2) post-emergence weed control only (glyphosate at 2.0% v/v plus oxyfluorfen at 1.0% v/v) and (3) pre-emergence herbicide (simazine at 1.8 pounds active ingredient/acre [a.i./acre] plus oxyfluorfen at 1.0 pounds a.i./acre), followed by post-emergence herbicide applications (glyphosate at 2.0% v/v plus oxyfluorfen at 1.0% v/v). Cultivations and herbicide applications were timed according to grower season using a Radius Weeder cultivator (Clemens and Company, Wittlich, Germany). The cultivator used a metal knife that ran 2 to 6 inches below the soil surface cutting weeds off in the vine row; it had a sensor that caused it to swing around vines. Pre-emergence herbicides were applied in winter with a standard weed sprayer, and post-emergence herbicides were applied in spring through fall as needed with a Patchen Weedseeker light-activated sprayer (NTech Industries, Ukiah, CA).

Weed control strategies were factorially arranged with three cover crop treatments in the row middles (the cover crop treatments will not be discussed here, but for more information on this trial see Smith et al, 2008). Weed control (in-row, main plot) and cover-crop (middles, subplot) treatments were arranged in a 3 x 3 split-block design with three replicate blocks covering a total of 23 vineyard rows (7 acres). Each block contained six vine rows and six adjacent middles. Weed control treatments were applied along the entire length of each vine row (300 vines). Each replicate main plot-by-subplot treatment combination included 100 vines.

Weed evaluations: Weed evaluations were carried out at 4 to 6 week intervals through the summer by using one 100-foot long transect per plot and recording the species of weed encountered at each foot marker. The data was used to estimate percent ground cover in each plot.

Grape yield, fruit quality and vine growth: Fruit weight and cluster number were determined by individually harvesting 20 vines per subplot. Prior to harvest a 200-berry sample was collected from each subplot for berry weight and fruit composition determination. Berries were macerated in a blender and the filtered juice analyzed for soluble solids as Brix using a hand-held, temperature-compensating refractometer. Juice pH was measured by pH meter and titratable acidity by titration with 0.133 normal sodium hydroxide to a 8.20 pH endpoint. At dormancy, shoot number and pruning weights were measured from the same 20 vines.

Results

Shifts in weed communities: The three weed control strategies quickly developed differences in the number and species of weeds that survived the weed control treatments. For instance, there were more winter weeds in the cultivation treatment than the other two weed control strategies (Figure 1). This was largely due to the presence of weeds such as shepherd's purse, which were not effectively controlled at the frequency of cultivations used in the vineyard (Figure 2). In addition, the cultivation left islands of weeds next to the trunk of the vines as it swung around to avoid damaging them. By contrast, both pre and post-emergence weed control strategies used herbicides that effectively controlled nearly all winter weeds at this site.

Summer weed control was more complicated. All weed strategies had weaknesses that allowed on or more weed species to survive (Figure 3). For instance, the cultivation treatment allowed weeds such as purslane to easily survive for the same reasons mentioned above for the survival of shepherd's purse in the winter (Figure 4).

The post-emergence treatment, with the use of the combination of glyphosate and oxyfluorfen, allowed marestail to build up in 2001 and 2002. This weed became a serious problem in 2003 (Figure 5), and in 2004 and 2005, the grower included glufosinate in the mixture specifically to control this weed.

The main weed that became an issue in the pre-emergence treatment was yellow nutsedge. The simazine + oxyfluorfen followed by post-emergence treatments of glyphosate + oxyfluorfen provided partial control of this weed, but did not eliminate it (Figure 6).

One interesting observation was the development of a

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compacted layer in the soil with the use of the cultivator. Soil compaction was not significantly different at any depth in 2003 ($P = 0.420$ for all depths). However, in 2004 and 2005 soil compaction began to increase in the cultivation treatment compared to the other two weed control treatments. In 2005, the cultivation treatment had significantly greater soil compaction at the 4 to 7-inch depth than both the post-emergence and pre-emergence weed-control treatments ($P = 0.0206$), and at the 8 to 11-inch depth, soil compaction was significantly greater than the standard treatment ($P = 0.0087$), but not greater than in the post-emergence treatment ($P = 0.2884$) (Figure 7). The blade of the cultivator passes through the soil at 2 to 6 inches deep, which may explain why greater soil compaction was measured there. Cultivations often also occurred when the soil was still moist following an irrigation, which may have contributed to the development of compacted layers over time.

In spite of higher soil compaction in the cultivation treatment and differences in weed populations, no differences in crop yield or fruit composition were observed from 2001 to 2005 due to weed control treatments. Weed control treatments also had no effect on vine growth, based on shoot counts and pruning weights taken at dormancy.

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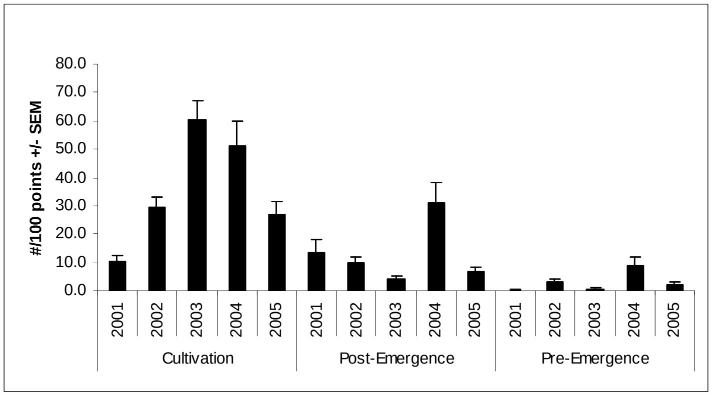

Figure 1. Total spring weeds in the three weed control strategies over five years

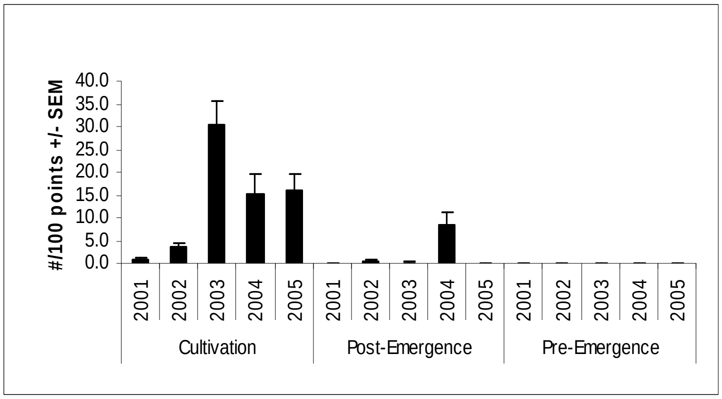

Figure 2. Shepherd's purse in the three weed control strategies over five years

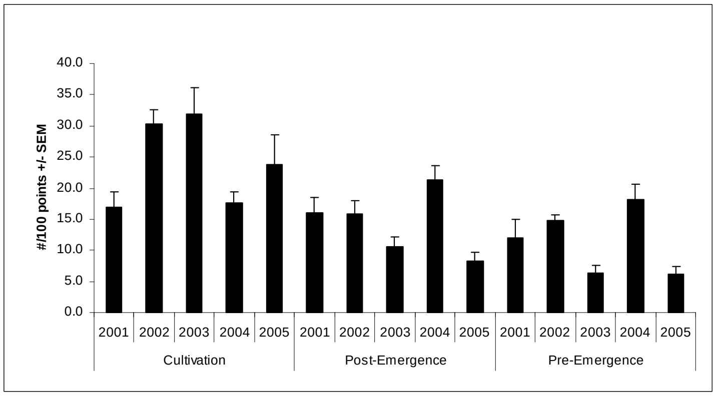

Figure 3. Total summer weeds in the three weed control strategies over five years

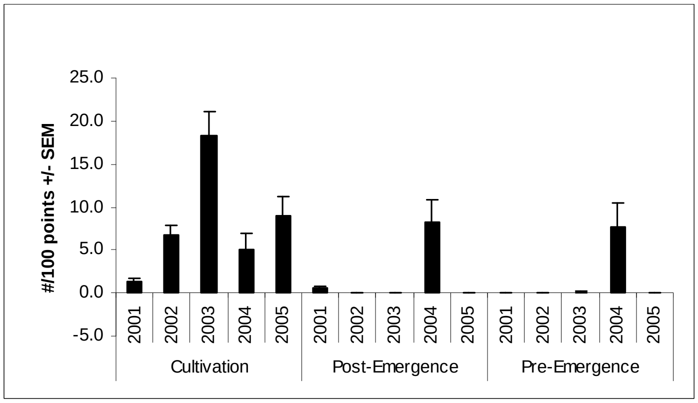

Figure 4. Purslane in the three weed control strategies over five years

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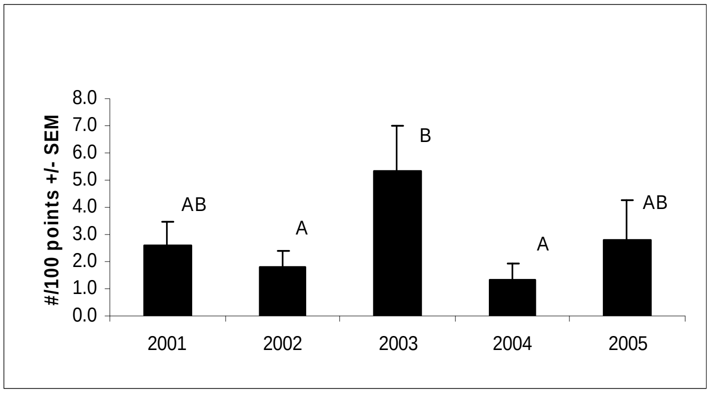

Figure 5. Marestail in the post-emergent treatment over five years

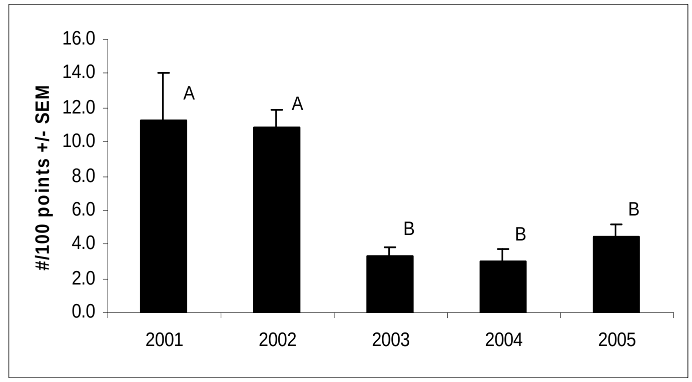

Figure 6. Yellow nutsedge pre-emergent + post-emergent treatment over five years

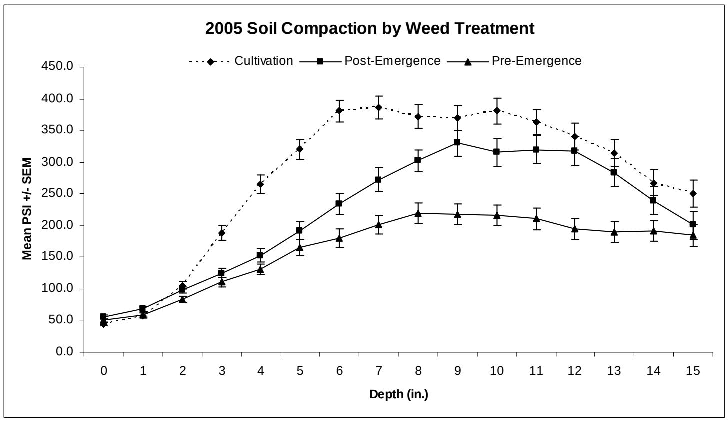

Figure 7. Impact of weed control strategies on soil compaction after five years of treatment

Tools to Control Medusahead in California

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Medusahead(Mh, *Taeniatherum caput-medusae*), an invasive grass from Eurasia, has invaded one million acres of California annual grasslands, oak woodlands, chaparral, and Great Basin grass and shrublands. Once Mh invades, it becomes a detriment to the whole ecosystem, reducing biodiversity, commercial and wildlife grazing value, and recreation value of rangelands. Reduction of medusahead will result in greater biodiversity, lower risk and intensity of fires, and greater grazing capacity.

We conducted several studies to develop novel methods to control medusahead that are cost-effective and simple. We studied precision grazing with sheep and cattle, mowing, application of glyphosate, and concentration of grazing with attractive livestock supplement. All methods are based on a detailed knowledge of the phenology of medusahead.

Medusahead phenology

Phenological information about Mh and associated species was collected in twelve sites in eleven counties of California during the growing seasons in 2006, 2007, and 2008. Medusahead is characterized by a late development relative to other species, which gives us a window to apply control methods that are not selective. By the time Mh produces inflorescences, most of the more desirable associated species have already produced enough seed to have a good stand in the next season.

After it produces an inflorescence, Mh is very unpalatable and strongly avoided by livestock. Thus, control methods must be applied late enough to allow for desirable species to reseed themselves, and early enough to prevent Mh from flowering and setting seed. These conditions restrict the time window to about 2-3 weeks in late spring.Given the short time window, land managers must forecast the time of control to get all resources ready for treatment. We classified Mhphenological stages (Table 1) and developed models to predict phenology based on location and climate factors. These models will be available at the Weed and Rangelands websites of UC Davis. The best timing for control can vary widely in the different counties in California (Figure 1).

Precision Grazing

Pastures treated with precision grazing in 2007 were measured again in 2008 to determine the ultimate effectiveness of treatments in reducing medusahead reproduction and populations. The treatments were as describe inTable 2.

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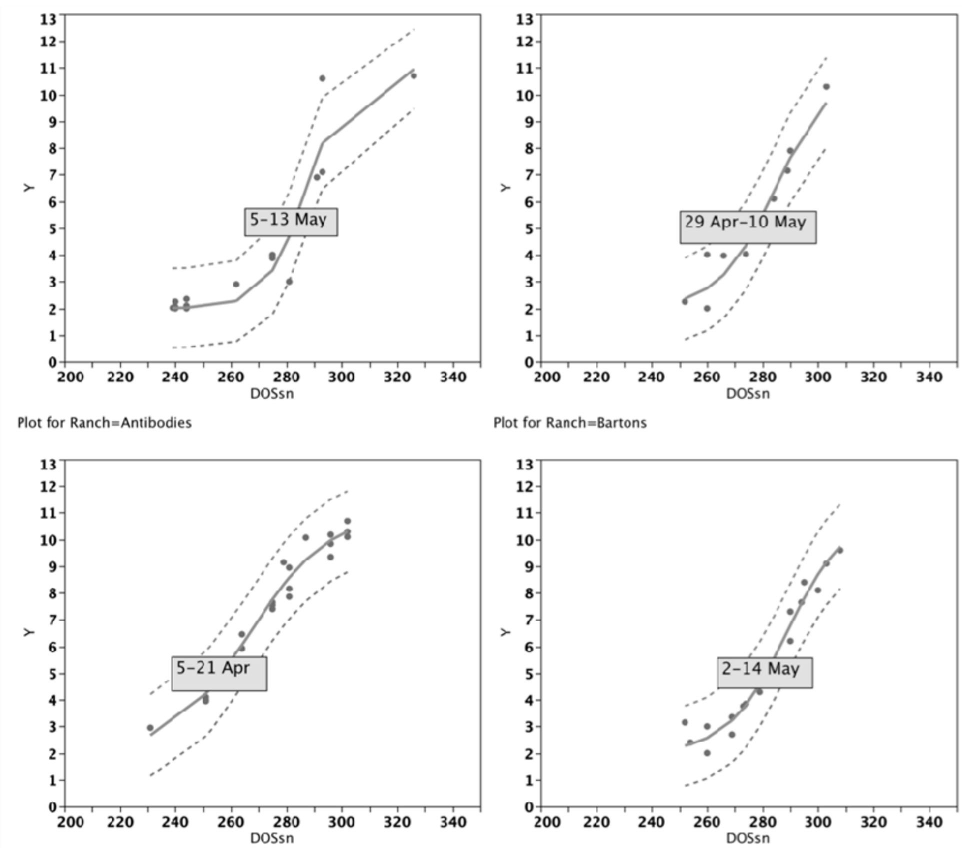

Figure 1.Phenological stage of medusahead in several Counties as a function of the number of days since the start of the season (when rainfall within a week exceeded 0.5 in.). From left to right and top to bottom: Yolo, San Luis Obispo, Stanislaus, Tehama. Boxes on graphs indicate the time of greatest susceptibility to treatment.

Statistical analyses detected no differences among treatments; regardless of the duration or level of utilization obtained. This means that even the treatments with the lowest stocking density and longest grazing duration achieved levels of control similar to those of higher stocking densities. Precision grazing was very effective in controlling medusahead. Both in 2007 and 2008, medusahead seed production in areas treated with precision high-intensity grazing was less than ¼ of seed production in areas grazed under the normal management (Figure 2). This indicates that medusahead did not recover on the season following treatment.

Grazing treatments not only reduced medusahead seed production but also reduced its cover in 2008. The reduced cover by medusahead resulted in less area covered by thatch, more area covered by other species and more bare ground. The increase in bare ground is a potentially negative effect of the high grazing intensity. The persistence of this and its consequences should be checked before the high intensity grazing can be prescribed without reserve.

Table 1.Phenological stages of medusahead. Precision grazing must be applied before stage R5. Mowing and herbicide can be applied until R7.

Stage Code	Description
V1	Plant Germinated
V2	Early vegetative, before elongation of internodes
V3	Late vegetative, elongation of internodes and boot stage
R4	From emergence of awns to full emergence of seedhead
R5	From fully emerged seedhead to opening of florets. Anthesis. Visible anthers.
R6	Anthesis to closure of florets. Beginning of kernel formation.
R7	Kernel elongation inside floret until it reaches full length.
R8	Seeds in milk stage. Kernels occupy full length of palea.
R9	Seeds in dough stage.
M10	All seeds in seedhead are mature and hard. Plants are not dead yet. There is some red, brown and green in the seedheads. Glume veins are dark.
D11	Tiller is dead and dry. Color is uniform, sandy yellowish but not grey. Seeds shatter.
L12	Grey plant remains obviously from the previous season.

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Table 2. Characteristics of the grazing treatments applied to control medusahead at the Antibodies site, Yolo County, California in 2007.

Plot #	# Days	# sheep	%use	Begin	End	Sheep-days	Feed lb	kg/Sheep-day
3	16.0	4	0.47	10-Apr-07	26-Apr-07	63.9	2.7	16
10	16.9	4	0.24	9-Apr-07	26-Apr-07	67.6	2.7	9
13	15.0	5	0.45	11-Apr-07	26-Apr-07	74.8	3.4	15
4	9.1	8	0.30	10-Apr-07	19-Apr-07	73.2	5.4	7
5	14.1	8	0.56	7-Apr-07	21-Apr-07	112.7	5.4	13
9	14.9	8	0.62	9-Apr-07	24-Apr-07	119.2	5.4	15
8	15.9	8	0.58	7-Apr-07	23-Apr-07	127.4	5.4	12
6	7.0	10	0.34	7-Apr-07	14-Apr-07	69.7	6.7	11
12	9.0	10	0.28	11-Apr-07	20-Apr-07	90.3	6.7	8
11	8.0	13	0.50	12-Apr-07	20-Apr-07	104.0	8.7	12
7	8.1	14	0.44	7-Apr-07	15-Apr-07	113.5	9.4	10
14	9.0	14	0.62	12-Apr-07	21-Apr-07	125.4	9.4	13

The heavy grazing did not affect seed production by other species as much as it affected the target weed. This was expected because of the precision treatment timing relative to phenology. Although not significantly different, seed production of non-target species tended to be a bit lower in treated than non-treated areas. The composition of the grazed areas changed to be dominated by softchess (*Bromushordeaceous*) and filaree (*Erodiumbotrys*), which are good forage species.

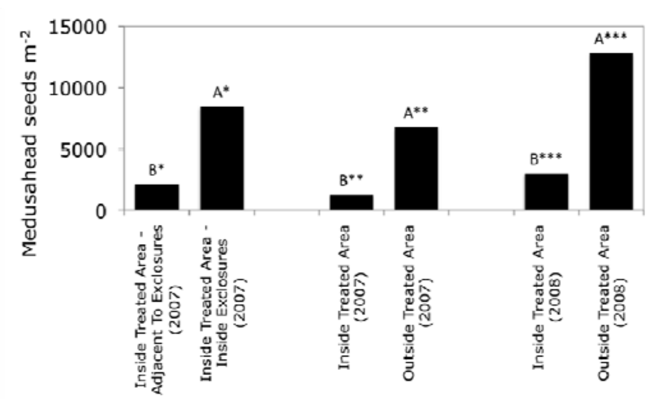

Figure 2. Mean medusahead seed productivity in paired observations from precision-grazed plots and exclosures within the plots (where livestock could not graze) and areas outside the plots (where livestock had continuous access) in 2007 and 2008 (the same and subsequent year of precision grazing treatment). Means represented by neighboring columns with different letters are significantly different at the 0.05, 0.01, and <0.0001 level when marked with *, **, and ***, respectively.

Effect of mowing on medusahead reproduction and density

Medusahead has invaded a large proportion of the Dunnigan Hills region of Yolo County, California. This region is characterized by gentle slopes and little presence of rocks. Most areas have a history of rain-fed barley production. Old fields have very high density of medusahead, which reduces the grazing value. This area has a very heavy Mh infestation; in some patchesmedusahead thatch has accumulated to the point that it smothers itself.

Mowed and control areas were established in 2007 and 2008. We established five transects in the areas mowed and determined botanical composition prior to mowing by visual estimation of cover. Medusahead cover prior to mowing ranged from 47 ± 5.4 to 23 ± 4.6 %. The other main species were *Torilissp*., *Trifoliumhirtum*, *Vicia* sp., *Bromushordeaceus* and *Avenabarbata*. Preliminary measurements taken on 4 June 2007 indicated that medusahead seed production in mowed and control areas were 140 ± 35 and 3030 ± 900 seeds m^{-2} at the end of the season when mowing took place. Transects were measured again on 8-9 May 2008 and photos were taken of twenty 0.5 x 0.5 quadrats spaced every 5 m in each transect. The impact of mowing on medusahead was visually obvious. The rancher reported that sheep and cattle concentrated on the mowed areas because of the greater availability of palatable species and reducedmedusahead thatch.

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Application of Glyphosate

We tested precise application of glyphosate at various phenological states of Mh. We hypothesized that applications that are too early will lead to excessive reduction in forage production, because glyphosate would kill all plants before forage accumulation. Applications that are too late may result in poor control because seeds that are close to viability may becomeviable before the herbicide kills the plant.

Glyphosate was applied at 16 and 32 oz. per acre in a 1% water solution early (5 March 2008), mid (19 March 2008), and late (2 May 2008) season. Each combination of dose and date was applied to four plots. Each plot had a control band in the center where no herbicide was applied. As expected, the early and mid applications killedall vegetation and produced little forage. A later application significantly reduced medusahead without obliterating the season's forage. Cost of application of herbicide was $15/ac, including labor, fuel, herbicide and machinery.

There were no effects of dose or date of application on the degree of control. All treated areas hadsimilar proportions of medusahead in the seedling stage (Figure 3). At the beginning of the season following the application of herbicide (2008), treated plots had significantly lower proportion of Mh than control plots. In the following season (2009), both treated and control areas had a lower proportion of Mh than controls in the first season. This decline in the number of Mh plants in the control areas may be related to the general reduction in Mh density achieved in the whole experimental area, which probably resulted in fewer seed reaching both treated and untreated areas.

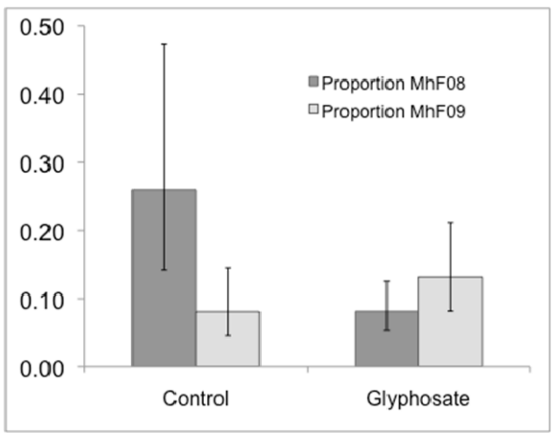

Figure 3.Effect of glyphosate on botanical composition at the beginning of the season. Herbicide was applied during the spring of 2008 and proportion of seedlings that were medusahead was determined at the beginning of the 2008-9 (dark bars) and 2009-10 (light bars) seasons.Vertical lines represent the 95% confidence intervals

The early application of herbicide resulted in a significantly lower forage production that in the control (Figure 4). Herbicide application in the other two dates did not affect forage production relative to their controls. Forage production in the following year tended to be greater in treated plots, and was significantly greater in the plots treated early. This was an unexpected result and may have been due to a compensatory or renewal effect of the complete vegetation removal caused by the early application. Given that control areas were bands in side the treated plots, it is likely that the early application removed competition and released resources to those plants in the control band.

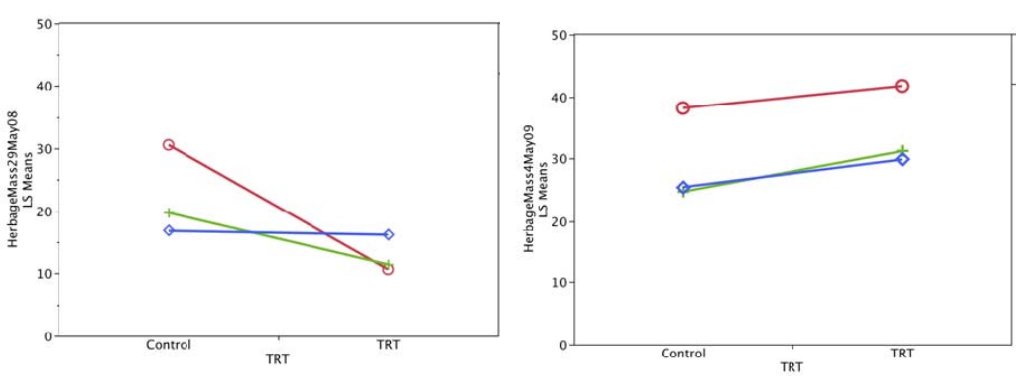

Figure 4. Total forage production at peak standing crop at the end of spring in 2008 (left) and 2009 (right). Circles represent application of herbicide on 5 March, crosses represent application on 19 March, and diamonds represent application on 2 May 2008. On the left graph, the only significant difference is between the control and treated areas for the early application. On the right graph, the only difference is between early application and later ones.

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Conclusions

Good levels of medusahead control were achieved with application of precision grazing, mowing and herbicide. The key aspect of the treatments was a precise timing of treatment relative to the phonological stage of medusahead relative to other desirable species. A preliminary economic analysis indicated that all treatments were advantageous because they resulted in increased usable forage or greater value than the cost of the treatment. Medusahead has already invaded and is permanently established in most of northern California, and is moving south. Thus, any control treatment has to be incorporated into the regular ranch management activities to be successful in the long term .

2011 Student Scholarship Winners

The CWSS was pleased to make awards to deserving students this year at the annual meeting in January in Monterey. Undergraduate scholarships were awarded to 1st place ($2000) to Stacey Haack, UC Davis; 2nd place ($1000) to Lennel Mendoza, Cal Poly, San Luis Obispo; 3rd place ($500) Sarah Bell, CSU, Fresno; and 4th place to Sonia Rios, Cal Poly Pomona. Graduate student scholarships were awarded to 1st place ($2000) to Rachel Brush, UC Davis. Please be sure to encourage young people to apply for these awards in the coming year. Information on the award programs can be obtained by contacting Rob Wilson at rgwilson@ucdavis.edu or at the CWSS website www.cwss.org.

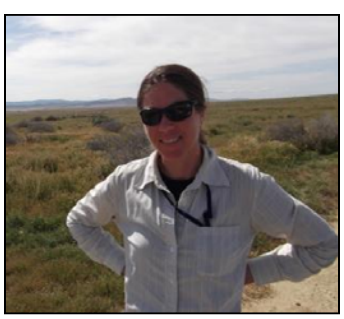
Biographical sketches of award recipients:

Stacey Haack is in her second year as an undergraduate student at the University of California Davis. She is majoring in Plant Sciences with a double emphasis in Plant Breeding and Genetics as well as Crop Production. Though this line of studies, she is gaining exposure to multiple disciplines and levels of plant science research, coupled with active involvement in related internship positions both on and off campus. Upon graduation, she plans to immediately pursue graduate studies in an applied plant sciences discipline with specific interest in the application of biotechnology principles to the development of new modes of actions for weed management. Beyond her studies, she sees herself in either private sector herbicide development research or in advising and diagnostic work in an agricultural system, using her interdisciplinary education and work background in weed and pest management systems to effectively assist growers in analysis and decision making.

Lennel Mendoza is studying at California Polytechnic State University of San Luis Obispo pursuing a B.S. in Forestry and Natural Resources, concentrating on Fire Science and Communications. Her advisor, Dr. Walter Mark, is an expert on forest entomology and pathology, forest protection, and integrated pest management. In the near future, she hopes to work for a federal or private agency managing natural resources

Sarah Bell will be a junior and attending California State University, Fresno. Her major is Plant Science, and after graduation plans to get a Pest Control Advisor license and work in the agricultural industry.

Sonia Rios is studying at California State Polytechnic University, Pomona and pursuing a B.S in Plant Science, minor in Pest Management. Her advisors are Greg Partida and Dan Hostetler. She would like to pursue a career with the UC Cooperation Extension or practice pest management in the private sector. She plans to obtain her Pest Control Advisor's and Certified Crop Advisor's licenses.



Rachel Brush is a graduate student with the UC Davis Weed Science Program pursuing a master's degree in Horticulture and Agronomy. Rachel's interests are broad and include wildland weed management, ecological restoration, and botany. She would like to eventually work on land management planning for wildlands and working landscapes, specifically in the areas of weed management and restoration. Rachel's master's thesis topic is "The biology and life history traits of *Dittrichia graveolens* (stinkwort)" which focuses on identifying the characteristics that make *D. graveolens* a successful invader in California. The research for this project is well underway and should provide a better understanding of the life cycle and specific biological characteristics of *D. graveolens* which can then be used to improve predictive models of distribution and develop control strategies. In her spare time Rachel enjoys hiking, snowshoeing, and botanizing in the desert!

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