Jon
By
David Haskell

He is a man with morals and integrity,
He has never drank a “lite” beer in his life!
And he packs a quick sense of humor,
That is keener than a Spyderco® knife.

Jon is our wildlife biologist.
He gives the quail and sunfish a voice.
He puts a face on the toxic feeding studies,
And reminds us registering pesticides is still a choice.

Now the grateful crawdads waved their claws,
When he kicked fipronil out of the rice paddy.
And the yellow-legged frogs croaked a sigh of relief,
They didn’t have to testify against CATS big daddy.

Jon keeps us amused with his latest hunting story,
And the big one that always gets away.
But he doesn’t take it all too seriously,
This man still remembers how to play.

He can spot a wild boar from fifty yards,
And a wedding ring from seventy-five.
He has respect for game that’s wary.
Because he knows he could be captured alive.

He is a bachelor with peculiar habits,
Resisting all forms of masculine decay.
He is always searching for that perfect miss,
That won’t make him give up his bachelor ways.

Jon has a knack for fixing machines,
He knows how to awaken horsepower.
He’s not afraid to get grease on his hands,
And he only charges two Fosters an hour.

He keeps his red Porsche spit-polished,
And his T-bird under the covers at night.
And all of his guns are well oiled.
He likes his toys to look show-room tight.

But the man does have an Achilles heel,
That causes even his best friends to scoff.
He tries to befriend one-armed bandits,
Thinking their friendship will eventually pay off.

So Jon’s a man who really likes his beer.
The question is, How does he stay so thin?
Maybe it’s those long and fibrous Iowa roots,
That let him suck it up and transpire it through his skin.

PIGGY SMITH
By
David Haskell

The tractor cabs piled along his driveway,
Mark the entrance with boneyard charm.
Inside is a group of faded red buildings,
The last remnants of the family pig farm.

But the fields around the site are empty.
The dismantled chassis have been hauled away.
And the salvaged tracks, rollers and pony motors,
Are being cured like hams for the holidays.

The dusty gravel is now covered with concrete.
The cracked plastic is gone from the counter top.
And the white linoleum floor in the show room,
Makes the office look more like a butcher shop.

The honey voice of his niece welcomes you,
She reads the specials and takes your parts order.
Piggy Smiths is rated four stars for ambience.
And he was written up in the Junkyard Reporter.

But don't let the blond and the palm tree fool you,
This man makes his living selling pre-owned rust.
Offering choice cuts of used farm machinery.
From origins you hope you can trust.

It's Piggy Smith's business philosophy.
"Make'm squeal the first time they come in.
You have to train these farmers just like weaners.
To eat whatever feed is left in the bin".

The counter man seems to be in a big hurry.
He drops my part on the scale with a clank!
He quickly slides the weights on the scale arm.
And adds one more item for the deposit to the bank.

Paying twenty dollars a pound for rusty pig iron.
It's enough to make a grown man scream.
Selling USDA cuts marked prime.
This pig farmer's son has finally seen the green.
His dismantlers pick the carcasses clean,
And his parts men sort out the best.
They tag the parts that are genuine,
And then they primer and paint the rest.

But he personally settles every equipment buy.
It’s the wheeling and dealing he likes the most.
Where one person only sees a tired old sow,
Piggy Smith sees hidden cuts of lean pork roast.

So don’t sell the family Cat to this butcher.
Because he’s got his thumb on the scale somewhere.
He’ll make you think he’s doin you a favor.
But that favor is just a well hidden snare.

“Used Cat parts aren’t selling like they used to.
The collectors have come and skinned off the cream.
Left me with piles of yellow scrape metal.
And now making any money is just a daydream.”

“But I would like to help you with the broken D2.
Even though I have several just rusting away.
Haul it over here and let me take a look.
Maybe it will be worth something someday”.

So how did Piggy Smith make a small fortune?
Selling parts from broken down machines.
He knew which parts are worth more than the whole.
And then he sold them like fine cuisine.

REFLECTIVE MULCH AND SHADE CLOTH EFFECTS ON WEED MANAGEMENT IN FIELD-GROWN ZINNIAS IN THE SAN JOAQUIN VALLEY

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Summary

A field experiment near Fresno demonstrated that reflective, silver-over-black polyethylene mulch effectively suppressed weed growth in zinnias (*Zinnia elegans* cv. Dahlia Flowered Blue Point) for cut-flower production. The mulch reduced the time needed to hand-weed plots by 85%, and mean weed biomass per plot by 97%, over the bare soil control. On the other hand, use of polymer shade cloth rated at 30% light reduction had no effect on weed management. Opaque, reflective mulches can be useful for weed management in warm-season ornamental crops in the San Joaquin Valley.

Introduction

Open-field production of ornamental cut flowers in California is concentrated in coastal areas, where moderate temperatures prevail year-around. Cut flower production in the San Joaquin Valley (SJV) is very limited, primarily due to more extreme cold winter and hot summer air temperatures. Zinnias are a heat-loving summer annual valued for use in ornamental borders and beds, and as cut flowers. Due to their environmental preferences, zinnias as a cut-flower crop could be compatible with the hot and dry summer climatic conditions prevalent in the SJV.

Previous studies in the SJV have shown increased flowering and fruiting of a variety of plants as a result of culture under enhanced light conditions using reflective mulches. Some of the benefits have arisen from non-chemical pest management by repulsion of insects (Stapleton and Summers, 2002; Summers et al., 2004) and weed suppression. However, other studies have shown enhanced flowering and fruiting with reflective mulch in the absence of major pests (Mahmoudpour and Stapleton, 1997; Mitchell et al., 2000). In these cases, increased reflected light into the plant canopy has been suggested as the mechanism for the plant responses (Stapleton and Summers, 2002; Summers *et al*, 2004). Apart from numerous pest management benefits, the deployment of mulches and plant coverings provides soil temperature and other micro environmental modifications which may benefit crop growth.

Most of the economically important plants which have been evaluated in conjunction with reflective mulches have been producers of edible products. There is little information available on effects in field-grown ornamental flower or foliage crops. The objectives of these experiments were to evaluate effects of reflective mulch and shade cloth on weed management in zinnias.

Materials and Methods

Zinnia seeds (cv. 'Dahlia Flowered Blue Point') were sown in commercial potting mix and germinated in flats according to standard greenhouse conditions. Plants were transplanted to the field ca. 5 wk after seedling emergence. The reflective mulch treatment consisted of an aluminum metallized over black, reflective polyethylene film placed directly on beds. The low light treatment beds were tented over the plant canopies with black polymer shade cloth rated at 30% light reduction. The netting was attached to wooden posts ca. 0.91 m (36 in) height above the bed level. A treatment combining the reflective soil mulch and the shade net canopy cover also was done, as was a bare soil control, to give a 2x2 factorial experimental design. Four replicate plots per treatment were used, with each replicate 6 m (20 ft.) long. Guard rows of the zinnia plants were grown around the perimeter and between the replicates of the experimental area. A single flower color series, 'Golden Dawn', was used for all data collection.

Plants were irrigated conventionally using a surface drip system, and received weekly fertigation with 17% calcium-ammonium nitrate (CAN-17) in the irrigation water. Although weed growth was sparse on the planting beds following land preparation, paraquat was applied over the entire experimental area one wk prior to transplanting, followed four days later by hula-hoeing, to eliminate all emergent weeds at the beginning of the field experiment.

Four weeks after transplanting (October 14), a two-man field crew was sent into the experiment to hand-weed each plot. Both men worked together to weed each plot, and they were timed with a stopwatch. Weeds removed from each plot were then loaded into paper bags, screened to remove adherent soil, and placed in a drying oven. Following the drying period, weed masses from each plot were again screened to remove soil, then weighed to determine total weed biomass. Data were analyzed using the GLM procedure in SAS software.

Results and Discussion

The predominant weed taxa in the experimental area were barnyardgrass (*Echinochloa crus-galli*), nutsedge (*Cyperus* spp.), pigweed (*Amaranthus* spp.), and carpetweed (*Molluga verticillata*). The mean time needed by the two field workers to weed each reflective mulch plot was 1.8 minutes, as compared to 11.8 minutes for the bare soil control, 13.1 minutes for the shade cloth, and 2.1 minutes for the combination of the reflective mulch and shade cloth. This translated into an 84.6% time reduction for the reflective mulch over the bare soil control. Factorial ANOVA gave a significant effect of reflective mulch ($P<0.05$), while the shade cloth factor was insignificant. No significant interaction between the reflective mulch and shade cloth was found.

In terms of total weed dry weight, the reflective plastic mulch was again successful at inhibiting weed growth ($P<0.05$). The mean dry weed biomass per mulch plot was 8.1 g, compared to 320.6 g per plot for bare soil. This corresponded to a 97.5% reduction in weeds using mulch rather than bare soil. Shade cloth allowed 403.7 g of weed growth per plot, while the combination of mulch and shade cloth allowed 9.8 g. Factorial ANOVA gave no significant effect of shade cloth use, or for the interaction of mulch and shade cloth.

Weed growth on bare soil, whether in open sunlight or under shade cloth, was distributed over the entire bed areas. On the other hand, weed growth in reflective mulch plots was confined to the periphery of the plastic sheets and the planting holes.

Conclusions

This field experiment showed that opaque, reflective polyethylene mulch, but not shade cloth, was effective for managing weeds in zinnias for cut-flower production. The results indicated that reflective mulch can be useful for non-chemical weed management in warm-season ornamental crops in the San Joaquin Valley. Other data not shown here demonstrated that the use of reflective mulch gave increased cut-flower yields, as well.

Acknowledgements

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IGNITE AND LIBERTYLINK COTTON EVALUATIONS FOR THE CALIFORNIA PRODUCTION SYSTEM

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Abstract Herbicide tolerant cotton varieties provide growers a weed management option that can both reduce weed control costs and provide effective management of hard-to-control weeds. Although Roundup Ready varieties comprise 40% of the Acala and Upland cotton acreage, the evaluation and integration of LibertyLink cotton into the California cotton production system will provide growers with an additional control option and herbicide resistant management tool. Field studies were conducted from 2002 to 2004 to evaluated weed control efficacy and tolerance of both LibertyLink and non-LibertyLink Acala cotton to Ignite (glufosinate). Ignite was applied over-the-top of LibertyLink FM966L cotton in the 4 to 5 leaf stage when pigweed (*Amaranthus* spp) and black nightshade (*Solanum nigrum*) were in the 2 to 8 leaf stage. Control was excellent when weeds were 4 true leaves or less with control being poor when weeds were 5 true leaves or greater. When Ignite was tank mixed with either Staple (pyrithiobac sodium) or MSMA, the 5 true leaf weeds were effectively controlled. There were no differences in control regardless of whether Ignite followed a PPI application of Treflan (triflurin) or not. No injury was observed on the cotton with Ignite alone, although some injury was noted when tank mixed with Staple or MSMA. Ignite applied post-directed to non-LibertyLink Acala cotton exhibited mild injury to the lower stem and leaves contacted by the spray solution. Plant mapping indicated no detrimental effect to fruiting nodes. Both pigweed and black nightshade in the 2 to 4 leaf stage were effectively controlled.

Introduction Herbicide tolerant cotton varieties provide growers a weed management option that can both reduce weed control costs and provide effective management of hard-to-control weeds. Although Roundup Ready varieties comprise 40% of the Acala and Upland cotton acreage, the evaluation and integration of LibertyLink cotton into the California cotton production system will provide growers with an additional control option and herbicide resistant management tool.

Materials and Methods Field studies were conducted from 2002 to 2004 to evaluate weed control efficacy and tolerance of both LibertyLink and non-LibertyLink Acala cotton. Treatments were divided into Treflan (trifluralin) pre-plant or not. Ignite alone or in combination with Staple, MSMA or Dual Magnum was applied over-the-top (OT) of FM966L cotton in the 4 to 5 leaf stage when pigweed (*Amaranthus* spp) and black nightshade (*Solanum nigrum*) were in the 2 to 8 leaf stage. Sequential treatments of Ignite in combination with Staple, MSMA and Dual Magnum were applied directed (DIR) when the cotton was at the 12 to 14 leaf stage. OT treatments were applied with a tractor drawn sprayer with 8002 flat fan nozzles delivering 16 to 20 gallons per acre spray solution at 40 psi. DIR applications were made with two OC-02 nozzles per row. Evaluations of weed control and crop injury were taken throughout the season and the cotton was harvested for yield in 2004.

Results and Discussion

2002 Puncturevine (PV) exhibited 90 to 100% control at 9 and 23 DAT. Ignite at 0.522 lb ai/A exhibited the greatest control of barnyardgrass (BYG) at 84% at 9 DAT, by 23 DAT no treatment exhibited acceptable control of BYG at 18 to 38% control. Field bindweed (FB) was suppressed at both 9 and 23 DAT at 38 to 55% control at 9 DAT and 30 to 40% at 23 DAT. At 9 DAT, the greatest control of tumbling pigweed (PW) was exhibited by both rates of Ignite tank mixed with Ammonium Sulfate (AMS). At 23 DAT, no treatment exhibited acceptable control of

PW. The greatest cotton injury was exhibited by Ignite at both rates tank mixed with AMS at 74 to 85% injury. Ignite alone exhibited 18 to 20% injury. Post directed application of Ignite to non LibertyLink cotton results in slight necrotic lesions to the lower portion of the plant that is contacted by the spray solution.

2003 Weed size at application is critical to control as is indicated at the 6/11 (9 DAT) evaluation. Treflan alone or Ignite + Staple either with or without Treflan preplant appeared to overcome the size differential. All treatments except Treflan followed by Staple+ Prism exhibited excellent control of 4 TL or less PW and BNS. The 5 TL or greater stage PW was effectively controlled by Treflan ppi, Ignite + Staple with or without Treflan ppi. Treflan ppi exhibited no control of BNS and all treatments except Ignite tank-mixed with Staple either with or without Treflan preplant exhibited unacceptable control. By 7/8, after cultivation, the treatments exhibited 84 to 100% control of new germination of both PW and BNS.

2004 At 8 and 13 DAT, the OT treatments provided excellent control of black nightshade. The greatest injury was exhibited by the OT treatment of Ignite + MSMA but not significantly different from Ignite + Staple at 8 DAT. By 13 DAT, Ignite + Staple was exhibiting significantly less injury than Ignite + MSMA. The OT application of Ignite + Dual II Magnum exhibited greater injury than the DIR application. Treflan followed by Ignite OT and DIR, and Ignite + Staple, MSMA or Dual II Magnum and applied DIR provided good to excellent control of field bindweed at 7 DAT the DIR application. Ignite + MSMA applied OT still exhibited the greatest crop injury at this time. The greatest yield was exhibited by Treflan PPI followed by an OT and directed application of Ignite at 5945 lb of seed cotton/A. The lowest yield was exhibited by the OT application of Ignite + MSMA at 5312 lb. Although the Ignite and Dual II Magnum OT application exhibited significantly greater injury than the DIR application, there were no significant differences in yield at 5625 and 5735 lb seed cotton/A.

Conclusion Ignite will be an effective cotton weed and resistance management option, however it is important to remember that weed stage of growth at application is critical for satisfactory results.

WEED MANAGEMENT IN ALMONDS AND GRAPES

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Introduction Weed management in both young and established almonds (*Prunus dulcis*) and grapes (*Vitis vinifera*) is important to ensure proper growth and seasonal development. Many growers have reduced or eliminated weed management to conserve their financial resources. However, this is a mistake as weeds will compete for water, nutrients, sunlight and space, interfere with effective harvest and physically reduce yield. New materials have been tested in trees and vines for efficacy and crop safety in 2002, 2003 and 2004.

Materials and Methods All tests were applied with CO2 backpack sprayers delivering a spray volume of 20 GPA at 40 psi thru 8002 flat fan nozzles.
2002: 2 year old almonds on a 15 by 22 ft spacing & 4 year old grapes on a 7 by 11 ft spacing were divided into 2 tree or 4 vine plots and treated on 11/30 (vines) & 12/7, 01 (almonds). Evaluations were conducted on 2/14 & 4/15 (78 & 128 DAT) in almonds and 2/26 & 4/15 (68 & 116 DAT) in grapes.
2003: 3 year old almonds on a 15 by 22 ft spacing and 5 year old grapes on a 7 by 11 ft spacing were divided into 2 tree or 4 vine plots and treated on 1/30 (almonds) and 2/4 (grapes). Evaluations were conducted on 3/28 and 6/25 (57 & 146 DAT) in almonds and 4/10 and 6/24 (65 & 140 DAT) in grapes.
2004: 6 year old vines on a 7 by 11 ft spacing were divided into 4 vine plots and treated on 2/12. Evaluations were conducted on 3/22 & 5/24 (38 & 101 DAT).

Results
2002 Studies in 2 year old trees and 4 year old vines. Goal alone or tank-mixed with Visor, Surflan and Roundup, Rely and Agridex, or Shark and Agridex, Prowl alone, and Chateau tank-mixed with Roundup were evaluated on almonds. At 78 DAT all treatments exhibited excellent control with a range of 84 to 100% except Prowl at 75%. At 128 DAT, Goal and Visor treatments had reduced efficacy at 71 to 77%. All other treatments provided greater than 80% control. In the vine study at 68 DAT, all treatments except Visor (at 25 and 56% respectively) exhibited excellent control of oats and mustard. All treatments provided excellent control of chickweed and all but Visor and Prowl (at 75 and 79%) performed well on fleabane (*Conyza bonariensis*). At 116 DAT Visor and the low rate of Chateau exhibited reduced efficacy on oats (*Avena sativa*) at 10 and 76% respectively. All treatments exhibited excellent control of mustard (*Brassica nigra*). Goal and Visor, Visor alone, and Prowl (39 to 60%) did not adequately control spikeweed (*Hemizonia pungens*). Fleabane control ranged from excellent to poor at 69 to 94%.

2003 Studies in 3 year old trees and 5 year old vines. Chateau tank-mixed with Surflan and Rely, Envoke at various rates or tank-mixed with Touchdown IQ, an experimental material tank-mixed with Roundup and standards of Goal tank-mixed with Surflan and Roundup or Rely were evaluated on almonds. All treatments provided excellent control of all weeds at 57 DAT. At 146 DAT, all treatments exhibited excellent control except the Goal, Surflan, Roundup and COC tank-mix at 74%. The same treatments with the addition Shark tank-mixed with Princep and excluding those including Envoke were tested in the vine study. At 65 DAT, all treatments exhibited good to excellent control of mustard and filaree (*Erodium spp.*). Only the Shark tank-mix without Roundup exhibited unacceptable control of fleabane. Neither Shark tank-mix performed adequately on oats. At 140 DAT control ranged from 65 to 98% for fleabane.

2004 A study in 6 year old vines included 2 formulations of Goal alone or tank-mixed with Glyphomax Plus or Surflan and Glyphosate, Chateau tank-mixed with Surflan and Rely or Glyphosate, an experimental material tank-mixed with glyphosate, Shark tank-mixed with Princep and Roundup, and Outlook tank-mixed with Prowl and Rely. All treatments exhibited good to excellent control of all weed species at 38 DAT with the least control of fleabane exhibited by Goal 4F alone. Control was reduced by 101 DAT with either Goal formulation alone, Goal 2XL tank-mixed with Glyphomax Plus or Surflan and Glyphosate, and the tank-mixes of Outlook with Prowl and Rely exhibiting unacceptable control.

Conclusions Many of the new materials being developed and registered for use in tree and vine weed management show great promise as effective tools for growers. Rates of active ingredients required for effective weed control are often reduced with these new materials and restricted use based on season is less of an issue. More materials available provide more choices to growers and may lead to more efficacious and economical use of herbicides.

SESSION B:

TURF SESSION

COMPARISON OF SULFONYLUREA HERBICIDES FOR TRANSITION TO WARM-SEASON TURF

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Desert golf courses, sports turf facilities, and turfgrass landscapes are typically overseeded with a winter turfgrass as the summer bermudagrass goes dormant. Spring transition is when the winter turfgrass is replaced by bermudagrass for the summer turfgrass. Typically, perennial ryegrass should begin to recede when spring-summer temperatures rise and growth of the winter dormant bermudagrass is stimulated. Bermudagrass growth is encouraged by manipulating irrigation and fertility, lowering heights of cut, and cultivation of the spring turf. Ryegrass is stressed by the cultural practices that promote bermudagrass, however, many ryegrass cultivars tend to tolerate and survive the high summer temperatures. Selective herbicides can effectively remove ryegrass while the bermudagrass emerges from dormancy. In recent years, the class of sulfonylurea herbicides have demonstrated efficacy in removing ryegrass in the spring without causing injury to the bermudagrass. Some of the very early sulfonylurea herbicides, metsulfuron (Manor*/Blade*) and chlorsulfuron (Corsair*), were used for weed control in small grains or noncrop situations. More recently registered were rimsulfuron (TranXit*), foramsulfuron (Revolver*), and trifloxysulfuron (Monument*) and still in the development stages are flazasulfuron (Katana* proposed) and sulfosulfuron (Certainty* proposed).

The most rapid response and effective ryegrass removal occurred with the latest applications made in June compared to applications made in April or May. Ryegrass removal occurred at 8 days after treatment (DAT) with the latest applications in late June. Applications in May showed that between 16 and 29 DAT, flazasulfuron, foramsulfuron, rimsulfuron, trifloxysulfuron, and chlorsulfuron removed most of the ryegrass. Foramsulfuron, rimsulfuron, trifloxysulfuron, and chlorsulfuron are available products that demonstrated good efficacy when applied during the spring. Higher rates were more effective when applied in the early spring. Regrowth of ryegrass occurred with some lower rates of herbicides applied in April. Flazasulfuron at the rates tested was extremely active and further research at lower rates is needed before it is registered for use as a transition-aid. Sulfosulfuron and metsulfuron were least effective for removing ryegrass. Height of cut and mowing frequency influenced herbicide performance. Ryegrass removal was prolonged to 41 to 56 DAT with less mowing at a higher cut on a driving range.

These transition-aid herbicides have the potential to offer precise ryegrass removal at a specific time in the spring and/or rid ryegrass from shady areas, golf course roughs, or anywhere it may tend to last longer into the summer. Optimal use of transition-aid herbicides will provide aesthetically pleasing turfgrass in the spring when bermudagrass growth resumes after ryegrass is removed.

SULFONYLUREA HERBICIDES FOR SEDGE CONTROL IN TURF

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Sedges are considered some of the most difficult weeds to control in turfgrass sites. Although often called ‘nutgrass’, sedges are not grasses but belong to the cyperaceae family (while grasses are in the poaceae family). In California, purple nutsedge (*Cyperus rotundus*), yellow nutsedge (*Cyperus esculentus*), and green kyllinga (*Kyllinga brevifolia*) are the common sedges found in turf sites. Both purple and yellow nutsedge reproduce primarily from tubers while green kyllinga is a non-tuberous, rhizominous species of sedge. One reason sedges are difficult to control is the extensive underground plant structure. Herbicides must translocate to the rhizomes and tubers for control of new plant growth for effective weed control. Some foliar active herbicides may burn existing foliar but fail to translocation in sufficient quantities to effect tuber viability. A relatively new class of herbicides, particularly in turf, is the sulfonylureas. Members of this herbicide class have a varied range of safety to turf and weed spectrum depending on structure. Some the chemical characteristics of these herbicides that make them effective for control of nutsedges are water solubility and activity by both foliar and root uptake. Manage (Halosulfuron) was the first sulfonylurea herbicide registered in CA for sedge control in turf. Field use had shown Manage to be an effective tool for control sedges in both cool and warm season turfgrasses. Manage tends to be more effective for control of yellow nutsedge than purple or green kyllinga. Trifloxysulfuron-sodium, Monument, is a new broad-spectrum herbicide for post-emergence weed control in warm season turfgrasses that shows excellent activity on the major sedge species. Federal registration of Monument 75 WG occurred in 2003, and is pending registration in CA. Other new herbicides for sedge control are sulfosulfuron (pending turf registration) and flazasulfuron (not registered). These new herbicides are effective on a broad range of turf weeds besides sedges, and will probably be labeled for use on warm-season grasses only. Sulfonylurea herbicides are active at low AI concentrations. Water solubility and soil persistence are pH dependent, increasing under alkaline conditions. Most of the new sulfonylurea herbicides labeled (or pending labeling) for turf use have a short soil half-life, less than 30 days even under alkaline conditions. Use rates of Monument for sedge control are 0.33 to 0.56 oz per acre. It has been in turf field trials since 1996 and has shown excellent activity on purple nutsedge, yellow nutsedge and green kyllinga. Controls of these weeds exceed 85% with one or two applications and compare favorable to current herbicide standards. Monument is safe to use on bermudagrass and zoysiagrass turf on golf courses, sports fields, sod farms and commercial properties. Sulfonylurea herbicides will play a larger role in the weed control strategies of turfgrass managers in the near future as new products gain registration.

BIOTECHNOLOGY IN TURF, CURRENT STATUS OF ROUNDUP READY BENTGRASS

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Introduction

Transgenic crops have grown from 4.2M acres planted in 1996 to over 167M acres in 2003, a forty fold increase. In 2004, over 90 percent of all soybeans grown in the United Sates were derived from the tools of biotechnology. Further, over 70 million farmers in thirty countries around the world are currently producing, importing, or growing biotech crops.

Benefits

Farmers are finding that biotech crops are less expensive and less labor intensive to produce. Over $600 million of chemicals have not been applied to Roundup Ready soybeans. Canola farmers save 14 million gallons of fuel a year. Bt-cotton and corn have reduced insecticide use by 4.5 million pounds. It has been determined that Bt-protected corn has reduced insect feeding and the resulting molds and mycotoxins that are harmful to livestock and humans. In addition, No-till and conservation tillage is saving one billion tons of precious top soil per year. As an aside, over 80% of today's drugs are developed with the aid of biotechnology.

Issues in Turfgrass Management

Dr. Peter Dernoden of University of Maryland recently summarized his perspective on issues surrounding bentgrass management (2000). He summarized his study with the following observations:

- Few herbicides are currently being registered for selective bentgrass control while several herbicides needed.
- Most herbicides have a more narrow range of safety to bentgrass requiring lower rates on bent relative to other turf species.
- Due to the lower rates often the outcome of control efforts is incomplete control of problem weeds.

Root pruning and associated plant phytotoxicity and other related issues ends-up with turf that has less tolerance to stress events, poorer aesthetics, and often result in more complaints from users. Finally, overseeding timing and success is negatively impacted by soils with carry-over issues from herbicides with long reseeding intervals.

The Development of Glyphosate Tolerant Creeping Bentgrass

Monsanto and Scotts Co. have cooperated on the development of Glyphosate Tolerant Creeping Bentgrass (GTCB). Results of this cooperation have produced commercial candidates that have shown the following characteristics.

Turf Quality – Composite of all Characteristics

shoot density appropriate to function (both fairway and greens-grade varieties)
disease tolerance
environmental tolerance
wear tolerance and recuperation from wear (a function of vigor)

Supporting Evidence

These lines were derived from existing cultivars that were of commercial quality. Regulatory studies submitted with the petition to APHIS showed that over twenty five studies were conducted over the last three years. This included variety trials equaling 113 location-years.

Golf course demonstrations were placed on more than thirty four locations across the country. Efficacy and weed control studies were conducted by university, Scotts, and Monsanto field scientists totaling over twenty-four locations.

GTCB Benefits

Researchers and golf course superintendents have identified through testing and observations important benefits for this new technology for golf including: simplified and selective weed management, reduced turf maintenance inputs chemistry, the ability to implement IPM principles including the inputs of fungicides, PGR's, fumigants, insecticides, and nematicides. They have also demonstrated the ability to have a focused species management using Best Management Practices (BMP's). They have determined the ease of establishment of new stands, and conversion of older stands to GTCB. They have shown reduced clippings collection with mowing due to weed presence, all resulting in greater player satisfaction.

Current Issues

The United States Agriculture, Plant Health Inspection Service (APHIS) concluded that issues brought forward from the U. S. Bureau of Land Management, and the United States Forest Service regarding pollen flow issues warranted the status of a 'major federal action' and deregulation was viewed as a "*precedent setting, controversial, and posing uncertain environmental impacts*", thus requiring an Environmental Impact Statement (EIS) to be prepared, prior to deregulation of the technology. Concerns from BLM rose primarily around gene escape issues and desire for effective and labeled alternate controls should escapes occur. The EIS enables a full vetting of issues by all interested parties and enables APHIS to approve GTCB with conditions, if needed. This action by APHIS is consistent with direction that the agency has with respect to the regulation of "novel" GM plants. The EIS sets a procedure for future generations of turf/grass candidate petitions to the agency and should greater certainty in process, timing, and future agency decision making.

Regarding the area of research to satisfy APHIS and ensure a sustainable technology surrounds the issues of acceptable alternate controls, Monsanto researchers have identified several effective herbicides capable of controlling GTCB. Among those identified include some of them listed here: Generally, pollen flow is not anticipated in golf course management due to mowing heights on putting greens and in fairways where flowering would not occur. In the case where pollen would be an issue in grass seed production, effective buffers are established, and sites monitored to measure for any escapes. When found plants could simply be dug and devitalized, and desirable plants planted and established, or plants could be treated with one to several viable herbicides currently being screened for their effectiveness. Among those found to be effective: sethoxydim, diuron, clethodim, sulfosulfuron, glufosinate, fluazifop-methyl, and imazapyr. Other herbicides are still under review. In addition to determining control, products are being used in various application regimes, and evaluated for issues of bentgrass control, soil residual, plant-back, use in riparian or wetland areas, and overseeding issues.

Glyphosate Tracking Study

Previous studies showed that tracking was temporary in duration and was observed within 20 minutes of application. No serious long term turf damage was observed. The plot lay out consisted of an 8-10 foot band of treated area with a 60 foot area perpendicular to the treated area where tracking would be observed. Four quarts of glyphosate (RoundupPro®) was applied in the 8-10 foot band perpendicular to the untreated alternate first cut rough of tall fescue and Kentucky bluegrass. Sprayed length was determined by the size needed to accommodate three replications of tracking types and three types of tracking i.e. 0-5 minutes, 20 minutes (mins) and 18-24 hours post application under light dew conditions.

The objective of the study was to determine the potential of glyphosate tracking from treated glyphosate tolerant creeping bentgrass (GTCB) greens or fairway managed turf as a surrogate for GTCB vegetation growing adjacent areas of conventional fescue (fine or tall), perennial ryegrass or Kentucky bluegrass first cut roughs.

The treatments were laid out in a split plot design with two factors. The primary factor was types of traffic and the secondary traffic was post tracking timing after application. Three types of traffic were tested; (a). Foot traffic, (b). Weighted hand pull cart and (c). Motorized golf cart. The secondary factor was laid out as sub-plots where the three types of traffic were taken through the glyphosate treated area at three different timing intervals [(i). 0-5 mins (ii). 20 mins and (iii). 18-24 hours after the glyphosate application. All tracking equipment were cleaned and dried between treatments. A pressure hose water sprayer was used to rinse the treated tires and shoes to prevent any cross contamination. The trial was established under mid day turf conditions and the glyphosate was applied with a carrier volume of 30 gallons per acre. A 3 foot width for each tracking event and 8-10 sprayed zone was established. The 'tracking zone' (untreated adjacent area) extended 60 feet from the treated zone. The tracking treatments passed through the treated area into and through the entire 'tracking zone' within the time sequences identified. The tracking devices were cleaned and dried between passes through the treated areas.

The following data was taken:

a) Levels of turf injury were rated on a 0-10 scale by methods of tracking, herbicide and timing after application at 7, 14, 30 and 60 DAT, where 0=no injury and 10=dead turf.
b) Percent injury in 5 foot segments through the tracking zone was rated.
c) Length of tracking was measured.
d) The extent and levels of injury were described.
e) Pictures of treatment effects showing the extent and types of injury symptoms at 14 and 21 DAT were taken.

Table 1. Tracking of glyphosate onto untreated first cut roughs of tall fescue and Kentucky bluegrass.

Treatment	5 ft	10ft	5ft	10ft	5ft	10ft	5ft	10ft	5ft	10ft
	7 DAT*		14 DAT		21 DAT		30 DAT		60 DAT	
Foot Traffic After 0-5 minutes	0.0 a§	0.0 a	1.67a	0.00a	2.0ab	1.3ab	1.3a	1.0 a	0.7ab	0.7 a
Foot Traffic After 20 minutes	0.0 a	0.0 a	0.67a	0.00a	1.0 b	0.7 b	1.0 a	0.7 a	0.3ab	0.3 a
Foot Traffic After 18-24 hours	0.0 a	0.0 a	0.00a	0.00a	1.0 b	0.3 b	0.7 a	0.3 a	0.0 b	0.0 a
Weighed Pull cart After 0-5 minutes	2.7 a	2.0 a	2.33a	1.00a	4.0 a	3.0 a	2.7 a	2.0 a	2.0ab	1.0 a
Weighed Pull Cart After 20 minutes	1.0 a	0.3 a	0.67a	0.33a	1.7 b	1.7ab	2.3 a	0.7 a	1.0ab	0.0 a
Weighed Pull Cart After 18-24 hours	0.3 a	0.0 a	0.33a	0.00a	1.0 b	0.0 b	1.0 a	0.0 a	0.0 b	0.0 a
Golf Cart After 0-5 minutes	1.3 a	1.0 a	1.43a	0.50a	2.7ab	1.3ab	3.7 a	2.0 a	2.3 a	1.0 a
Golf Cart After 20 minutes	1.3 a	1.3 a	1.50a	1.67a	3.0ab	3.0 a	2.7 a	1.3 a	1.3ab	0.3 a
Golf Cart After 18-24 hours	0.3 a	0.3 a	0.33a	0.33a	1.0 b	0.7 b	0.7 a	0.0 a	0.0 b	0.0 a

*DAT indicates days after treatment of glyphosate.
§Means were separated using Duncan's New Multiple Range Test (α = 0.05). Means within a column followed by the same letter do not differ significantly.

The weighed pull cart treatment within 0-5 minutes of application at 7 days after treatment (DAT) resulted in highest injury (2.7%) in the first 5 foot segment closest to the treated zone, but the level of injury was not significantly different than the control or any of the other treatments (Table 1). The effect of glyphosate injury by tracking was observed as a temporary stunting and yellowing and the injury did not exceed 4% with any of the treatments.

CROSS-RESISTANCE PATTERNS TO ALL ALS-INHIBITING HERBICIDE GROUPS IN *CYPERUS DIFFORMIS* L

Aldo Merotto Jr; Maria Dolores Osuna Ruiz; Albert J. Fischer, Marie A. Jasieniuk
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Weed control with ALS (acetolactate synthase)-inhibiting herbicides in California rice has become problematic due to evolved resistance to bensulfuron-methyl. However, these herbicides offer multiple advantages, and new compounds are being developed for use in California rice. Various mutations on the ALS gene determine different cross-resistance patterns. The specific mutations will dictate the relative success of existing and new ALS-inhibiting herbicides. The objective of this study was identify the cross resistance patterns in *C. difformis* for future determination of the corresponding mutations on the ALS and their distribution in the rice areas of California. Three biotypes from California (WA, BI and AS) and one biotype from Italy (IR) were evaluated in whole plant bioassays and "in vitro" studies of ALS enzyme activity The herbicides and their respective herbicide families were: bensulfuron-methyl and IR5878 (sulfonylurea); imazethapyr (imidazolinone); penoxsulam (triazolo-pyrimidine-sulfonamide); bispiribac-sodium (pyrimidiny benzoate); and propoxycarbazone-sodium (sulfonylamino-carboxyl-triazolinone). Both types of assays were conducted twice. At the whole plant level, the biotypes AS and BI were equally susceptible to all herbicides, the biotype IR was resistant to all herbicides except penoxsulam and the biotype WA was resistant to the other herbicides and moderately resistant to penoxsulam. The ALS activity evaluation confirmed the same pattern of resistance found in the whole plant assay indicating that the mechanism of resistance in the WA and IR biotypes is due to an altered ALS enzyme with reduced sensitivity to the herbicides. Therefore, the control of resistant populations and mainly the design of prevention strategies to resistant evolution are viable by alternating ALS herbicide groups.

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CONTROL OF HEDGE PARSLEY *(TORILIS ARVENSIS)*

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University of California, Davis, Cooperative Extension

Hedge-Parsley or beggar's tick is an upright annual weed that grows 6-18 inches tall. The white flowers are found in compound umbels 1/2 to 1 inch wide and the seed heads have coarse bristles with hooks. It flowers from April through July on most soil types and is a growing concern in many rangelands and natural ecosystems. In March 2004, we treated hedge parsley with six herbicides [Transline® (clopyralid), Arsenal® (imazapyr), Plateau® (imazapic), Garlon 4® (triclopyr), Roundup Max® (glyphosate), and Telar® (chlorsulfuron)], each at three rates. The trial was conducted in Amador County, California. Plots measured 10' x 20' and each treatment was replicated 4 times in a randomized block design. Treatments were applied using a CO2 backpack sprayer delivering 20 gal/A through four 8002 nozzles at 20 p.s.i. Treatments were evaluated on 3 June 2004. Hedge parsley was completely controlled at all rates of Plateau®, Garlon 4®, Roundup Max®, and Telar®. These four herbicides had different effects on other vegetation in the plots; for example, a native tarweed (*Madia* sp.) showed some tolerance to the Plateau® treatments, but was completely killed by Garlon 4®, Roundup Max®, and Telar® applications. Arsenal® gave partial control of hedge parsley and Transline® failed to effectively control hedge parsley even at the highest rates.

USE OF TRIFLOXYSULFURON FOR A SUCCESSFUL OVERSEEDING PROGRAM

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Trifloxysulfuron-sodium is a sulfonylurea herbicide which can be used as a post emergence control of grasses, sedges and broadleaf weeds in turf. Field experiments were conducted at California State Polytechnic University, Pomona with Trifloxysulfuron. The treatments were laid out in a randomized block design with four replicates. Trifloxysulfuron was applied at 17.3 and 29.4 g a.i ha-1 with 0.25% v/v of non-ionic surfactant, 21, 14, 10 days before overseeding with perennial ryegrass on a 'GN-1' and 'Tiffgreen' bermudagrass fairway. Visual rating for weed control, bermudagrass injury and ryegrass injury was recorded every two weeks after overseeding. Trifloxysulfuron at 17.3 and 29.4 g a.i ha-1 applied 14 days before overseeding (DBO) resulted in 11 and 13 % injury to bermudagrass, respectively, compared to the control at 9 DBO. All herbicide applications resulted in 100% control of weeds 14 days after overseeding (DAO). Both rates of trifloxysulfuron applied 21 DBO had significantly lower ryegrass injury, compared to the 29.4 g a.i ha-1 applied at 14 DBO. 14 DAO there was no significant difference in the level of injury of ryegrass between the Trifloxysulfuron treatment applied at 21 DBO and the control. Trifloxysulfuron at 29.4 g a.i ha-1 applied at 14 and 10 DBO resulted in a 7 % injury on ryegrass compared to the control at 28 DAO. Trifloxysulfuron treatments at 21 DBO resulted in no ryegrass injury at 28 DAO. At 35 and 49 DAO there was no significant difference in the level of ryegrass injury between all the herbicide treatments.

EVALUATION OF HERBICIDE PERFORMANCE IN WINTER FALLOW BEDS

John S. Rachuy (Staff Research Associate), Steven A. Fennimore (CE Weed Specialist) and Jose A. Valdez (Staff Research Associate)
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Summary

Fallow bed weed management for lettuce is often difficult to obtain in winter due to limited field accessibility and the sensitivity of seedling lettuce. Therefore, an herbicide application method that will provide good weed control for the duration of the fallow winter period is beneficial for long-term weed management in vegetable crops. Two evaluations of herbicide efficacy for fallow bed weed control were conducted near Salinas, California. Four herbicides were applied to peaked/fallow beds at monthly pre-plant intervals, beginning three months prior to crop planting. Weed control was evaluated prior to planting and during crop establishment. Residual herbicide effects on crop vigor (phytotoxicity), stand and yield were monitored. The highest rate (0.188 lb ai/A) of Chateau/Valor, when applied up to 90 days pre-plant, significantly damaged and reduced the crop stand, therefore reducing the yield. To prevent carryover and lettuce yield reduction, Chateau/Valor at 0.188 lb ai/A should not be applied within 90 days of planting. The 0.063 lb/A rate of Chateau/Valor, Shark, and all the Goal treatments show promising results and have some potential for use as pre-plant fallow bed herbicides for lettuce. The variation in weed control and crop effects seen between the Hartnell and Spence studies may be attributable to the differing soil textures; and to the higher amount of rainfall that occurred during the Spence study period, which moved the herbicides deeper into the soil horizon.

Objective

The research objective was to evaluate pre-plant herbicide application timings for potential use in winter fallow beds prior to lettuce cropping.

Materials and Methods

Two trials were established to evaluate pre-plant herbicide application timings for weed control on fallow beds prior to lettuce planting. The trials were initiated in January 2003 (Hartnell farm) and December 2003 (Spence farm) on USDA-ARS properties, near Salinas, CA. Each experiment was established in a randomized complete block design, containing four replicate plots per treatment. Each plot consisted of a single, 40-inch wide bed. Plot lengths were 25 feet at Hartnell and 20 feet at Spence. The Hartnell test site contained sandy loam soil, with 2.1% organic matter and a pH of 7.0. The Spence test site contained loamy sand soil, with 1.0% organic matter and a pH of 7.2.

Pre-plant herbicides, Chateau/Valor (flumioxazin) 50WG at 0.063, 0.094, and 0.188 lb ai/A, Goal (oxyfluorfen) 4F at 0.25 and 0.5 lb ai/A, Goal (oxyfluorfen) 2E at 0.25 and 0.5 lb ai/A, and Shark (carfentrazone) 2E at 0.032 lb ai/A were applied to fallow unshaped (peaked) beds at approximately 3 months (~ 90 days), 2 months (~ 60 days) and 1 month (~ 30 days) prior to planting. Applications were made using a CO2 pressurized backpack sprayer with handheld spray boom. A single, 8002 even-fan nozzle was used to band the spray solution over the peaked beds. The spray system was calibrated to deliver 40 GPA.

Iceberg lettuce ‘Sharpshooter’ was planted (direct seeded) on April 30, 2003 (Hartnell) and March 8, 2004 (Spence). Following planting, a preemergence application of Kerb (pronamide)

50W at 1.2 lb ai/A was made to the entire test plot. The Kerb was applied as a 5-inch band over each of the two seed lines per 40-inch bed.

Weed populations were quantified prior to thinning and cultivation/hand weeding. Weed densities at Hartnell were measured using a 0.25m² quadrat on April 16 and May 21, 2003. Weed densities at Spence were measured using a 0.25m² quadrat on March 3 and a .265m² quadrat on April 6, 2004. The total weeds/0.25m²/plot were calculated, and the herbicide efficiency (% weed control) for each treatment was determined. The major weeds present were shepherd's-purse (Hartnell/Spence), burning nettle (Hartnell) and pigweed (Spence). Lettuce stand was measured just prior to thinning on May 16, 2003 (Hartnell) and March 25, 2004 (Spence). Crop injury ratings (0–10 scale: 0 = no injury, 10 = all plants dead) were taken on May 21, 30, June 6 and 13, 2003 (Hartnell), and April 27, 2004 (Spence). Marketable heads were harvested at crop maturity and sorted by size on July 8, 2003 (Hartnell) and May 25, 2004 (Hartnell). The sorted heads were counted, weighed, and then combined for total yield. All weed and crop assessment data were subjected to ANOVA, with mean separation performed using Student-Newman-Keuls' LSD (P=0.05).

Results

At the pre-plant weed density count for Hartnell; all treatments in the three pre-plant application intervals significantly reduced total weed populations, with the exception of Shark at the 3 month pre-plant, when compared to untreated check. At the same evaluation for Spence, only the Chateau/Valor, Goal 4F and Goal 2E treatments at 90 days pre-plant, and the Goal 2E at 0.5 lb ai/acre treatment at 60 days pre-plant significantly reduced total weed populations. Chateau/Valor at 0.188 lb ai/A applied 90, 60, and 30 days before planting and Chateau/Valor at 0.094 lbs ai/A applied 60 and 30 days before planting reduced the lettuce stand in 2003 but not 2004. The Shark and Goal treatments did not reduce lettuce stand either year. In visual injury evaluations, Chateau/Valor at 0.188 lb ai/A damaged the lettuce at all application dates, while Chateau/Valor at 0.094 lb/A resulted in lettuce injury ratings >2.0 only at the 30-day interval in 2003. Chateau/Valor at 0.188 lb/A applied 60 and 30 days prior to planting reduced the number of lettuce heads, and reduced lettuce fresh weights in both 2003 and 2004 when applied 90, 60 and 30 days before planting. Chateau/Valor at 0.094 lb ai/A applied 30 days pre-plant reduced lettuce fresh weights in 2004 only. Chateau/Valor at 0.063 lb ai/A applied 90 days pre-plant was safe on lettuce in 2003 & 2004. The Goal treatments did not reduce yield in 2003; however in 2004 Goal 4F at 0.5 lb ai/A applied 30 days pre-plant reduced yields. Shark applied 30 days pre-plant reduced lettuce head numbers and fresh weights in 2004 but not 2003.

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COMPETITION BETWEEN COWPEA COVER CROP AND WEEDS

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Competitive cover crop varieties are needed to reduce weed problems and herbicide use. Identifying specific crop traits related to competitive ability would provide breeders with useful information that could be used to develop an ideotype for highly competitive cover crop varieties. Cowpea varieties with different growth habits were grown with sunflower or purslane to determine which growth habit (erect, semi-erect, and prostrate) is more competitive to weeds. Regression models were used to analyses additive experiments and replacement series experiments. The results showed that erect varieties were more competitive to weed than semi-erect varieties and prostrate varieties. However, the simple regression models don't provide much information with competitive mechanisms which are helpful to breed new cowpea varieties. An ecophysiological model, INTERCOM, is used to understand competitive mechanisms. Validated INTERCOM model will provide us with more information about competitive cover crop traits, including competitive growth habit.

RESISTANCE OF RESTORED CENTRAL VALLEY GRASSLAND COMMUNITIES TO YELLOW STARTHISTLE (CENTAUREA SOLSTITIALIS) ESTABLISHMENT

Steve Young, Joe DiTomaso, and Guy Kyser
University of California, Davis

Yellow starthistle is commonly found throughout California in rights-of-way, non-crop areas and rangelands. Eradication is only possible with strict adherence to several management techniques, including mechanical, chemical and biological methods. The establishment of native plant communities can also be used to control yellow starthistle. Field studies were conducted near Davis, California to determine resistance to the establishment of yellow starthistle by native plant communities with different life histories. Mixed communities were used that consisted of early (aboveground biomass accumulation in spring), late (some aboveground biomass in early summer and high growth investment in roots), early-late season native plant species. In addition, *Elymus glaucus* (blue wildrye), a native perennial grass, and *Grindelia camporum* (gumplant), a native perennial forb, were established as monoculture communities. Following the establishment of native plant communities in the first year, yellow starthistle was seeded into selected plots the second year. In late season and early-late season communities, yellow starthistle cover was less than 5% three years after seeding. Three years after the addition of yellow starthistle in *E. glaucus* and *G. camporum* communities, yellow starthistle cover was 2% and 8%, respectively. The early season community was ineffective in resisting yellow starthistle invasion and establishment. Late season species, especially *E. glaucus*, were resistant to the establishment of yellow starthistle, which maybe a result of increased shading and uniform use of soil water by late season species.

CONTROL OF TREE TOBACCO (NICOTIANA GLAUCA)

Scott Oneto, Joseph M. DiTomaso, Guy B. Kyser, Sergio Garcia, Sarah Hale
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Tree tobacco is a native of Argentina. It is a slender, erect, 6-20 foot high shrub or small tree found in sandy or gravelly soils along riparian areas, roadsides, near cultivated areas, around old dwellings and ditch banks. It is a common weed throughout much of the southwest and is steadily expanding its range. During early October 2003 several herbicide application techniques were tested for its control in San Benito County, California. Treatments were made shortly before *Nicotiana* leaf drop. Herbicides tested included Chopper® (imazapyr), Garlon 4® (triclopyr ester), and Roundup Max® (glyphosate). Application methods included foliar, drizzle, cut stump and basal bark. Each treatment was replicated 10 times in a randomized block design with an individual trees serving as a replicate. A preliminary evaluation was performed in May 2004. Early results indicate that Roundup Max® appears to control tree tobacco either as a foliar spray, drizzle, or cut stump application. Chopper® also showed excellent control with all rates tested and application techniques employed. For Garlon 4®, only the basal bark and cut stump treatments provided excellent control. Trees will be re-evaluated in 2005 to confirm the effectiveness of the treatments. To determine if timing of application is significant to herbicide effectiveness, the trial was replicated in spring 2004 and will be evaluated in spring 2005.

APPLICATION OF HYPERSPECTRAL IMAGERY FOR DETECTING INVASIVE AQUATIC AND RIPARIAN SPECIES IN THE SACRAMENTO-SAN JOAQUIN DELTA

Melinda Mulitsch 1, Emma Underwood 1, Jonathan Greenberg 1, Susan Ustin 1, Robert Leavitt 2, Lars Anderson 3, Marcia Carlock 4, 1 California Space Institute Center of Excellence & Center for Spatial Technologies and Remote Sensing, University California Davis, 2 California Department of Food and Agriculture, 3 USDA-ARS Weed Science Program, University California Davis, 4 California Department of Boating and Waterways

The University of California, Davis, the California Department of Boating and Waterways, and the California Department of Food and Agriculture cooperated on a project to evaluate the use of hyperspectral imagery for detecting invasive aquatic and riparian species in the Sacramento-San Joaquin Delta in California using 3 m HyMap hyperspectral imagery. The HyMap sensors capture 126 discrete bands of electromagnetic radiation in the visible, near infrared, and short wave infrared wavelengths (400 to 2500 nanometers). The target invasive aquatic weeds were the emergent water hyacinth (*Eichhornia crassipes*), the submerged Brazilian waterweed (*Egeria densa*), and the riparian weeds purple loosestrife (*Lythrum salicaria*) and perennial pepperweed (*Lepidium latifolium*). Ten flightlines covering approximately 400 km2 were acquired on July 1, 2003. 164 flightlines covering approximately 3,400 km2 were acquired from June 25 through July 7, 2004. There were sufficient differences in the spectral signatures of the invasive species to allow us to distinguish them from native vegetation and develop maps of their occurrence. Data were analyzed using linear spectral mixture analysis for aquatic weeds and mixture tuned matched filtering for the riparian weeds on the levees. The results show the target weeds were mapped with a classification accuracy of 90.6% when compared to 2003 sample sites. Preliminary results show that the submerged Brazilian waterweed can be distinguished from Coontail (*Ceratophyllum demersum*), American pondweed (*Potamogeton nodosus*), and the Common waterweed (*Elodea canadensis*). The results indicate that hyperspectral imagery can be used to detect, map, and quantify the distribution of the target weeds within the Sacramento- San Joaquin Delta.

SEDIMENT-APPLIED HERBICIDES FOR AQUATIC PLANT MANAGEMENT: PROMISING PRODUCTS FOR A DAUNTING PROBLEM

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Due to increasing concerns about pesticide residues in water and increasing demands for compliance with California NPDES permits, there is an urgent need for soil-active aquatic herbicides that can be used under seasonal drawdown conditions in western irrigation canals as well as lake and reservoirs where water levels can be manipulated. Drenching exposed canal sediments with acetic acid has been shown to reduce aquatic weed propagule viability (e.g. in *Potamogeton* spp and *Hydrilla verticillata*), and to impede sprouting of rhizomes in *Spartina altlerniflora*. This paper summarizes preliminary results from simulated drawdown studies on SePro's SP1019 herbicide (penoxsulam) suggest that this material may provide control and suppression of problematic pondweeds while exhibiting little lateral off-site movement. Rectilinear containers filled with natural canal sediments were planted ca. 5cm deep with propagules of sago pondweed (*Stuckenia pectinatus*) and American pondweed (*Potamogeton nodosus*). Penoxsulam was applied to air- exposed sediments at 200gal/acre at 25, 50, 100, or 200 g/ha ai and subsequently immersed in tanks 48 hrs later. Rates of 50, 100 and to 200 g/ha suppressed germination by over 90% in the first 30 days. Adjacent propagules in unexposed sediments did not appear to be affected by the applications. Rates of 100 and 200 g/ha continued to suppress plant growth only in the center treated sections up to 45 DAT. Flowering was also suppressed in both species up to 45 DAT at rates of 50, 100 and 200 g/ha. Results suggest that draw down application of penoxsulam has potential for suppression of weeds that interfere with irrigation delivery systems, but practical use needs to be examined in field tests.

DIVERSIFYING WEED MANAGEMENT OPTIONS IN RICE USING ALTERNATIVE TILLAGE AND PLANTING TECHNIQUES

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Alternative rice establishment systems were developed and evaluated for their potential to reduce weed recruitment of targeted weed species and facilitate the use of herbicides with alternative mechanisms of action, such as pendimethalin and glyphosate, which may control weed biotypes resistant to herbicides used in conventional water-seeded rice. Evaluated rice establishment systems included 1) conventional water-seed rice, 2) conventional drill-seeded rice, 3) water-seeded rice after spring tillage and a stale seedbed, 4) water-seeded rice after a stale seedbed without spring tillage, and 5) drill-seeded rice after a stale seedbed without spring tillage. Species compositions of weed communities were distinctly different among establishment systems as the water-seeded systems were dominated by sedge and broadleaf weed species but the drill-seeded systems were dominated by grass weed species. In the drill-seeded systems, grass control from pendimethalin and cyhalofop-butyl was > 89%. Glyphosate used in the stale seedbed systems reduced grass populations by 85 to 100% in drill-seeded rice and broadleaf/sedge weed populations by nearly 100% in the water-seeded rice. In the water-seeded/stale seedbed/no till system, a pre-plant application of glyphosate was the only herbicide application required for nearly 100% weed control over the growing season. Rice yields did not differ ($P > 0.1$) among these establishment systems. Therefore, the alternative rice establishment systems evaluated in this study may be used to effectively manipulate weed species recruitment and enable the use of herbicides that may control weed biotypes resistant to herbicides used in conventional water-seeded systems.

IGNITE AND LIBERTYLINK COTTON FOR THE CALIFORNIA PRODUCTION SYSTEM

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Herbicide tolerant cotton varieties provide growers a weed management option that can reduce weed control costs and provide effective management of hard-to-control weeds such as nutsedge, field bindweed and annual morningglory. Herbicide tolerant varieties have also allowed growers to explore alternative production systems such as conservation tillage. Environmental benefits have included reduction of dust into the air due to reductions of cultivation. Planting of herbicide tolerant crops is an accepted practice to reduce PM10 emissions in growers "Conservation Management Plans" required by the San Joaquin Valley Unified Air Pollution Control District. Although Roundup Ready cotton varieties comprise 40 percent of the Acala and Upland acreage, the evaluation and integration of LibertyLink cotton into the California cotton production system will provide growers with an additional control option and herbicide resistant management tool. Field studies were conducted from 2002 to 2004 to evaluate weed control efficacy and tolerance of both LibertyLink and non LibertyLink cotton to Ignite (glufosinate). Ignite was applied over-the-top of LibertyLink FM 966L cotton in the 4 to 5-leaf stage when pigweed (amaranthus spp) and black nightshade (Solanum nigrum) were in the 2 to 8-leaf stage. Control was excellent when weeds were 4 true leaves or less with control being poor when weeds were 5 true leaves or greater. When Ignite was tank mixed with either Staple (pyrithiobac sodium) or MSMA the 5 true leaf weeds were effectively controlled. There were no differences in control regardless of whether Ignited followed a PPI application of Treflan (triflurin) or not. No injury was observed on the cotton with Ignite alone, although some injury was noted when tank mixed with Staple, MSMA or Dual Magnum (metolachlor). Ignite applied post directed to non LibertyLink cotton exhibited mild injury to the lower stem and leaves contacted by the spray solution. Seed cotton yields of Ignite alone were significantly greater than the untreated control. When tank mixed with Staple, MSMA or Dual Magnum yields tended to be lower. Seed cotton yields of post directed Ignite on non LibertyLink cotton were lower, but not significantly lower, than the untreated control.

FINDING EFFECTIVE HERBICIDE TREATMENTS FOR FENNEL (*FOENICULUM VULGARE*)

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Fennel is an introduced perennial wildland weed of low elevations throughout California and is particularly extensive on Marine Corps Base Camp Pendleton in San Diego County, the site for this study. Experimental objectives are to find effective rates of two herbicides: glyphosate and triclopyr, either singly or in combination, that also minimize damage to other plant species. In February of 2004 we treated small regrowing fennel plants, approximately 20-30 cm high that had been burned in the wildfires of October 2003. Seven treatments were applied as broadcast applications over the entire plot. In addition, each of the herbicides was applied as a spot spray to just the fennel to reduce effects on other plant species. We used a completely randomized design with four replications. Broadcast treatments were applied with a CO2 pressurized sprayer while spot spraying used a hand pumped backpack sprayer. Data collected included cover estimates for fennel and native purple needlegrass (*Nassella pulchra*), biomass estimates for fennel, and visual evaluations of weed control. All of the herbicides, except the broadcast applications of glyphosate, controlled fennel well when observed approximately 6 weeks after treatment. The broadcast applications also controlled other weeds present (annual grasses and filaree), the spot spray did not. None of the treatments effected purple needlegrass. All treatments except the low rate of glyphosate reduced fennel cover compared to the untreated control. All treatments reduced fennel biomass compared to the untreated control. Broadcast herbicide treatments that included triclopyr reduced fennel biomass better than the broadcast treatments of glyphosate.

BIOLOGICAL CONTROL OF PURPLE LOOSESTRIFE IN CALIFORNIA – CURRENT STATUS

Baldo Villegas and Dale Woods, CDFA Biological Control Program, Sacramento, CA

Purple loosestrife, *Lythrum salicariae* L. (Lythraceae), is an exotic, invasive weed of wetlands and riparian areas in many parts of the United States and Canada. It is native to Europe, Asia, and northern Africa and was introduced into the United States prior to 1800 because of its herbal and ornamental qualities. Once established, the plant produces millions of small seeds that can be spread by wind, transported by wildlife, and carried long distances by water currents. In California, purple loosestrife has been reported in a number of locations throughout the state. Many small infestations have either been eradicated or being controlled by herbicidal treatments by staff from the California Department of Food & Agriculture in cooperation with County Agriculture Departments. However, there are still some well established infestations in Butte, Kern, Shasta and Siskiyou Counties. In 1996 the Biological Control Program initiated a biological control program directed towards the largest infestations of purple loosestrife in California. To date four biological control agents have been released in the state. The agents include two species of weevils, *Hylobius transversovittatus* Goeze (Coleoptera: Curculionidae), a root boring weevil, and *Nanophyes marmoratus* (Goeze) (Coleoptera: Curculionidae), a flower-bud weevil, and two leaf-feeding beetles, *Galerucella calmariensis* L., and *G. pusilla* (Dufft.) (Coleoptera: Chrysomelidae) which were approved for release in California in 1998. The root-boring weevil, *Hylobius transversovittatus* was the first agent released in California. The early releases involved the placement of weevil eggs in the loosestrife stems at two sites in Butte and Shasta Counties. Subsequent releases involved the releases of adult weevils in the same areas as wellas Kern County from 2000-2004. The main damage is by the larvae, which can cause extensive damage to the loosestrife roots. To date there have been recoveries of the weevils only in Shasta County. The flower-bud weevil, *Nanophyes marmoratus* was first released in small numbers in Butte and Shasta Counties in 1997. The adult weevils feed on the foliage and terminal growth thus impacting flower and seed production by the plants. Furthermore, the larvae feed directly on the seeds. Additional weevil releases have been made in Butte, Shasta and Kern Counties in 2002-2004. Establishment has been confirmed at two sites in Shasta County since 2003. The focus of the releases of on purple loosestrife since 1998 has been the release of two species of leaf-feeding beetles, *Galerucella calmariensis* and *G. pusilla.*. These beetles damage the plant by the both the adults and larvae feeding on the foliage and the new tips. In many areas of Canada and the United States where these beetles have been released the damage to the foliage by the adults and larvae have been spectacular especially after about 5-6 years after the initial release of the beetles. There are also documented cases where the beetles are having an impact in reducing infestations of purple loosestrife. In California, the beetles readily established where they were released particularly in those sites that where spring generation releases were made. No signs of establishment have been observed where the summer generation of the beetles was released. Due to many factors involving improper site selection and low release numbers of the biological control agents, many of the early releases failed to establish particularly in Butte County. In 2001-2004 better site selection and large scale releases at fewer sites were made in Butte, Kern and Shasta Counties. Since spring 2003, good establishment by the two leaf beetles has been confirmed in Kern and Shasta Counties and it is hoped that this will lead to biological control of purple loosestrife in those areas.

DEMONSTRATION OF THE EFFECTIVENESS OF PRE-EMERGENCE HERBICIDES APPLIED THROUGH LOW-VOLUME IRRIGATION SYSTEMS

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Chemigation is a potential mitigation measure for both leaching and runoff, however, most of the pre-emergence herbicide residues detected in ground water are not labeled in California for application through low-volume irrigation systems. The objective of the first-year study was to develop data on the adoption of chemigation as a management practice for mitigation of pesticide movement to ground water. The study was conducted at three citrus orchards in Strathmore and Lindsay, CA Tulare County. Three treatments (Control-no herbicides, Growers' standard practices-tank mix of simazine and diuron, and Chemigation- tank mix of simazine and diuron) were applied at each citrus orchard, and data were collected on the effectiveness of the practice to mitigate ground water contamination, on the effectiveness of the pesticide under the new management practice, and on potential economic impacts. Soil herbicide concentration was significantly related to soil depth. Soil samples collected 1 and 45 days after application revealed that the majority of the herbicides remained in the upper three inches of soil, as was expected with the soil types (heavy clay). Soil samples collected 120 days after application revealed that simazine was undetectable at two of the three sites, and that very low concentrations of diuron were detectable at all three sites. The chemigation treatment was found to mitigate groundwater contamination, and the simazine and diuron effectively controlled weeds when applied by chemigation. Currently, chemical companies are interested in pursuing label amendments to allow chemigation as a mitigation measure, and part two of this study is underway.

IS IT WEED RESISTANCE OR JUST PERSISTENCE?

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Many growers and managers have remarked lately that they are spending more money and time but certain weeds seem to be increasing in their production venues. Some suggest that the herbicide is not doing its job and that the weeds must be resistant. Weed tolerance that is inherent and resistance which can be induced by selection pressure and subsequent reproduction coupled with persistence, a result of either partial tolerance or the weeds ability to propagate between major cultural operations within the crop growth cycle, can often lead to shifts in vegetation inventories. In most of these cases we are dealing with herbicide chemistries that have presented low risk of resistance developmental potential and the inventory shifts appear to be locally driven by cultural selection pressures as these “escape” weeds are just as susceptible if addressed and treated at the proper time and stage.

Vegetation management is an integrated system that is venue based but must encompass a weed definition or management philosophy that recognizes crop culture and reproduction as selection criteria that lead to either resistance or persistence. A ten point series of management criteria for annual crops are presented and two of these escape management and crop residue management are illustrated to show how these can be used as reinforcement in a planned vegetation management program.

Future selection pressures from crop culture are going to arise in the San Joaquin valley as we move to more permanent bed culture, from buried drip and controlled traffic systems, and more potential reliance on less herbicide chemistry due to an increased use of engineered herbicide-tolerant crops (EHTC’s) such as Round-up Ready and Liberty-Linked products. Regulatory restraints on tillage and application with newly implemented suggestions in the San Joaquin valley from the Air Pollution Control District will further confound management. Record keeping and flexible management with reinforcing weed control practices to prevent propagation will be necessary with these added constraints and restraints. The question of resistance or persistence is moot if we take every opportunity to interrupt weed life-cycles.

57TH ANNUAL CALIFORNIA WEED SCIENCE SOCIETY CONFERENCE
PRESIDENTIAL ADDRESS

Presented by Debra Keenan

MISSION STATEMENT

The California Weed Science Society provides information exchange on weed science and technology through an annual conference, publications, and other activities; advises stakeholders on matters pertaining to weeds; facilitates cooperation among individuals, agencies, and organizations; encourages careers in weed science; and promotes professional growth and interaction for its members in California.

A POLL OF GROWERS AND PCA'S: TOP CONCERNS

- Need to educate the Public
- New chemicals
- New technologies

EDUCATION OF THE PUBLIC SECTOR:

- Issues that affect Agriculture and the public
- As a Society we need to help educate the public

AVAILABILITY OF NEW HERBICIDE

- 10 to 15 years of research
- $ 50 million plus
- Low a.i.'s
- lower amounts per ac
- Fewer manufacturers
- More laws restricting registration of materials
- Risk cup assessment
- ADI
- Environmental concerns
- Politics

FUTURE OF THE SOCIETY

- Our Bylaws have been adopted
- New Board of Directors

Thank you
Presidential Address
Debra Keenan
Research 2000
January 2005
CWSS

PLANT BIOTECHNOLOGY: THE BASICS

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Biotechnology refers to the use and manipulation of living organisms, or their products, for specific human purposes. Humans have been using other organisms for their benefit for a long time. However, modern-day biotechnology generally refers to the manipulation of organismal DNA for specific purposes. Often, this involves the identification and isolation of genes for valuable traits in one species and their insertion into another. Biotechnology, based on DNA manipulation, is possible because genes are multipartite consisting of regulatory and coding regions, DNA of all organisms is chemically identical, and the same genetic code is used in all organisms. Thus, genes and gene parts can be interchanged among organisms. The manipulation and exchange of DNA among organisms forms the basis of plant biotechnology, or recombinant DNA technology, today.

Recombinant DNA technology uses specialized techniques to transfer a gene or DNA segment from one organism to another, i.e. to “recombine” DNA from two different organisms. These techniques can be divided into four basic steps: gene splicing, gene cloning, plant transformation, and plant regeneration. Gene splicing consists of the construction of recombinant DNA molecules using restriction enzymes that cut DNA and other enzymes, called DNA ligases, that rejoin, or ligate, DNA fragments from different sources. The resulting recombinant DNA molecules include the novel desired gene that is to be transferred. During gene cloning, millions of copies of the desired gene are produced. This step is normally accomplished with the help of a “vector”, which introduces the desired gene into host bacterial cells that reproduce and, at the same time, produce multiple copies of the desired gene. The most common vectors are plasmids, which are small, circular DNA molecules found in bacteria.

During plant transformation, the new gene is introduced into a plant chromosome. Two methods are commonly used, *Agrobacterium*-mediated gene transfer or the “gene gun” method. In many plant species, one or a few genes can be introduced via the naturally occurring pathogenic soil bacterium, *Agrobacterium tumefasciens*. For other species, a microprojectile gun shoots DNA, coated onto microscopic beads, at high speed into plant cells directly. Some beads carry the DNA into the cell, where it is incorporated into a plant’s chromosomes. Once the desired gene is incorporated into the chromosomes of at least some living plant cells and these cells are identified and separated from untransformed cells, whole plants are regenerated from the transformed cells. All cells of the regenerated plants will contain the gene of interest.

Recombinant DNA techniques have dramatically increased the possibilities for crop improvement. Whereas traditional breeding is limited to the traits and genes that are present in a crop species or its close relatives, recombinant DNA technology can potentially introduce novel traits and genes from any source, including other organisms.

TRANSGENES FOR WEED MANAGEMENT - THE PAST, PRESENT, AND FUTURE

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Theoretically, transgenes can be used in weed management in several ways, but only transgenic herbicide-resistant crops are currently commercialized. As of 2005, only two herbicides, glufosinate and glyphosate, are used with herbicide-resistant crops. Three transgenes are used with various glyphosate-resistant crops and one is used with glufosinate-resistant crops. The prospects are not good for the introduction of crops resistant to herbicides other than these two within the next five years. No transgenes have been introduced that would reduce synthetic herbicide input. Other ways of using transgenes for weed management are: 1) to enhance efficacy of weed biocontrol agents; 2) to make crops resistant to parasitic weeds; and 3) to enhance crop allelopathy. An example of enhancing biocontrol agent efficacy is that of the work of Amsellem et al. (2002) in which the gene for the Nep 1 phytotoxin was inserted into the mycoherbicidal fungus *Colletotrichum coccodes*. This enhanced the virulence of the mycoherbicide on weeds, also extended its host range to crops. The work of Westwood (2005) and others in which the gene for sarcotoxin from the flesh fly was put into tobacco is an example of making a crop resistant to a pararsitic weed. This gene made tobacco somewhat resistant to *Orobanche aegyptiaca.* The approach of having the crop produce its own natural herbicide (allelochemical) could greatly reduce synthetic herbicide input. Our laboratory is working on enhancing the allelopathic potential of *Sorghum* spp. crops by enhancing production of the allelochemical sorgoleone

Amsellem, Z. et al. (2002) Engineering hypervirulence in a mycoherbicidal fungus for efficient weed control. *Nature Biotechnol.* 20, 1035-39.

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BIOTECH AT THE BALLOT BOX

Martin Lemon,Technical Resources Manager
Monsanto Company

Biotech crop acreage continues to increase worldwide even as some special interest groups lobby for GE bans.

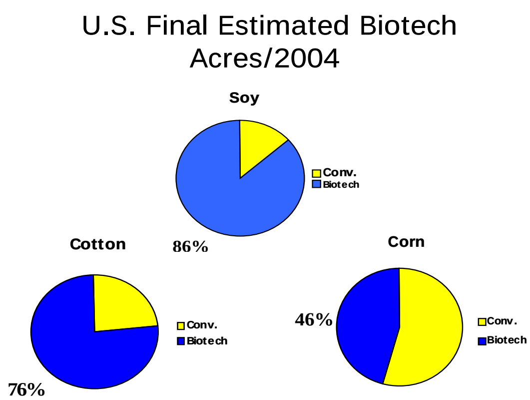
Worldwide biotech crop value reached $44 billion in 2003-2004 in the five countries accounting for about 98 percent of all biotech crop hectares and values (1 hectare = 2.47 acres). The leading five countries in global biotech crop value in 2003-2004 were the United States, Argentina, China, Canada and Brazil.

Table 1. Top Biotech Crop Producing Countries (2003-2004)1

Country	Crop Value Produced (billions)
United States	$27.5
Argentina	$8.9
China	$3.9
Canada	$2.0
Brazil	$1.6

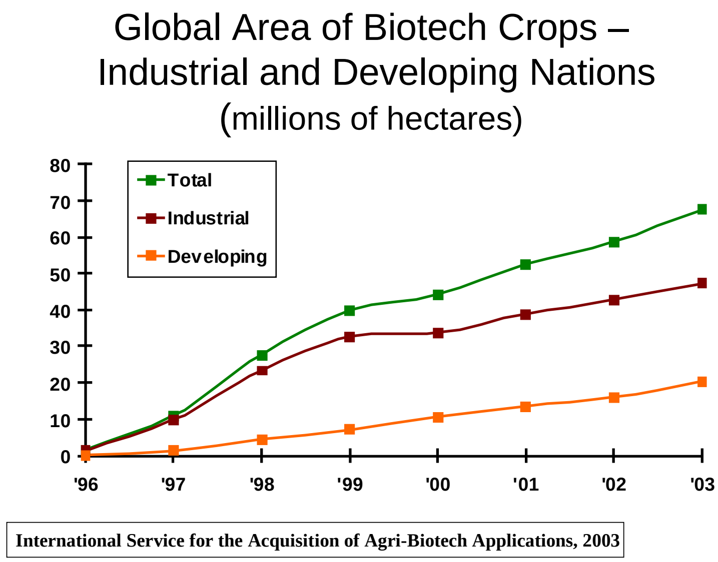
Worldwide, four biotech crops, soybeans, cotton, corn and canola, accounted for virtually all of the biotech values and planted area. In the United States, soy, corn, and cotton were the main GE crops planted in 2004. Figure 1 shows the estimated U.S. acreages for soy, cotton, and corn for 2004.

Figure 1. USDA Biotech Planting Estimates for 2004.



But adoption of GE crops is not confined to these five countries. Eight other countries have significant acreages of commercial biotech crop production: South Africa, Mexico, Australia, India, Romania, Spain, Philippines, and Uruguay. Biotech crops have a cultural and agronomic fit and are being readily adopted in developing countries around the world.

Figure 2. Global Area of Biotech Crops, 2003[2]



In spite of this rapid and expanding adoption, there have been recent efforts by anti-GE coalitions to ban the planting of GE crops in some California counties through use of the initiative process. Four California counties had anti-GE crop initiatives qualify for inclusion on the November 2004 ballot. The ballot initiatives were defeated by the voters in three counties (Butte, San Luis Obispo, and Humboldt) by fairly wide margins, but the Marin County initiative was passed by the county's voters by a similar significant margin. The demise of the anti-GE initiatives in Butte and San Luis Obispo counties is noteworthy because these counties are, to a greater than lesser degree, agriculture counties. Had the voting public approved the initiatives in these two counties it would have sent a chilling message to agriculture producers in other areas of the state and to the politicos in Sacramento. Too, it would certainly have embolden the anti-GE special interest groups to further, more far reaching attempts at banning GE crops. That these initiatives were defeated in agriculture counties should help solidify the position that California agriculture producers do not want others to limit their choices of crop production tools. Some farmers and ranchers noted that it was the attempt by non-agricultural outsiders to foist their agenda and philosophy on what was best for agriculture, as the biggest reason for the initiative's failure.

Other people within the electorate have expressed concerns about the initiative process more generally. Since the inception of the initiative process in 1898 in South Dakota, citizens have been placing laws on state ballots. Unfortunately, the initiative process has recently been the tool of special interest groups who have been unable to get their special interest addressed by the state legislature. Sometimes the initiatives are so poorly written that they may be unconstitutional, contradict other laws or initiatives, and require evaluation by the courts. Special interest groups have learned to manipulate the initiative process, and some initiative campaigns are not above "selling" their initiative using less than factual information. Pulitzer Prize-winning historian Jack Rakove believes that, "the smaller the group, the more dangerous it is" noting that it takes relatively few signatures to get recalls and initiatives on the ballot[3].

Chief Justice Ron George of the California Supreme Court recently deplored the contemporary process itself as something that, although it began as a people's remedy, has been transformed into a tool of special interests[4]. What special interest groups constitute the backers of anti-GE initiatives is open to discussion; however, a cursory internet search shows some organic grower associations, anti-technology, anti-agriculture, and anti-pesticide groups have statements or positions of support on their web sites. A closer look reveals that some groups offer specific advice on how to take an anti-GE initiative from concept to reality.

Problems resulting from the initiative process in California are compounded at the county level when we take into account the economic realities of an open market; production costs and selling prices of crops grown in different but adjacent counties.

Certainly there are some lessons to be learned from the successes and failures of the recent anti-GE initiatives. How do the anti-GE special interest groups sell their message? What tactics have been utilized to their benefit and how are those opposed to these initiatives responding effectively? These and other questions will be addressed during the presentation.

Citations

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3 Top historian warns of flaws in California recall process, in the *Mercury News*, Oct 20, 2003.

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REGULATION OF BIOTECHNOLOGY, A PERSPECTIVE

David C. Nunenkamp, Deputy Secretary, CDFA

California is the birthplace of the US biotechnology industry, the base of 40% of all biotech companies, accounts for 47% of national R & D spending on biotech, and generates 53% of the nation's biotech revenues.

Yet the regulation of agricultural biotechnology is a hot, negative issue generated by fear mongers. Fear can lead to both great achievements and to tragic decisions and to poorly written and misguided public policy. The issues of concern surrounding biotechnology and food are understandable. Our government has done a dismal job of assuring consumers of the long-term safety of food made from genetically modified plants. People want to know if there are health risks associated with eating plants and animals who's DNA has been manipulated. They want to understand the effects on nature if these modified species enter the natural environment. Scientists have provided conflicting answers. The federal Food and Drug Administration has been missing in action – meanwhile, the use of genetically engineered crops has exploded. An estimated 70 percent of food products contain some ingredient derived from a gene-altered plant.
States with large Ag sectors are intensely interested in the economic promise of Ag biotechnology, recognize that the economic benefits could/will be jeopardized if public anxiety or market access for conventional crops is threatened, have an important stake in the oversight of Ag biotechnology not only to protect health and safety but to protect the economic interests, and most perfect that stake through a partnership with the federal regulatory program.

The federal Coordinated Framework for Regulation of Biotechnology established as a formal policy, based upon a coordinated, risk-based system to ensure new biotechnology products are safe for the environment and human and animal health. The "Framework" is predicated upon health and safety laws developed to address specific product classes. Separate but coordinated reviews are made by USDA, EPA, and FDA [depending upon the gene and host crop].

From the perspective of the California Department of Food and Agriculture (CDFA), the regulation of agricultural biotechnology is strictly a federal issue. Significant national and international implications and ramifications have resulted from the regulation of this industry and the perceived lack of regulation based on the unwarranted fears generated by activists opposed to the introduction of any genetically modified organism. The regulation of Ag biotechnology cannot and should not be compounded by individual states or local legislative units.

Details of the program and current dissatisfaction are discussed in the presentation.

AN UPDATE OF WEED MANAGEMENT ISSUES IN CONSERVATION TILLAGE SYSTEMS

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Tom Lanini, Jeff Mitchell, UC Davis
Steve Wright and Ron Vargas, UCCE Tulare and Madera County

Introduction

Tillage has been an essential component of traditional agricultural systems. However, intensive tillage in some cases has been found to adversely affect soil structure and cause excessive breakdown of aggregates leading to soil erosion in higher rainfall areas. Further, intensive tillage can negatively impact environmental quality by accelerating soil carbon loss and greenhouse gas emissions (Reicosky and Allmaras, 2003). Such concerns have led to the search for tillage systems that minimize negative impacts to the environment while maintaining sustained, economic crop productivity. The tillage systems being developed and studied to address these concerns can be broadly termed as 'conservation tillage' (CT).

Several states in the US have been exploring for innovative CT systems. However, findings of other states cannot be readily adapted to California because of differences in climatic and soil factors, dependence on irrigation and use of various forms of irrigation systems, and the diversity of cropping systems. Although the acreage under CT in California is relatively less than that of several other states of the US; as herbicide-tolerant crop (HTC) varieties, mainly cotton and corn, have increased so has the interest in CT systems in California.

Besides the availability of HTCs, increased fuel prices, access to better CT equipment, GPS technology, and environmental air quality issues have all resulted in an increased interest in CT systems in California. Further, Conservation Management Plans now required by the San Joaquin Valley (SJV) Unified Air Pollution Control District, list HTCs [Roundup Ready (RR)] and the reduction of cultivations as practices acceptable in dust reduction. Therefore, this paper focuses on the weed management issues and suggests some techniques for the successful adoption of CT systems in California.

Tillage and Weed Management

Tillage affects weeds by: uprooting, dismembering, and burying them to depths too deep for emergence; changing the soil environment and promoting or inhibiting their germination and establishment; and moving their seeds vertically and horizontally. Tillage is also used to incorporate herbicides and to remove surface residues which might otherwise impede herbicide incorporation by sprinkler irrigation. In summary, tillage has been an important weed management tool. Any reduction in tillage intensity or frequency, therefore, poses serious concerns for weed management.

Very little data exists on weed dynamics in CT under California conditions. However, some studies in California showed that most black nightshade (*Solanum nigrum*) emerged from the top ½ inch of the soil whereas annual morningglory (*Ipomoea* spp.) emerged from the top 3 inches of the soil (P. Keeley, personal communication). Further, over 95% control of black nightshade could be achieved with deep plowing (K. J. Hembree, personal communication). Similarly, a significant reduction in annual morningglory emergence was observed following plowing. These results suggest that in the SJV cotton production systems using RR-CT technology, we may have to rely on some level of cultivation for controlling annual morningglory to avoid costly hand weeding. Some other problems associated with this system include the difficulty in controlling nutsedge (*Cyperus* spp.). Therefore, CT systems are still a challenge in RR cotton production systems.

Most perennial weeds are capable of reproducing from organs other than seeds. For example, nutsedge and johnsongrass (*Sorghum halepense*), generally reproduce from underground storage structures called tubers and rhizomes, respectively. These perennial reproductive structures may no longer be buried to unfavorable depths or may not be readily uprooted and killed with the implements used in CT as compared to conventional implements.

Trials of Wright and Vargas showed that most effective purple and yellow nutsedge control in cotton was achieved using a combination of glyphosate in a RR system combined with mulching seed beds and cultivating 2-3 times using sweep type cultivators. Similarly, cultivation was necessary to successfully control field bindweed (*Convolvulus arvensis*) in blackeye beans in a study in Denair, CA (Shrestha et al. 2003). Therefore, some level of cultivation may be necessary for perennial weed control in certain cropping systems in California.

Weed seedling emergence and timing of weed control operations in CT

Some weed seeds require scarification and disturbance for germination and emergence. The germination and emergence of such weed species may be suppressed under CT systems. For example, a study in small grains and beans showed a reduction in wild radish (*Raphanus raphanistrum*) emergence under CT than in soil inverting tillage systems (Shrestha et al., 2003).

Presence of surface residue may influence soil temperature and moisture regimes thus affecting weed seed germination and emergence patterns over the growing season in CT systems. Therefore, timing of weed control may have to be altered. Soil surface residue can interfere with herbicides so there is a greater likelihood of weed escapes if residue is not managed properly or herbicide application timing or rates are not adjusted. Again, very little data exists on timing of weed emergence as influenced by CT systems in California.

Herbicide use and CT

Burndown herbicides

Weeds present at the time of crop planting in CT systems may need to be controlled with nonselective burndown herbicides such as glyphosate, paraquat etc. These herbicides have to be applied prior to crop emergence (Hartzler and Owen, 1997). However, these herbicides lack residual activity. Therefore, applications should be as close to crop planting or emergence, as the label will permit, to avoid further weed emergence prior to the crop. Growers may perceive this burndown herbicide application to be an increase in their chemical costs because tillage would control these emerged weeds in conventional or standard tillage (ST) systems. However, fuel, labor, and energy cost comparison between burndown herbicide application in CT and tillage in ST systems need to be taken into consideration.

Preemergence herbcides

In ST systems, residue is generally not present at the time of preemergence herbicide application. However, in CT systems crop residue may be present at the time of herbicide application and this may affect the performance of the herbicide as the residue can intercept the herbicides and affect their distribution (Hartzler and Owen, 1997). Most preemergence herbicides can be surface applied but they must be incorporated either by water or mechanically. Rainfall often is not dependable in the central valley. Therefore, sprinkler irrigation or mechanical incorporation may need to be used in CT systems. Further, the increase in surface organic matter may bind up some of the herbicide and thus rates may need to be increased to achieve adequate control. Cover crops left on the surface present a different situation for preemergence herbicides. Cover crop mulches are seldom uniform and thus it is common to see thick mulch and bare ground in the same field. However, it was observed that a thick mulch may be sufficient alone in controlling weeds, whereas in areas where the mulch is thin or non-existent, the herbicides are effective (Lanini et al., 1989). The planter also moves mulches and crop residue away from the seed line and creates a relatively clean zone for good herbicide action, where it is needed most.

Postemergence herbicides

Postemergence herbicides work equally well in CT and ST systems. However, it should be noted that residue on the soil surface in CT systems may interfere with effective herbicide contact with emerging seedlings. Hartzler and Owen (1997) suggest that growers wait until weeds become established and then control them with postemergence herbicides because weed emergence is less uniform in CT than in ST systems. Similarly, crop emergence and development may not be uniform in CT systems compared to ST systems, particularly for plantings made during cool periods of the year, and where there is a lot of surface residue. In spring and summer plantings, this difference in weed emergence timing would be expected to be much less. Adoption of CT systems has been enhanced by the development of HTCs as postemergence herbicides can be applied during the growing season with relatively low risk of crop injury. However, when postemergence herbicides are applied aerially, it must be cautioned that growers should not wait too long because canopy closure by the crops may intercept the aerially applied herbicide thus reducing the contact between the herbicide and the weeds under the crop canopy. This phenomenon was noticed in RR forage corn grown in narrow (15 inch) rows in California. Therefore, identification of the best timeframe for postemergence herbicide application in HTCs is critical in CT systems in California.

Residual activity of herbicides

Persistence of residual herbicides for a longer period may be a concern in CT systems. For example, Vargas and Wright found crop injury due to persistence of prythiobac sodium (Staple) in a CT study. Staple was applied to cotton but the following tomato crop suffered considerable stand loss due to carry-over of the herbicide. Among the tillage systems compared, injury was most severe in the complete no-till system. Similar carryover of another sulfonylurea and crop injury was also observed in corn. In CT systems with reduced tillage, residual herbicides may not be diluted sufficiently in the soil profile, as they are in conventional systems. This may lead to injury of the subsequent crop. Therefore, herbicide selection in CT systems is important to avoid losses to subsequent crops in the rotation.

Herbicide-tolerant crops (HTCs) and CT

HTCs have allowed growers to begin to transition into CT systems in California and other states. The advantage of HTCs, mainly RR, has been the ease of applying glyphosate over-the-top with excellent crop safety and weed control. Production costs have also decreased as growers have made fewer trips across fields in applying herbicides, reduced cultivations, and hand weeding operations. Reducing cultivation and eliminating hand weeding have reduced costs from $25- 150 per acre depending upon weed species and density. UCCE cotton cost studies indicate an average savings of $60 per acre savings with RR cotton compared to conventional cotton (UCCE, 2003).

Potential for weed resistance to specific herbicides and weed shifts is always a concern with herbicide programs, but with HTCs in a CT system, weed resistance may be of greater concern. HTCs as in the case of RR crops tend to promote the continuous use of glyphosate, this probably may induce species shift or development of herbicide-resistance in weeds. If tillage is also eliminated, an important tool for managing resistant weeds is also eliminated. Studies of Wright have already shown weed shifts in Tulare as more annual morningglory was observed in the CT plots. Although CT systems are often practiced in conjunction with HTCs, conventional varieties, herbicides with different modes of action including residual herbicides, or cultivation will also need to be integrated to prevent herbicide-resistance and species shifts.

Alternative techniques for weed management in CT

Mulches

Any material that blocks light will suppress or prevent the growth of weeds. Layers of organic residue mulches such as municipal yard waste, straw, hay, wood chips, etc., can be used as mulch, with thicker layers providing the best control of annual weeds (Makus et al., 1994). Organic mulches breakdown with time and the original thickness typically reduces by 60% after one year. Coarse green waste works better as a mulch. Organic residue mulches are rarely used in vegetable production in California because of their costs, as well as the additional hauling and spreading costs.

Cover crops can be grown, under cut and left on the beds to form an organic mulch (Lanini et al., 1989). Plants used to produce organic mulches include various cereals, clovers, vetches and fava beans (Abdul-Baki and Teasdale, 1993). The advantage of growing the mulch in place is that it is rooted and thus will not be blown away in windy locations. Organic mulches provide some weed control, depending on the thickness and ability to block light, as well as other benefits on the growth of row crops. However, thick mulches have created some difficulties in direct seeding of crops (Lanini et al. 1989), but less so with transplanting. Cover crop mulches are currently the subject of a great deal of research in the interior valleys on crops such as processing tomatoes, but at present, their use is limited.

Cultivation

Tillage is a time-tested technique to control weeds in crop production. Many approaches and philosophies regarding cultivation exist. A new generation of cultivators has been developed to remove weeds from between the seed rows, and in some situations, from the seed row (Wallace and Bellinder, 1992). Cultivators, such as brush hoes work the soil in a circular direction and thus do not remove surface residues. Knives that run parallel to the soil surface and undercut weeds also preserve surface residues. Use of cultivation to eliminate perennial weeds was discussed earlier.

Weed Burning

Flaming is a popular method of controlling weeds in organic production systems. It is used on a wide variety of crops preemergence: peppers, carrots, onions, parsley, potato and parsnips (Melander, 1998). In addition, flaming is used postemergence on young onion (Rifai et al., 1996) and garlic or as a directed treatment to the base of tougher crops such as corn or cotton when they are twelve or more inches in height (Schlesselman et al. 1989). Flaming is one of the more economical methods of controlling weeds in organic vegetable operations with the costs varying from $30 - 35 per acre depending upon the amount of propane that is consumed in the operation (Klonsky et al., 1994). Flaming works best on small broadleaf weeds, and less well on grasses or large weeds. Grasses have growing points at or below the soil surface and often recover following flaming and large broadleaf weeds can often recover after partial top removal.

Subsurface drip irrigation

Drip irrigation tape buried 6 – 12 inches below the surface of the bed can provide moisture to the crop and minimize the amount of moisture that is available to weeds on the surface (Grattan et al., 1988). If properly managed, this technique can provide significant weed control during the non-rainy periods of the year. The use of subsurface drip irrigation also eliminates the need to maintain furrows for irrigation.

Summary and conclusions

California has very diverse and complex cropping systems than other parts of the US. Therefore, findings on weed management in CT systems from elsewhere may not be readily adapted to California. However, there are several examples of the biology of weeds, seed bank dynamics, and management techniques that can be applicable to our conditions. Several examples of which were presented in this paper. Studies are also being conducted in California to develop weed management in CT systems.   Results of these studies will be shared as they become available. The principles and philosophy of weed management, however, remains the same in CT and ST systems. Monitoring weed communities and patch dynamics, timeliness of weed management operations, rotation of herbicides, and minimizing weed seed return are all essential components of CT as in ST systems. Some alternative techniques to manage weeds were also presented. Adjustments will have to be made in CT systems for weed management, for example, cultivating some difficult to control weeds. Finally, proper weed management is essential for the success of CT systems.

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COMMON GROUNDSEL, AN INCREASING PROBLEM IN THE LOW DESERT

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Background

Common groundsel (*Senecio vulgaris*) is a difficult to control, poisonous weed that has become established in LaPaz County and is becoming increasingly widespread. This weed has been present in alfalfa grown at higher elevations for many years but did not become established in the low desert production areas until recently.

Common groundsel belongs to the composite or sunflower family. This family comprises about 900 species including many weeds that have been historical problems, including sowthistle, prickly lettuce, marstail, sunflower, camphorweed, cocklebur, povertyweed, dandelion, thistles and others. This family also includes several major crops including lettuce, artichokes and flowers such as chrysanthemum, marigold and daisy. Common groundsel contains pyrrolizidine alkaloids (PA), which are toxic to cattle and horses. PA does not seem to affect sheep. Other weeds in the *senecio* genus, such as tansy ragwort (*Senecio jacoboca*), are more toxic.

Small and isolated infestations of this weed have been reported over the past several years in the low deserts. The first large scale and heavy infestation was reported about 6 years ago in La Paz County, AZ. This weed has now spread into alfalfa throughout La Paz and Riverside Counties. No confirmed findings have been reported in Yuma County.

The seed from this weed is easily dispersed by wind, water, machinery and animals. It flowers at the same time sheep graze alfalfa fields. The proliferation of groundsel can also be correlated to the widespread use of the imadazlionone herbicides, Raptor and Pursuit, which are weak on this family of weeds.

Economic Impact

Common groundsel is a winter annual that begins to emerge in October and is present until May. Typical cutting dates, yields and value of alfalfa in Parker, AZ are presented in Table 1.

Cutting Date	Yield (T/A)	Price ($/T 22yr. ave.)	Value ($/A)
Feb.	0.98	101	99
Mar	1.46	104	152
May	2.16	94	203
June	2.21	80	177
July	1.79	80	129
Aug.	1.03	72	74
Sept.	0.84	72	63
Nov.	0.69	95	66

Table 1. Cutting date, yield and value of non-dormant alfalfa in the low desert.

The yield and value information used in this table are taken from "Alfalfa market prices – 1981-2002, Yuma Co. Farm Notes, Jan. 2003" and "UC Imperial Alfalfa Cultivar Trial 2001 yields, Feb. 2002."

The cuttings that are affected by this winter annual weed are those that are produced in November, February and March. The annual value of these cuttings from the above table is $317/Acre. Common groundsel is considered a poisonous weed and much of the hay containing significant amounts of this weed cannot be sold to dairy, feedlot or retail markets. Groundsel is not poisonous to sheep and it can be grazed. Sheep grazing normally returns 20 to 30 dollars per acre to the grower. Subtracting this from the value of the November, February and March cutting brings the approximate loss due to common groundsel at $290 per acre.

According to the University of Arizona Herbarium, Common groundsel has largely been an urban weed with samples occasionally being collected in urban landscapes. Prior to our first finding in 1998 in the Butler Valley of La Paz County, it had not been reported as an agricultural problem. Over the past six years this weed has spread throughout the Parker Valley. Infestation estimates by alfalfa growers and pest control advisors range from 10 to 15 percent or 6300 to 9450 acres. Common groundsel has not yet been reported in alfalfa in any other county in Arizona. It has spread to almost 10,000 acres in La Paz County over the past six years and continues to spread. At a value of $290/Acre, this represented a loss of approximately $1,827,000 to $2,740,500 in 2003.

Control Options

Common groundsel is a problem both in new alfalfa that has been planted in the fall and older stands that have become weak. A healthy, thick stand of alfalfa that is cut frequently seldom has serious weed problems. Cutting frequency decreases during the winter months due to slower growing conditions and this is when groundsel is most troublesome. Herbicides are needed at this time of the season to keep weeds in check. Since groundsel is a relatively new weed in Arizona alfalfa, information on the efficacy of currently available and potential new herbicides for controlling it in the low desert was not available. Therefore, a test was conducted during the 2003-2004 season to evaluate herbicides for efficacy and crop safety.

The test was conducted in a second year alfalfa field heavily infested with common groundsel along Mohave Road, North of Agnes Wilson Road. The test contained six preemergence and five postemergence herbicides. The preemergence treatments were applied on 10-29-03 when the alfalfa was 1-3" in height and the postemergence treatments were applied on 11-25-03 when the alfalfa was 4-12" in height and the groundsel was 1 leaf to 3 inch rosette. These treatments were applied with a backpack sprayer calibrated to deliver 20 gallons of spray solution per acre. The plot size was 42' by 100' with 3 replications. Visual evaluations of percent control were made on 1-28-04. Table 2 summarizes the trial results.

Table 2: Control of Common groundsel in alfalfa.

Herbicide	**Rate (A)**	**Time**	**Control (%) ***
Eptam 7E	4 pts.	Pre	37 c
Zorial 80	2.5 lbs.	Pre	92 a
Velpar 2L	2 pts.	Pre	97 a
Sencor 75 DF	0.6 lbs.	Pre	57 b
Visor 2EC	2 pts.	Pre	90 a
Chateau WG	4 oz.	Pre	95 a
Sencor 75 DF	0.6 lbs.	Post	90 a
Velpar 2L	2 pts.	Post	98 a
Gramoxone Max 3 EC	2.7 pts.	Post	87 a
Pursuit 2 EC	6 oz.	Post	68 b
Raptor 1 EC	6 oz.	Post	68 b

* Ave. of 3 reps LSD (0.05)=5.97

Letters in "Control (%)" after numbers are used to indicate statistical differences. Numbers with the same letter are not statistically different from one another.

Control with the preemergence treatments ranged from 37% with Eptam to 97% with Velpar. Eptam was sprayed on the surface and incorporated with the irrigation water within 2 days. Better deposition and control may have been achieved if it had been applied as a water run application. Velpar has been used for 20 years on dormant and semi-dormant varieties with excellent results but an Arizona registration for low desert production is not likely because of crop injury observed to non-dormant alfalfa. Chateau SW also produced excellent control in this test. This is a new herbicide produced by Valent that is currently registered for use in soybeans, peanuts, and cotton. Registration is being actively pursued in Arizona and California on alfalfa. Visor also produced very good to excellent control. Visor is produced by Dow Agro Sciences and is currently registered on oranges and grapefruit but Dow is not currently pursuing a registration in alfalfa. Sencor is registered for use in alfalfa following sheeping or cutting when little crop foliage is present and provides excellent control of groundsel in postemergence applications. Poor control of common groundsel was achieved with preemergence applications of Sencor. The only currently registered herbicide that produced excellent preemergence control in this test was Zorial. Excellent early postemergence control was achieved with Velpar and Sencor. Gramoxone produced good control when applied to very small weeds with good coverage. Larger weeds or those receiving partial coverage would not ordinarily be controlled. Buctril is another contact herbicide that was not included in this test because it is registered only on seedling alfalfa. Both Pursuit and Raptor were weak on this weed.

In addition to weed control, crop safety to both the current and potential rotational crops is a concern. Table 3 illustrates the crop safety of the herbicides included in this test. Eptam, Zorial and Visor all were very safe to the alfalfa. Chateau SW, Pursuit and Raptor produced moderate crop injury. Pursuit and Raptor caused stunting and shortened internodes. Injury from these herbicides was temporary, lasting 20 to 30 days. Sencor, Gramoxone and Velpar produced unacceptable crop injury. Sencor caused severe chlorosis and stunting. Velpar caused severe leaf burn, bronzing and stunting. Gramoxone burned off all of the crop foliage present at the time of application. The new growth was normal.

Table 3. Safety of herbicides to alfalfa (% phytotoxicity)

	0-10	10-20	20+
Eptam	■		
Zorial	■		
Visor	■		
Chateau		■	
Pursuit		■	
Raptor		■	
Sencor			■
Gramoxone			■
Velpar			■

Residual herbicide activity is a concern throughout Arizona where alfalfa can be rotated at any time to vegetables and other field crops. In La Paz County, the principal crops are alfalfa, cotton and grain. Table 4 illustrates the plantback intervals for the herbicides included in this test. These range from 0 to 40 months, depending upon the crop to be grown. Herbicides with plantback restrictions of greater than 12 months are often avoided in the last year of an alfalfa crop. Of the eight herbicides included in this test, only Eptam, Gramoxone and Chateau SW can be considered safe to the most sensitive rotational crops grown within one year of the last application. Zorial is a pigment inhibitor that produces a distinctive lack of chlorophyll in affected crops. It has been difficult to use in Arizona except in long term perennial crops such as trees and vines. Chateau SW, on the other hand, has been found to be safe to most crops in less than 12 months after the last application.

Table 4. Plantback interval (Months)

Eptam	0
Gramoxone	0
Chateau	1-12
Zorial	1-16
Senecor	4-18
Raptor	3-26
Pursuit	4-40
Velpar	12-24

Summary

Common groundsel is a difficult to control, poisonous weed that has become established in LaPaz County and is becoming increasingly widespread. Economic losses in 2003 have been estimated to be nearly $3 million and are likely to be higher in 2004.

Tables 5 and 6 summarize the weed control, crop safety and plantback restrictions for the herbicides evaluated in this test. The plantback intervals for Visor have not been established in the low desert and the manufacturer of this product is not currently seeking new registrations.

Table 5. Control, safety and plantback interval for preemergence herbicides in alfalfa.

Preemergence

Herbicide	***Control***	***Safety***	***Plantback***
Eptam	Poor	Good	Good
Sencor	Poor	Moderate	Moderate
Visor	Very good	Good	?
Zorial	Excellent	Good	Poor
Chateau	Excellent	Good	Moderate
Velpar	Excellent	Poor	poor

Table 6. Control, safety and plantback interval for postemergence herbicides in alfalfa

Postemergence

Herbicide	***Control***	***Safety***	***Plantback***
Pursuit	Poor	Moderate	Poor
Raptor	Poor	Moderate	Moderate
Gramoxone	Very good	Poor	Good
Senecor	Very good	Poor	Moderate
Velpar	Excellent	Poor	poor

Visor, Zorial, Chateau and Velpar were the preemergence herbicides that were effective in controlling groundsel. Only Zorial (Solicam) is currently registered. Gramoxone, Sencor and Velpar were effective post emergence. Velpar is not registered in the low desert and crop safety was poor for both Sencor and Gramoxone.

Other herbicides that are registered on alfalfa in Arizona that were not included in this trial are: Balan, which is only registered as a preplant treatment; Trifluralin and 2,4-DB, which have been tested in other areas and found to be ineffective on common groundsel; Poast and Select, which are effective only on grasses; and Buctril, which is registered only on seedling alfalfa.

INFLUENCE OF ENVIRONMENTAL CONDITIONS ON GROUNDSEL AND WINTER WEED CONTROL IN ALFALFA

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Abstract:

Common groundsel *Senecio vulgaris* is a weed problem in alfalfa throughout much of California. Groundsel is a major problem in newly planted and established fields because of toxic alkaloids that are poisonous to livestock, especially horses. In recent years, erratic groundsel control has been reported with hexazinone herbicide. Hexazinone is the main herbicide for winter weed control in alfalfa and is one of the few options for controlling common groundsel.

To help understand this erratic groundsel control with hexazinone, a two-year study was conducted under both field and greenhouse conditions.
Results from a field study in February 2003 with postemergence and preemergence hexazinone applications indicated possible hexazinone resistant groundsel.
Groundsel seeds were collected from the above field and in November 2003 a greenhouse study was initiated at U.C. Davis. Results showed that there was no evidence of herbicide resistance. However, groundsel control from a postemergence hexazinone application varied depending upon plant size.

A second field study was initiated in November of 2003 looking at various treatments and timings of postemergence hexazinone applications. The same treatments were applied in November, December and January, approximately 30 days apart. Results showed 100% control groundsel from the November and January applications but only 30% control when applied in December. The poor results from December suggested possible environmental interactions occurring.

In March 2004 a third field experiment was initiated to evaluate the influence of limited sunlight on groundsel control from cloudy or foggy conditions. The treatments included full, partial and no sunlight. The groundsel plants were covered for six days after a postemergence herbicide application. Treatments included were; three rates of hexazinone, one rate of paraquat and an untreated check.. Groundsel control with hexazinone was affected by the amount of light intensity by as much as 50%. Herbicide rates were also a factor; the higher rates were less impacted by the low light intensity treatments. Light intensity had less impact on groundsel control with paraquat.

Introduction

Weeds are a major pest in alfalfa because they can reduce forage quality by competing for light, water, space and nutrients. Some weeds can contribute toxic alkaloids in feeds. Common groundsel *Senecio vulgaris* is such a weed and is found throughout the alfalfa growing regions in the central valleys of California. Since groundsel germination occurs between October through March, it is a major problem in the winter months in newly seeded and established alfalfa fields. The Northern San Joaquin and Sacramento Valleys of California have reported erratic groundsel control with winter postemergence hexazinone applications. Velpar is one of the major herbicides used in California's alfalfa production system. Therefore, understanding and investigating this groundsel problem would be very important economically to our growers. Research was initiated in 2003/2004 to study several variables that may have contributed to this erratic groundsel control with hexazinone.

Materials and Methods

Herbicide Timing Field Experiment. A field study was initiated in 2003/04 to evaluate hexazinone rates and tank mix combinations applied postemergence on three timings. The applications were made November 11, 2003, December 12, 2003 and January 16, 2004. Plot size were 10 by 15 feet, four replication and arranged in a randomized complete block design for monthly timings. The three timings trials were stacked adjacently in an area of the field were poor groundsel control had been previously reported. Groundsel population was heavy and evenly distrusted throughout the trial area. Treatments were applied with a C02 pressurized sprayer, 35 PSI in 40 G/A of water (Table 1). Visual weed control data on groundsel and other weed species were made 30 and 60 DAT.

Solar Radiation/Light Intensity. In the above field, a follow up experiment was conducted in March 2004 to evaluated hexazinone performance given different intensities of sunlight reaching the plants. During the winter months, it's not unusual to have consecutive days of fog or cloudy conditions that can result in the reduction of photosynthesis in plants. A reduction in sunlight intensity may have a negative affect on weed control; particularly with herbicides that are photosynthetic inhibitors.
The following treatments were applied postemergence and were exposed to three light intensities; (1) hexazinone 0.25, 0.50 and 1.0 lb ai/A, (2) paraquat 0.47 lb ai/A and (3) Untreated Check. The treatments were exposed to full sunlight, no sunlight (black plastic) and partial sunlight using a 40% shade cloth that covered the plots. They remained covered for six days after application before removing. See Table 1 for application data. Evaluations were made at 6, 21 & 29 days after treatment. Solar radiation measurements were calculated using a nearby electronic weather station (Page 3).

Greenhouse Experiment. A greenhouse observation study was initiated on the U.C. Davis campus on 11/1/03 by Dr. Tom Lanini to investigate efficacy and possible resistance to hexazinone. Groundsel seeds were collected from the Hasting Island alfalfa field were a previous hexazinone application resulted in poor groundsel control. Seeds were planted into nine flats which were approximately 30 cm x 25cm in size, 8 cm deep and filled with a Yolo fine sandy loam soil. Postemergence applications were made using a greenhouse track-sprayer, 8002 flat fan nozzles in 25 G/A of water. On 11/7/03, three flats were selected based on the uniform growth stage of the groundsel (seedling-cotyledon). One half of each flat was covered with saran wrap to create a untreated check. Hexazinone was applied at 0.75 lb ai/A. Using the above procedure, on 11/14/03 three more flats were treated with 0.75 lb ai/A of hexazinone. Groundsel plants were in the 1-2 true leaf growth stage. A third application was made on 11/30/03 to groundsel in the 508 true leaf stage. Hexazinone rate was increase to 1.0 lb ai/A. Following treatment, the saran wrap was removed and periodic visual evaluations were made on groundsel growth and % control.

Results and Discussion

Herbicide Timing Field Experiment. Thirty days after treatment, November and January applications of hexazinone at 1.0 lb ai/A gave 92 and 100% groundsel control, respectively. The December application resulted in only 46% groundsel control (Table 2). Visual evaluations taken 60 DAT gave similar results; November, January and December applications 98, 100 and 47% groundsel control, respectively (Table 3). On all applications dates, treatments which included either hexazinone or diuron gave excellent control of *stellaria media*, *capsella bursa-pastoris* and *lamium amplexicaule*. Since all treatments were included in the same field, other variables had to be considered which may have contributed to the poor results from the hexazinone December application. Weather data was obtained from a remote weather station located near the test site which furnished hourly updated information. The weather information listed below is data summarized by month and was accessed from the UC IPM website @ http://www.ipm.ucdavis.edu/ for the Thornton weather station site.

<u>November Application</u>.
Rainfall= 0.14” 10 DAA
Ave Temperature = High 60ºF& Low 44ºF
Solar Radiation units= 5012 for 30 DAA

December Application

Rainfall= 0.36” 18 Hrs AA
Ave Temperature= High 55ºF & Low 42ºF
Solar Radiation units= 3595 for 30DAA

<u>January Application</u>
Rainfall= 0.13” 7 DAA
Ave Temperature – High 51ºF & Low 42ºF
Solar Radiation Units 5873 for 30 DAA

March Application – Light Intensity Study

Rainfall= 0.40” 23 DAA
Avg Temperature= High 74 F & Low 45 F
Solar Radiation Units 13,990 for 30 DAA

Two factors noticeably different on the December timing was rainfall occurrence within 18 hours following application totaling .58” over a 48 hour period. Generally, 18 hours is usually enough time for herbicides to be absorbed by the plant without affecting efficacy. A surfactant was added to the herbicide treatments, which also enhances penetration and uptake in cool wet conditions. For these reasons rainfall was not considered a primary factor.
The other variable was cloud cover and fog, which was present and often occurs in winter months in the Central valley and Delta region. There are periods in which the sun may not break through for days or weeks at a time seriously impeding the plants ability to photosynthesize. Therefore, solar radiation measurements were calculated for a 30-day period after each application. A Pyranometer instrument was used for measuring total solar radiation units.
The December application 30-day period accumulated approximately 1500 units less of solar energy, which amounted to a 30% reduction compared to November and January dates. This posed a strong possibility that lack of sunlight was a principal contributor to the reduced groundsel control.

Solar Radiation/Light Intensity. Results for the simulated light interaction study are in Table 4. Under the three light intensity scenarios, it was clear that the dark treatment with no sunlight and the partial sunlight treatment reduced hexazinone effectiveness by 50% on groundsel (Table 5). Even after the covers were removed, control did improve over time but the lower rate never equaled the control in the full sunlight treatment. This experiment did show an interaction between herbicide rate and light intensity. The lowest rate of 0.25 lb ai/A never did reach acceptable control levels at any light intensity. A final rating 29DAA showed that eventually, the higher rates of hexazinone under partial sunlight intensity gave results equal to the full sunlight treatments (80-95%).

Greenhouse Experiment. Postemergence applications of hexazinone were very effective in controlling groundsel up the two-leaf stage of growth. When hexazinone was applied to groundsel in the cotyledon growth stage, complete death occurred within 3 DAA. Groundsel treated in the 1-2 leaf stage, complete death occurred by 7 DAA. The 5-8 leaf groundsel plants were injured and most died, but a couple of the larger plants survived, although stunted. Some new groundsel emergence was observed 38 DAT. These plants were obviously suppressed and seeds were not produced before the experiment was terminated. Since daily overhead irrigation was used, the hexazinone may have leached out of the germination zone therefore allowing some groundsel to emerge. It was observed that growth was greatest around the edges of the flats, perhaps indicating preferential water flow and thus leaching.

In conclusion, plant size influenced control but the groundsel did not show resistance to hexazinone.

Summary

Field and laboratory research experiments indicated that postemergence and preemergence activity of hexazinone applied alone at 0.5 lb ai/A can be effective in controlling common groundsel and other weed species in alfalfa providing sunlight conditions exist during and for a several days after application. Low rates applied to groundsel beyond the 4-leaf stage may give unsatisfactory results. When overcast, foggy conditions exist during and following application for several days, weed control was greatly reduced and hexazinone should be tank mixed with paraquat under those conditions. The tank mix combination of hexazinone + paraquat provided the best overall weed control under all weather conditions and weed size.

Table 1. Herbicide timing and light intensity application information.

	November	December	January	March - Light Intensity Trial
Application	11/20/03	12/22/03	1/16/04	3/2/04
Air temp	63°F	53°F	54°F	52 F
RH	70%	97%	74%	72%
Wind	3 mph	4 mph	0	5 mph
Cloud cover	100%	100%	100%	0%
Alfalfa	3”	5”	6”	7-8’
Groundsel	Coty – 4 leaf	3-8 leaf	3-8 leaf	9” flowering
Henbit	Coty-4 leaf	2-8 leaf	3-10 leaf	
Shepherdspurse	2-8 leaf	6-14 leaf	6-18 leaf	
Chickweed	Coty-4 leaf	4-10 leaf	6-12 leaf	
Spray volume	40 GPA	40 GPA	40 GPA	40 GPA

Crop oil concentrate = herbimax @ 1% VV
Non ionic surfactant = Unifilm 707 @ 0.25% VV

Table 2. Response of groundsel (SENVU) 30 DAT to postemergence herbicides applied on three dates of application.

Treatment	Rate	SENVU Control at 30 DAT		
		%		
		Nov	Dec	Jan
Hexazinone + diuron	0.5 + 1.6	100	30	98
Hexazinone + diuron	1.0 + 1.6	100	47	100
Hexazinone + diuron	1.5 + 1.6	98	73	100
Hexazinone + diuron + Paraquat	0.5 + 1.6 + 0.47	100	100	100
Hexazinone + diuron + Paraquat	1.0 + 1.6 + 0.47	100	100	100
Diuron	1.6	10	0	33
Paraquat	0.47	100	93	100
Hexazinone	1.0	92	46	100
Paraquat + Hexazinone	0.47 + 0.5	100	100	100
UTC		0	0	0
LSD		5.31	5.73	3.12

Table 3. Response of groundsel (SENVU) 60 DAT to postemergence herbicides applied on three application dates.

Treatment	Rate	SENVU Control at 60 DAT		
		%		
		Nov	Dec	Jan
Hexazinone + diuron	0.5 + 1.6	98	27	100
Hexazinone + diuron	1.0 + 1.6	100	48	100
Hexazinone + diuron	1.5 + 1.6	100	73	100
Hexazinone + diuron + Paraquat	0.5 + 1.6 + 0.47	100	100	100
Hexazinone + diuron + Paraquat	1.0 + 1.6 + 0.47	100	100	100
Diuron	1.6	0	0	30
Paraquat	0.47	92	93	100
Hexazinone	1.0	98	47	100
Paraquat + Hexazinone	0.47 + 0.5	100	100	99
UTC		0	0	0
LSD		2.20	7.37	9.06

Table 4. Response of shepherd' purse (CAPBP), henbit (LAMAM) and common chickweed (STEME) 60 DAT to postemergence herbicides applied on three application dates.

Treatment	Rate	% Control 60 DAT								
		NOV			DEC			JAN		
		CAPBP	LAMAM	STEME	CAPBP	LAMAM	STEME	CAPBP	LAMAM	STEME
Hexazinone + diuron	0.5 + 1.6	100	85	100	100	100	100	100	100	100
Hexazinone + diuron	1.0 + 1.6	100	95	100	100	100	100	100	100	100
Hexazinone + diuron	1.5 + 1.6	100	93	100	100	100	100	100	100	100
Hexazinone + diuron + Paraquat	0.5 + 1.6 + 0.47	100	98	100	100	100	100	100	100	100
Hexazinone + diuron + Paraquat	1.0 + 1.6 + 0.47	100	90	100	100	100	100	100	100	100
Diuron	1.6	100	90	100	100	100	100	100	100	100
Paraquat	0.47	50	83	90	73	40	90	33	30	85
Hexazinone	1.0	100	93	97	100	100	97	100	100	100
Paraquat + Hexazinone	0.47 + 0.5	100	87	100	100	90	100	100	98	100
UTC		0	0	0	0	0	0	0	0	0

Table 5. Groundsel (SENVU) response to postemergence hexazinone and paraquat applications under three light intensity scenarios.

Treatment		Rate Lb/A	SENVU Control		
			%		
			6 DAT	21 DAT	29 DAT
Hexazinone	No light	0.25	0	25	40
Hexazinone	Full light	0.25	0	60	65
Hexazinone	Partial light	0.25	0	30	30
Hexazinone	No light	0.50	0	40	45
Hexazinone	Full light	0.50	0	65	85
Hexazinone	Partial light	0.50	0	40	80
Hexazinone	No light	1.0	0	45	45
Hexazinone	Full light	1.0	0	98	95
Hexazinone	Partial light	1.0	0	70	95
Paraquat	No light	0.47	75	100	100
Paraquat	Full light	0.47	98	100	100
Paraquat	Partial light	0.47	85	100	100
Check	No light	--	0	0	0
Check	Full light	--	0	0	0
Check	Partial light	--	0	0	0

OSPREY, A NEW HERBICIDE FOR WEED CONTROL IN WHEAT

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Osprey (mesosulfuron-methyl) is a Bayer Corporation product in the *sulfonylurea* herbicide chemistry group. Osprey is currently registered on wheat in California. Osprey is a unique herbicide for use on wheat in that it controls many of the grasses such as canarygrass and wild oats as well as numerous broadleaf weeds. Osprey is an ALS inhibitor. Growers will be able to make one trip across the field instead of the usual two trips that it currently requires controlling grasses with one herbicide and broadleaves with another. *Osprey will turn the wheat yellow 4-5 days after the application and may cause stunting.* The wheat will metabolize the herbicide over a 2-3 week period and the yellowing will slowly dissipate.

In the San Joaquin Valley, UC research has shown that Osprey *will control* the following *broadleaf* weeds in wheat: wild radish, chickweed, wild mustard, pigweed, shepherds purse, and henbit. It will *suppress* the growth of the following weeds: fiddleneck, yellow starthistle, common groundsel, and malva. Osprey has *provided control* of the following *grasses*: annual bluegrass, littleseed and hooded canarygrass, annual ryegrass, wild oat and *suppression* of hairy chess, soft, ripgut and downy brome.

In the Imperial Valley and lower desert, research has shown that Osprey *will control* the following weeds: londonrocket, malva, swine cress, wild beets, red clover, goosefoot, littleseed canarygrass, and wild oats. Some of the weeds *not controlled* include silversheath knotweed, rabbitsfoot grass, Mexican sprangletop and red sprangletop. Other weeds in the tests that were suppressed were annual sowthistle, sunflower, and purple nutsedge.

Observations indicate that Osprey in combinations with some other herbicides (Buctril, 2,4-D) may reduce the degree of grass control by 5-15%. An adjuvant is necessary and recommended by the label for maximum control. A nitrogen fertilizer solution is highly recommended to assure control under adverse conditions.

Planting back with different crops may be a problem in areas with close rotations because the material has a moderate level of persistence. The label ranges from 7 days to replant wheat up to 12 months to plant corn.

Even though there is some reduction of growth early in the stages of development, various trials have indicated no significant yield reductions with the use of Osprey.

TANK-MIX ACTIVITY OF REGIMENT™ CA PLUS TWO FORMULATIONS OF PROPANIL FOR CONTROL OF HERBICIDE SUSCEPTIBLE EARLY WATERGRASS AND HERBICIDE RESISTANT LATE WATERGRASS IN WATER SEEDED RICE

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Regiment CA (bispyribac-sodium) is a postemergence herbicide that has excellent efficacy against certain grasses, sedges and broadleaf weeds with selectivity for rice. It inhibits the plant enzyme acetolactate synthase (ALS), thus blocking branched-chain amino acid biosynthesis. Regiment CA controls sensitive species with a cessation of growth followed by chlorosis, necrosis, and plant death. Onset of symptoms usually occurs in 3 to 4 days.

Regiment CA has excellent activity on barnyardgrass, *Echinochola crus-galli,* early watergrass *E. oryzoides*, and late watergrass, *Echinochola phyllopogon,* with minimal phytotoxicity to the rice plant. Slight stunting of the rice may occur within 3 to 5 days of application. The rice plant recovers within 10 to 14 days. Phytotoxic response can be minimized with a good fertility program. Phytotoxicity does not have a negative effect on maturity or yield.

Regiment CA has a wide application window for control of barnyardgrass and watergrass. Regiment CA can be applied from 5th leaf to 2nd tiller stages of *Echinochola sp*. growth. Use rates range from 12 to 18 grams ai /A. Optimum use rates for herbicide resistant early watergrass are 15 to 18 grams ai /A. For herbicide resistant late watergrass, 18 grams ai/A is necessary. A non-ionic silicone based surfactant is required at rates of 0.125 to 0.25% v/v.

In 2003, joint testing was conducted between Valent USA Corporation and Agricultural Advisors Inc, to determine the tank-mix activity of Regiment CA and two formulations of propanil, Stam® DF, and SuperWham® .The trial site had a mixed population of herbicide susceptible early watergrass and herbicide resistant late watergrass1. Regiment CA was tested alone at rates of 5 and 18 grams ai/A plus Kinetic® at 0.125 % v/v and was compared to Regiment CA at 5 grams ai/A plus 4 lbs ai/A of Stam or Superwham plus Kinetic at 0.125 % v/v. Additional treatments included: Regiment CA at 5 grams ai/A plus SuperWham at 4 lbs ai/A plus COC at 2.5% v/v; SuperWham at 4 lbs ai/A plus COC at 2.5% v/v; and Stam DF at 4 lbs ai/A plus COC at 2.5% v/v. All treatments were applied when the watergrass was at the 5th leaf to 1st tiller stage at 15 gallons per acre.

Herbicide Susceptible Early Watergrass

Weed control ratings for herbicide susceptible early watergrass were taken at 16, 43 and 66 days after the application. The data taken at 43 days after treatment indicated that individual applications of Regiment CA at 5 and 18 grams ai/A provided 100% control. The tank-mix of Regiment CA at 5 grams ai/A plus Stam DF or SuperWham at 4 lbs ai/A plus Kinetic at 0.125% v/v provided 50% and 30% control respectively. A tank-mix of Regiment CA at 5 grams ai/A plus SuperWham at 4 lbs ai/A plus COC at 2.5% v/v provided 80% control. Individual applications of Stam DF and SuperWham at 4 lbs ai/A plus COC at 2.5% v/v gave 50% control.

Herbicide Resistant Late Watergrass

Weed control ratings for herbicide resistant late watergrass, were taken at 43 and 66 days after application. The data taken at 66 days indicate that individual applications of Regiment CA at 5 and 18 grams ai/A plus Kinetic at 0.125% v/v provided 47% and 90 % control respectively. The tank-mix of Regiment CA at 5 grams ai/A plus Stam or SuperWham at 4 lbs ai/A plus Kinetic at

0.125% v/v provided 33% and 30% control respectively. A tank-mix of Regiment CA at 5 grams ai/A plus SuperWham at 4 lbs ai/A plus COC at 2.5% v/v provided 40% control. Individual applications of Stam and SuperWham at 4 lbs ai/A plus COC at 2.5% v/v gave 30% and 33% control respectively.

In conclusion, the individual applications of Regiment CA at 5 grams ai/A and 18 grams ai/A plus Kinetic at 0.125% v/v provided excellent control of herbicide susceptible early watergrass. However, only the 18 grams ai/A rate of Regiment CA plus Kinetic at 0.125%v/v provided acceptable control of herbicide resistant late watergrass. The tank-mix combinations of Regiment CA at 5 grams ai/A plus Stam or SuperWham at 4 lbs ai/A plus Kinetic at 0.125%v/v appeared to be antagonistic and did not provide adequate control of either watergrass species. The tank-mix of Regiment Ca at 5 grams ai/A plus SuperWham at 4 lbs ai/A plus COC at 2.5%v/v did appear to be more efficacious on herbicide susceptible early watergrass when compared to Regiment Ca at 5 grams ai/A plus SuperWham at 4 lbs ai/A plus Kinetic at 0.125% v/v. The Regiment CA at 5 grams ai/A plus SuperWham at 4 lbs ai/A plus Kinetic at 0.125%v/v for control herbicide resistant late watergrass was no more efficacious than Super Wham at 4 lbs ai/A plus COC at 2.5%v/v by itself.

1. University of California and USDA, Annual Report, Comprehensive Rice Research, 2001.

Regiment™ CA Reg. TM of Valent USA Corporation.
Stam® DF Reg. TM of DowAgroSciences LLC.
SuperWHAM® Reg. TM RiceCo LLC.

BITTERCRESS (*CARDAMINE* SPP.) BIOLOGY AND CONTROL FOR NURSERIES

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Bittercress competes with the crop for water and nutrients. The presence of bittercress in the container reduces salability of crop and increases the chance that the weed will spread to other containers and other areas of the nursery.

There are primarily two species of bittercress (*Cardamine* spp.) that that are problems for nurseries in California. Lesser-seeded bittercress (C. *oligosperma)* is an annual that can grow to 12 inches (30 cm) tall but is usually found in the 3-5" range (7-13 cm). The stems branch from the soil line as a rosette. Leaves are lobed. Seedlings are bright green with leaves that are somewhat heart-shaped. The plant has small white flowers with 4 petals and narrow, 0.5 to 0.75 inch (1.3 - 1.9 cm) long seed pods. The other common bittercress species, hairy bittercress *(C. hirsuta)* is similar but has fewer, lobed or kidney-shaped leaflets.

The optimum environment for bittercress growth is cool and moist. It is more prevalent in the winter but can be found year-round in most nurseries in California due to heavy irrigation and the shade provided by the crop canopy. Optimal temperatures for growth are between 45 and 85°F.

The tiny seeds can be expelled several yards from the pod at maturity often landing in nearby containers, plastic tubing, or in potting media. The seed has been shown to stick to the soil on the outside of plastic containers and be moved throughout the nursery. The seed can also be easily carried in irrigation water. Seeds do not have a dormancy period and may germinate immediately. This, combined with the short life cycle (6 weeks), can result in a heavy weed population rather quickly.

Cultural control: Because of the short lifecycle of this weed and lack of dormancy of the seeds, it is important to monitor all areas for this weed. Not only should containers be inspected but also areas surrounding containers. Water should not be allowed to flow over this weed when draining since this will spread the seeds. Also, recycled water should be treated or screened to avoid reintroduction of this weed. Irrigation tubes should be wiped before replacing in an uncontaminated contained because seeds could be present on the tubing and pots should be washed on the outside to remove any seeds that are stuck to the sides.

Chemical control: Postemergent herbicides can be used to control bittercress in areas surrounding the containers but there is no selective material for use in a container. Preemergence herbicides are effective but care must be taken that the herbicide is applied prior to seed germination. Where bittercress is known to be problem, the herbicide must be applied as soon as possible and reapplied as needed. Over time, this will reduce the bittercress population. Preemergence herbicides effective for controlling bittercress include flumioxazin, isoxaben, oxadiazon, and oxyfluorfen, and oryzalin (see table below). Growers often need to combine handweeding with preemergence herbicides for complete control. For postemergence control, it is important to kill the plant prior to flowering. Directed sprays of contact or systemic herbicides are effective but care must be taken not to injure the crop. Sureguard (flumioxazine) is a newer material with postemergence activity that may be sprayed over the top. As with any postemergence herbicide that you have not tried, it is imperative to test this material on a few plants and observe for crop injury for at least 3 weeks before trying it on a larger scale.

Premergence herbicides, rates and percent bittercress control 30 and 60 days after treatment. (DAT)1.

	Herbicide Rate (lbs ai/A)	% Bittercress Control 30 DAT	60 DAT
Gallery	0.5	99	100
Snapshot DF	2	100	100
SnapshotTG	2.5	97	99
Ronstar	2	100	100
Predict	2.4	100	100
OH-2	3	95	98
Factor	1	100	100
Rout	3	100	100
Stakeout	1	100	100
Surflan	3	100	100
Kerb	1	82	87
So. Weed Grass	3	78	83
Control	--	0	0
LSD (P > 0.05)		8.5	13.5

1Bachman and Whitwell, undated.

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METHYL BROMIDE ALTERNATIVES FOR FIELD GROWN FLOWERS

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The cut flower and ornamental bulb industry relies heavily on the use of methyl bromide (MB)/chloropicrin (Pic) as a key pest management tool. Because of the broad-spectrum pest control provided by the fumigant combination (MB/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; its effective control of pathogens, nematodes and weeds with a single application prior to crop planting; and its cost effectiveness.

Currently, only three MB alternative fumigants are registered and available for cut flower fields, and intensive research is being conducted to optimize application technologies to improve their performance and reduce costs. The registered chemical alternatives are Pic, 1,3-dichloropropene (1,3-D), and methyl isothiocyanate (MITC) generators such as metam sodium and metam potassium (Table 1). Non-registered chemical MB alternatives are iodomethane (Midas, pending registration), propargyl bromide, and sodium azide that are currently being evaluated for their efficacy to control pathogenic fungi, nematodes, and weeds. Although most alternative fumigants can be applied into soil by shank injection, new technologies were developed to apply fumigants through drip irrigation systems. Attached is technical information on drip fumigation with available MB alternative fumigants.

We evaluated several alternative fumigants applied singly or in combination by shank injection and drip fumigation. Although combinations of fumigants (Pic alone or in a mixture with 1,3-D plus metam sodium) controlled fungal pathogens in most studies, weed control has not been as successful. Iodomethane/Pic (Midas 33/67) has given similar control to MB/Pic at standard rates. Drip fumigation with Midas at 200 lbs/ac, chloropicrin at 200 lbs/ac or 1,3-D/chloropicrin (Inline) at 200 lbs/ac gave similar flower yield, and was significantly better than untreated control. Application of metam sodium (40 gal/ac) one week after Pic, InLine, or Midas enhanced weed control, and significantly reduced little mallow and clover numbers. Fusarium and pythiaceous fungi were also reduced by sequential treatments.

DRIP FUMIGATION FOR CALIFORNIA CUT FLOWERS

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The most promising and cost-effective registered chemical alternatives to methyl bromide/chloropicrin (MB:CP) fumigation for production of cut flower and ornamental crops in California are chloropicrin alone or chloropicrin mixed with 1,3-Dichlororopropene (InLine™) applied in combination with metam sodium. Because these fumigants are less volatile than methyl bromide, they can be applied to the raised beds through drip irrigation systems. In drip fumigation, it is critical to distribute the water evenly throughout the field and throughout the target soil treatment zone. Also, chloropicrin and 1,3-Dichlororopropene should not applied simultaneously with metam sodium to avoid their rapid degradation in the irrigation water. Our research found that drip fumigation with InLine™ (300 lbs/ac) or chloropicrin (200 lbs/ac) followed five to seven days later with metam sodium (40 gal/ac) controlled soilborne pathogens and most weeds and produced yields comparable to those produced with MB:CP. This sequential application of metam sodium after chloropicrin or InLine™ has became the choice of growers in California who are adopting drip fumigation.

Iodomethane (Midas™), a very effective soil fumigant that has similar properties to methyl bromide, can be applied by shank injection or drip fumigation. When registered, several formulations of Midas™ (iodomethane/chloropicrin: 98:2, 67:33, 50:50, and 33:67) can be used for soil fumigation. Midas™ can be applied without metam sodium at 240 lbs/ac or at lower rates if metam sodium is used. Drip fumigation is desirable because workers are not required to be in the field during application. However, successful drip fumigation requires adequate soil preparation, good drip irrigation systems, dependable chemigation equipment, and early soil preparation and bed listing to accommodate longer plant-back time.

Soil Preparation:
As with all soil fumigation, the soil should be prepared and tilled properly. Soil water content should be adequate to initiate weed seed germination and pre-irrigation may be required prior to drip fumigation if the soil is dry. The beds should be free of clods and the plastic tarp used over the bed should not have holes or tears. Embossed tarp should be avoided to reduce volatilization loss of fumigants. Current soil preparation and bed listing practices used after methyl bromide fumigation are generally adequate. Any shanks or chisels should be removed when laying the plastic tarp to avoid creating channels in the soil, which can result in poor water and fumigant distribution in the soil bed. For good water distribution uniformity on steep or hilly grounds, the beds should be directed along the contour lines and the beds should not go uphill more than 4 ft. or downhill more than 8 ft. to avoid poor water distribution uniformity. Poor water distribution will result in poor fumigation. The use of virtually impermeable film (VIF) will enhance weed control in the bed. However, VIF holds fumigants in the soil for longer periods than the standard tarp and longer plant-back time or bed ventilation two weeks before planting may be required (refer to the pesticide label).

Amount of Water:
To achieve good lateral distribution of fumigants in sandy loam soils, 1.5 inch of irrigation water may be needed for to cover 6 to 8 inches horizontally on each side of the tape (fumigants spread more readily through dry soil than wet soil) and 18 inches depth. Table 1 lists the estimated amount of application water per 18 inches of soil depth recommended for drip fumigation of various soils. Although the fumigants move 3 to 5 inches beyond the wetting front,

the best treatment occurs within the wetted area. See Table 1 for recommended amount of water for the various soil types.

Application of fumigants in less than 1.5 inches of water (per treated area) will result in poor fumigant distribution and high volatilization losses that diminish the efficacy to control soilborne pathogens and may result in lower crop yields. In addition, application of fumigants with a small amount of water will result in precipitation of fumigants in the irrigation pipelines if the concentrations exceed their solubility limits (<2000 ppm). Drip fumigation with a larger amount of irrigation water will result in better fumigant distribution in soil and will reduce fumigant volatilization losses by increasing the amount of fumigant in the water phase and decreasing the total air space available for fumigant diffusion in soil. However, excessive amounts of water should be avoided and fumigant concentration in the main line should not be below 500 ppm or fumigant effectiveness might decline (see Table 2 for chloropicrin concentrations). Also, beds can become unstable and collapse with excessive water application amounts, and bed stability may limit the volume or application rate of water that can be applied. In sandy and loamy sand soils, limited lateral water movement may limit fumigant distribution. For these soils, closely spaced drip tape is recommended.

Drip Tape Flow Rate and Spacing:
The drip irrigation systems should provide high water distribution uniformity (DU) – over 90% is achievable. The drip system DU should at least be over 80% for drip fumigation. This will require use of a good system design and operation in which the pressure variation in the drip tape throughout the field is less than 3 psi (ie. from 6 to 9 psi). The system should free of leaks or clogged emitters, and should be flushed and pressure tested before fumigation. It is imperative to use good quality irrigation components and drip tape. Leaks cause fumigant loss and possibly odor and emissions problems.

Reconfiguration of drip tape spacing may be necessary for good water coverage across the soil bed. For sandy loam soils, one drip tape can cover up to 8 inches on each side using 1.5 inches of water. For narrow beds (<18 inches wide), one tap may be sufficient for drip fumigation. However, two drip tapes are recommended for wider beds (18 to 40 inches wide). A third drip tape may be needed for sandy soils (>90% sand) or if the bed top is wider than 40 inches. Drip tapes with flow rate between 0.5 to 0.67 gpm/100 ft are appropriate for most sandy and sandy loam soils in California (see Table 1). Low flow drip tape is optimum for drip fumigation, but application time becomes inconvenient when using drip tape with low rate drip tapes. High flow drip tape (> 0.7 gpm/100 ft) is not common in California and is not recommended except for soils with high water permeability.

Safety Rules and Chemigation Equipment for Drip Fumigation:
Read and understand the fumigant label and follow County Permit Conditions before starting the fumigation. Know the symptoms and emergency treatments for exposure to the fumigants. Monitor the application system and the field during application.

The fumigant cylinders are pressurized with nitrogen gas and metered directly into the irrigation pipeline or manifold. The meter can be a precision needle valve and flow meter, a needle valve and a scale, or a computer-controlled positive displacement meter. Fumigants are injected at low flow rates and accurate calibration of injection equipment is essential for proper application. Fumigant concentration in the main line may vary from 500 to 1600 ppm, depending on the soil, fumigant type, and water application rate. Refer to the pesticide label for appropriate concentrations. Good fumigant mixing with water in the irrigation pipelines is essential. A static mixing device is recommended to be installed after the point of injection to thoroughly mix fumigants with water before being distributed into the irrigation system laterals and drip tape.

The irrigation system must have a standard single check valve, low pressure drain, and vacuum relief valve (a “chemigation” valve) upstream of the injection point to prevent possible contamination of the water source by fumigants. The fumigant injector must be equipped with a check valve to prevent water from flowing back into the fumigant tank and an automatic quick-closing valve to stop fumigant injection when water flow is interrupted or loses pressure. The fumigant automatic shut-off valve can be electrically or hydraulically activated and should be normally closed at the injector. For more information on chemigation equipment, refer to the California Department of Pesticide Regulations web site: (http://www.cdpr.ca.gov/docs/gwp/chem/chemdevices.htm) and the Agricultural Commission Office in your County.

Many of the fumigants (including chloropicrin and InLine™) can damage PVC if left in the pipelines. This does not occur during application of the dilute fumigants, but can occur if the lines are not well flushed at the end of the application and the fumigant settles out and accumulates in low points of the distribution system. For this reason, it is critical to flush lines at the end of each application. The required flush water amount can be estimated as three times the volume of the mainline and laterals. Excessive flush should be avoided because it will dilute the fumigants around the drip tape.

Calculations Needed for Drip Fumigation:

- Determine the actual treated (bed) area, and total volume of water, and weight of fumigants to be applied.
- Calculate the time required for application based of the drip tape flow rate.
- Determine the fumigant application rate and concentration in irrigation water.

Table 2 shows chloropicrin concentrations as a function of application rate and water volume. A similar table can be prepared for InLine™ (one gallon weighs 11.2 lbs or 6.57 lbs 1,3-D and 3.73 lbs chloropicrin). Fumigant concentration in water can be calculated as follows:
Chloropicrin: ppm chloropicrin = 119826 x (? pounds chloropicrin/ ? gallons water)
InLine™: ppm (chloropicrin + 1,3-D) = 87872 x (? pounds InLine™/ ? gallons water)

Below 500 ppm, the efficacy of chloropicrin and InLine™ to control soilborne pathogens may become insufficient. Also, because the solubility of chloropicrin and 1,3-D in water is less than 2000 ppm at 20oC, exceeding 1500 ppm may result in precipitation of these fumigants in the irrigation pipelines. Metam sodium (or metam potassium) is water soluble and the generation of the active ingredient methyl isothiocyanate (MITC) occurs in the soil after metam application. However, a minimum of one inch of water is recommended for the sequential application of metam to sandy loam soils.

Table 1. Estimated water amount needed to treat <u>18 inches</u> of soil depth using two drip tapes. Application time and water volume were based on 30 inches average bed width (50 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	1.2 (19,551)	0.5 – 0.67	3.1 - 2.3	Pre-irrigation with one inch of water is needed
Sandy loam and fine sandy loam	1.5 (24,439)	0.5 – 0.67	3.9 – 2.9	Minimum of 1.2 inches is recommended
Sandy clay loam and loam	2.0 (32,586)	0.2 – 0.45	13.0 – 5.8	Split application for low flow drip tape
Clay, clay loam, and silty clay loam	2.4 (39,103)	0.2 – 0.45	15.6 – 6.9	Soils are not common in cut flower production

a One broadcast acre-inch of water is 27154 gallons. One bed acre-inch of water is 16293 gallons.

Table 2. Chloropicrin concentration (parts per million) during drip application

Gallons of water	Pounds of chloropicrin (without emulsifier)														
per acre	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
19000	946	1009	1072	1135	1198	1261	1324	1387	1451	1514	1577					
20000	899	959	1019	1078	1138	1198	1258	1318	1378	1438	1498	1558				
21000	856	913	970	1027	1084	1141	1198	1255	1312	1369	1427	1484	1541			
22000	817	871	926	980	1035	1089	1144	1198	1253	1307	1362	1416	1471	1525		
23000	781	834	886	938	990	1042	1094	1146	1198	1250	1302	1355	1407	1459	1511	
24000	749	799	849	899	949	999	1048	1098	1148	1198	1248	1298	1348	1398	1448	1498
25000	719	767	815	863	911	959	1007	1054	1102	1150	1198	1246	1294	1342	1390	1438
26000	691	737	783	830	876	922	968	1014	1060	1106	1152	1198	1244	1290	1337	1383
27000	666	710	754	799	843	888	932	976	1021	1065	1110	1154	1198	1243	1287	1331
28000	642	685	728	770	813	856	899	941	984	1027	1070	1113	1155	1198	1241	1284
29000	620	661	702	744	785	826	868	909	950	992	1033	1074	1116	1157	1198	1240
30000	599	639	679	719	759	799	839	879	919	959	999	1038	1078	1118	1158	1198
31000	580	618	657	696	734	773	812	850	889	928	966	1005	1044	1082	1121	1160
32000	562	599	637	674	711	749	786	824	861	899	936	974	1011	1048	1086	1123
33000	545	581	617	654	690	726	763	799	835	871	908	944	980	1017	1053	1089
34000	529	564	599	634	670	705	740	775	811	846	881	916	952	987	1022	1057
35000	514	548	582	616	650	685	719	753	787	822	856	890	924	959	993	1027
36000		533	566	599	632	666	699	732	766	799	832	865	899	932	965	999
37000		518	551	583	615	648	680	712	745	777	810	842	874	907	939	972
38000			536	568	599	631	662	694	725	757	788	820	851	883	914	946
39000			522	553	584	614	645	676	707	737	768	799	830	860	891	922
40000				539	569	599	629	659	689	719	749	779	809	839	869	899
41000				526	555	585	614	643	672	701	731	760	789	818	848	877
42000					542	571	599	628	656	685	713	742	770	799	827	856
43000					529	557	585	613	641	669	697	725	752	780	808	836
44000						545	572	599	626	654	681	708	735	763	790	817

USE OF DAZOMET (BASAMID®) FOR ORNAMENTAL PRODUCTION

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Background

In 2003, Kanesho Soil Treatment (a joint venture between Agro-Kanesho Co., Ltd. and Mitsui & Co., Ltd.) acquired several soil disinfestation products from BASF Corp., including Basamid® G granular soil fumigant. Certis USA, a wholly-owned subsidiary of Mitsui & Co., has assumed marketing and development responsibility for Basamid in the USA and Mexico.

Unlike most other fumigants, Basamid is inactive until it comes into contact with soil moisture and decomposes to release MITC gas, killing soil-dwelling organisms such as weeds, nematodes, insects, and fungi. Basamid can be user-applied without the extensive equipment, containment, and safety requirements of other soil fumigants. Plastic tarps are not required, although they may improve fumigation performance in some cases.

Basamid has been in use outside the USA for over 20 years, most extensively in Japan and Europe. It is registered in the USA for control of weeds, nematodes, and diseases in the production of cut flowers, conifer seedlings, potting media, turf, and nursery crops (including landscape ornamentals, nonbearing fruit trees and strawberry plants).

Properties of Basamid® G Soil Fumigant:

Active ingredient:

Common name:	dazomet
Chemical name:	tetrahydro-3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione
Empirical formula:	C5H10N2S2
Molecular weight:	162.3
Melting point:	104-105°C
Vapor pressure:	$6 \times$ 10-6 mbar at 20°C
Solubility:	Insoluble. in water, sol. in organic solvents

Formulated product:

Formulation:	Microgranules
Percent active ingredient:	99%
Specific gravity:	0.6 – 0.8 Kg/L
Appearance:	Grayish-white
Odor:	Slightly pungent
Packaging:	50-lb (22 Kg) bag
Shelf life:	2 years in unopened bag
Label hazard:	Warning, keep out of reach of children

Toxicology:

Oral LD50:	519 mg/Kg (rat), 120 mg/Kg (rabbit)
Dermal:	>2000 mg/Kg (rat), 7000 mg/Kg (rabbit)
Inhalation:	8.4 mg/L (rat)
Environmental toxicology:	Toxic to fish and algae

Non-irritating in rabbit eye and skin tests

Mode of action:

Upon contact with moist soil, dazomet is transformed into methylisothiocyanate (MITC) gas. MITC diffuses through the air spaces between soil particles and is toxic to soil-dwelling organisms such as weeds, nematodes, insects, and fungi.

Registration of Basamid G for food crop use

US EPA considers Basamid G a feasible alternative to methyl bromide fumigation as a result of IR-4 sponsored field trials in 1999-2002. EPA is currently reviewing Basamid G for registration in strawberries and tomatoes. Based on lack of residues in food crops, no expected risk based on dietary concerns, and pre-plant application to the soil, EPA's Hazard Evaluation Division has decided to evaluate Basamid as a non-food use pesticide. California's Air Resources Board is actively evaluating Basamid in trials to determine safety of this granular soil fumigant via bystander exposure.

Floriculture and Ornamental Plants

Growers of cut flowers, potted shrubs, and other ornamental plants must control soilborne pathogens and weeds in production units that may be small, dispersed, and more intimately associated within population centers and other sensitive areas compared to others who rely on soil fumigation for crop production. Basamid G provides this market with an effective alternative to methyl bromide and other custom-applied fumigants, with fewer use restrictions, permits, and worker safety training requirements. Basamid can be applied by the end user in small operations without specialized heavy equipment or incorporated into custom-built systems for soil disinfestation at a larger scale. In California, Basamid is applied primarily for weed and disease control in buffer zones and covered areas (such as hoop houses) where use of other fumigants is restricted or prohibited.

Forest Tree Nurseries

Basamid G has been used in forest tree nurseries for the production of pine and broadleaf seedlings since the early 1990's. Basamid is easily applied by nursery staff on their own schedule, with no need to cover the field with plastic. A clean start can be achieved for a new seedling crop without the logistical challenges of custom application or disposal of used plastic tarps.

Investigating Other Uses of Basamid® G

Seeding of roadsides, median strips, and other open areas with wildflowers has become a widely adopted method to reduce the cost of maintenance and enhance the scenic value of highways and other public lands. Existing grass and/or weeds must often be removed prior to reseeding to establish wildflowers, similar to renovation of a golf course fairway with new turfgrass. Basamid G can be applied by highway department personnel without the added expense of special equipment, custom applicators, or extra safety precautions, providing weed control equal to or better than methyl bromide fumigation (Skroch et al. 1992, Gallitano, 1993). The University of Georgia is currently evaluating Basamid for this use in cooperation with the Georgia Dept. of Transportation.

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WEED SURVIVAL IN YARDWASTE MULCH

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Urban yard waste is being used in considerable quantities in California agriculture as mulch for tree crops (Downer and Faber 1999). When used appropriately, organic mulches can reduce some disease incidence of citrus and avocado, control weeds, reduce water requirements, improve infiltration and soil structure (Faber et al 1996). The availability of large amounts of urban yard waste is a relatively recent phenomenon, since California passed a law in 1989 that mandates waste reduction to landfills. Households practice source separation and in the process, yard waste is kept separate from other household wastes. This material is collected by haulers, taken to a facility where it is cleaned of most contaminates (improperly discarded materials that often get mixed with the yard waste) and ground into 4-8 cm chips. Materials are stockpiled on site and then are delivered to a grower. Growers are spreading various amounts, but a standard practice is to spread 200 t/ha.

In order to keep costs down, these materials are generally not properly composted, although the decomposition process begins as soon as the homeowner collects the plant materials. The waste stream is variable depending on season and point of collection and weed propagules can be introduced into the waste stream with the plant materials such as lawn clippings, leaf litter or vegetable crop biomass.

Little mallow and California burclover are annual weeds that are very difficult to control due to high level of dormancy associated hard seed coats (Porqueddu et al. 1996) that aids their survival during fumigation with chlorpicrin (Haar et al. 2003). Yellow nutsedge and bermudagrass are the worst perennial weeds in irrigated agriculture in California that primarily reproduce by underground nutlets/tubers (nutsedge) or stolones/rhizomes (bermudagrass) (Hembree 1998, Mitich 1989). Survival of these troublesome weeds during mulching and in mulch storage piles can result in grower field contamination during mulch spreading. However, no repeated studies documented weed survival in yardwaste mulch over time. MgGiffen (2003-personal communication) reported 100% mortality of common mallow (*Malva neglecta*) and yellow nutsedge (*Cyperus esculentus*) after 26d burial in compost at 50 and 100 cm depths, while Hartz and Giannini (1998) found viable seed of several weed species during periodic yardwaste compost sampling.

The objective of this study was to evaluate survival of the two common troublesome annual and two perennial weeds in a static yardwaste piles and determine the effects of temperature and exposure time on weed propagule mortality.

Experiments conducted at Oxnard, CA compared survival of seed of little mallow and California burclover, rhizomes of bermudagrass and nutlets of yellow nutsedge in 7.6 m3 static piles of freshly ground mulch and 18 months aged mulch. Heat resistant permeable bags with weed propagules were placed at 0 (surface), 0.15, 0.3 and 1 m depths in the mulch piles and removed at 0.25, 1, 2, 4, 7, 14, 21, 28 and 56 d. The experiment was repeated three times (fall, winter and spring) and the patterns of weed survival in mulch were similar among the seasons (data not shown). All weeds were killed in freshly ground mulch after 2 d at 1 m and after 7 d at 0.3 m, however, germination and viability (for little mallow, due to high dormancy) were variable at 0.15 m and not affected at 0 m. Temperatures greater than 60 C generated at depths greater than 0.3 m in freshly ground mulch were most likely responsible for destruction of weed propagules. Weed germination and viability at all depths and removal times were not affected in aged mulch. Aged mulch, which has previously completed microbiological composting, did not heat up following pile creation (with exception of 1m depth that did heat up to 50 C). Thus, lethal temperatures achieved during fresh mulch composting are essential for weed propagule destruction.

However, the exact temperatures causing complete or partial mortality of studied weeds were not determined, thus, a controlled environment laboratory study was carried out. That lab study examined survival of the propagules of the four weeds at 80, 65, 50, 35 and 20 C in water saturated paper towels after 1, 3, 5 and 7-day exposure. Linear relationships between survival of the studied weeds and time and temperature were determined using SAS (1991) and provided good explanation of variability, except for burclover seed. With exception of burclover burs, no significant effect of time was observed in the studied 1 to 7 day interval and temperature range. The resulting relationships were:

California burclover burs, % germination = 99.5 – 2.27 Time (d) – 1.17 Temperature (ºC)
California burclover germination, % = 20.58 – 0.24 Temperature (C); (R^2=0.33)
Bermudagrass germination, % = 111.96 – 1.6 Temperature (C); (R^2=0.73)
Yellow nutsedge germination, % = 133.42 – 1.9 Temperature (C); (R^2=0.75)
Little mallow viability, % = 114.5 – 1.6 Temperature (C); (R^2=0.76)

Considering the relative ease with which temperatures can be measured, this equations provide useful estimates of levels of weed survival expected at least 1 day following exposure to the particular temperature (and time, in case of burclover burs). For example, 72 C for at least one day is needed to reduce viability of little mallow to 0%, thus, ensuring that the mulch will be free from little mallow.

The lethal temperatures established in the lab experiment corresponded closely with those recorded in the filed study with fresh much, however, temperature non-uniformity in constructed piles and, therefore availability of safe sites for weed survival may account for rare occurrence of viable weed propagules at what would be expected lethal temperatures. Most importantly, the studied troublesome weeds are likely to survive on the surface or at depth less than 0.3 m in fresh mulch piles. It is essential, therefore, to mix the mulch and expose the initially surviving weeds to lethal temperatures normally existing at depths greater than 0.3 m. These studies also showed that if re-infested, aged mulch has no mechanisms to suppress weeds and therefore may become a weed carrying substrate.

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CREEPING WOODSORREL CONTROL IN BERMUDAGRASS TURF

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Introduction

Creeping or yellow woodsorrel*, Oxalis corniculata L.,* is one of the most troublesome weeds in California turfgrass. It is a spreading herbaceous perennial that thrives in sun, shade, over/under fertilized lawns, and over/under irrigated areas. It is unknown how to keep this weed under control with cultural management.

Brief description of *Oxalis corniculata*

The cotyledons of creeping woodsorrel are oval in shape. 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.

Broadleaf herbicides for use in lawns

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 only partial control of oxalis in lawns.

Objectives of herbicide field trials

- To determine which active ingredients control oxalis.
- To compare similar products available at different concentrations to professional applicators and homeowners.

Methods and materials

- The experimental site was a Fresno city park with an extensive, uniform population of oxalis (average 85% weed coverage) growing in a well established, common bermudagrass turf.
- The experimental design was a split plot with 4 replications. Main plots (preemergence herbicides) measured 35 feet by 7 feet and sub plots (postemergence herbicides) were 3.5 feet by 7 feet in size.
- The herbicide applications were made with a CO2 backpack sprayer at 30 psi using 1.5 gal/1000 ft2 water volumes.
- Three preemergence herbicides were applied on November 18, 2003 and February 24, 2004: Dimension® (dithiopyr), Pendulum® (pendimethalin), and Barricade® (prodiamine).

- Nine postemergence broadleaf herbicides were applied on November 18, 2003 and February 24, 2004. Common broadleaf weed herbicides (2, 4-D, mecoprop, and dicamba) used in turf were tested. Homeowners have access to a less concentrated version of these herbicide combinations than do professional applicators. Two formulations (homeowner vs. professional) of three and four way combinations were tested and compared. Fluroxypyr (related to triclopyr) and Speedzone® (developed specifically for broadleaf weed control in warm season lawns) were also included.

A list of treatments including the herbicide trade names, common names, active ingredients, and concentrations is shown in Table 1.

Results

Visual ratings in December 03 and February 04 indicated that oxalis control was better in all plots receiving a postemergence herbicide application compared to the untreated check and the plots only receiving a preemergence application. In the December rating weed control by most postemergence herbicides was unsatisfactory (less than 5.0) and there was not much difference between homeowner and professional products. Speedzone Southern had higher ratings than common broadleaf weed killers, but products containing triclopyr and fluroxypyr brought the highest weed control ratings. By February weed control ratings were significantly better and there were no differences in any of the postemergence products. Untreated areas and plots with preemergence treatments only continued to have much lower weed control ratings.

All three preemergence herbicides were effective in keeping oxalis from germinating and over time had significantly higher weed control ratings than untreated plots.

Summary

Results showed that preemergence herbicides are effective in controlling creeping woodsorrel over time even when no postemergence herbicides are applied. Preemergence herbicides appear to be a vital component to extending oxalis control for an entire year. Several postemergence treatments provided good to excellent knockdown of existing populations of oxalis with little to no phytotoxicity (data not shown) to bermudagrass. Two active ingredients fluroxypyr and triclopyr provided better oxalis control sooner than other broadleaf weed killers, when applied in late Fall. Carfentrazone in Speedzone Southern® provided an extra boost to oxalis knockdown. Initially homeowner concentrations of postemergence broadleaf herbicides had less effect on oxalis control, but after 9 months and two treatments in combination with preemergence herbicides, there were no significant treatment differences between homeowner and professional products. This study will be repeated.

TABLE 1. List of Treatments

PREEMERGENCE herbicides (main plots)	**AMT/1000 ft2**
A. Dimension® - dithiopyr (12.7%)	1½ ozs
B. Pendulum WDG® - pendimethalin (60%)	(3.4lb/A) = 1¼ ozs
C. Barricade WG® - prodiamine (65%)	1½ ozs
POSTEMERGENCE herbicides (subplots)	**AMT/1000 ft2**
1. Untreated check	-
2. Homeowner Trimec (OSH) 2, 4-D (5.67%) MCPP (2.67%) dicamba (0.63%)	1½ oz
3. Professional Trimec 992 (Gordon's) 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 (Gordon's) 2, 4-D (5.83%) MCPP (2.93%) dicamba (1.46%) & MSMA (18.0%)	1½
6. Speedzone Southern 2, 4-D ester (10.49%) MCPP (2.66%) dicamba (.67%) carfentrazone (.54%)	1½
7. Lontrel clopyralid (40.9%)	¼
8. Starane (Vista) fluroxypyr (26.2%)	½
9. Lontrel + Starane clopyralid (40.9%) + fluroxypyr (26.2%)	¼ + ½
10. Confront clopyralid (12.1%) + triclopyr (33.0%)	¾

TABLE 2. Oxalis Control*
with POSTEMERGENCE Herbicides

Treated – NOV 18	Rating DEC 8, 2003	Rating FEB 20, 2004
Untreated	1.4	5.3
Preemergence only	1.5	5.4
Trimec H	3.5	8.0
Trimec P	5.0	9.4
Trimec + H	3.1	8.8
Trimec + P	3.3	8.8
Speedzone	6.1	8.3
Lontrel	4.6	8.5
Starane	7.9	9.3
Lontrel + Starane	8.3	9.8
Confront	7.5	9.8
LSD (P + 0.05)	**1.0**	**4.0**

* Visual Rating 1 – 10: 1 = No control 10 = 100% control

TABLE 3. Oxalis Control* with PREEMERGENCE Herbicides

Treated **NOV 03 & FEB 04**	Ratings **DEC 03**	**FEB 04**	**APR 04**	**AUG 04**
Dimension (dithiopyr)	5.0 a	8.9 a	9.4 a	9.0 a
Pendulum (pendimethalin)	5.0 a	8.7 a	9.4 a	8.6 a
Barricade (prodiamine)	5.0 a	8.1 a	9.3 a	8.8 a
Untreated check	1.5 b	5.4 b	5.3 b	1.5 b
LSD (P = 0.05)	2.7	2.9	2.1	2.8

*Visual rating scale 1 – 10: 1= No control 10 = 100% control

OVERVIEW OF USES OF "CHATEAU" IN VEGETABLE WEED CONTROL PROGRAMS

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Chateau® Herbicide is a broad-spectrum preemergence herbicide containing the active ingredient flumioxazin. Flumioxazin has been registered in the United States since 2001 for use in peanuts and soybeans and in other parts of the world since 1997 for use in tree fruit nut and vine crops.

Due to flumioxazin's broad weed spectrum, mode of action, and crop safety, there has been extensive support to expand flumioxaizn's use patters to many other crops. Regulatory programs have been completed, or are in process, for numerous new use patterns in vegetable crops. Registration was granted for use in onions, potatoes, and sweet potatoes in 2004. Registration is expected for use in garlic, fruiting vegetable row middles, and asparagus in 2006, and in cucurbit row middles and celery in 2007.

COVER CROP VARIETY AND SEEDING RATE EFFECTS ON WINTER WEED SEED PRODUCTION

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Abstract

Weed management is one of the most critical yield-limiting factors in organic crop production systems. Little is known about the impact of winter cover crops on winter weed population dynamics. The USDA-ARS organic research program in Salinas, California has conducted several trials examining the impact of cover crop management options on weed populations. The research focused on cover crop seeding rate and variety, mixture composition, and rotary hoeing. In a comparison of 1X (industry norm) and 3X seeding rates of rye, mustard and legume-rye cover crops, chickweed seed production was 224 seeds/m2 in the 1X legume-rye mix while seed production did not exceed 18 seeds/m2 in any of the remaining cover crops. In another experiment, increasing the cereal component or adding mustard to a mix reduced the number of weed seeds produced during the winter. Cover crop mixes with a high plant density that cover the ground quickly after planting are the most effective at reducing weed seed production. In poorly competitive cover crops, the rotary hoe provided an alternative means to control emerging weeds.

Introduction

Most cover crop research in the central coast of California has focused on nitrate leaching and nitrogen cycling. Little is known about cover crop effects on weed management. Preliminary work at the USDA-ARS certified organic site in Salinas indicated that legume-cereal mixes may exacerbate weed problems allowing high weed seed production (Brennan and Smith, 2003). Increasing the seeding rate increases crop competitive ability (Mohler, 2000) and in cash crops reduces weed seed production (Teasdale, 1998). Seeding rate effects on weed suppression in cover crops has received little research attention.

In poorly competitive cover crops, the rotary hoe may be used for weed control after cover crop emergence. It has been used to control weeds effectively in a variety of monocultures, but to our knowledge, has never been evaluated in mixed plantings. Multiple passes with the rotary hoe may help control weeds that germinate and emerge within the cover crop over an extended period of time (Leblanc and Cloutier 2001a).

The objectives of this paper are to report the impact of cover crop seeding rate, mixture, and rotary hoeing on weed biomass and weed seed return.

Materials and Methods

The cover crop variety and seeding rate trial is designed to examine the impact of cover crop variety and planting density (Table 1) on winter weed populations and summer vegetable production. Rye, mustard and a legume-rye cover crop mix were planted at two rates in the fall and measurements of cover crop biomass and ground cover were taken throughout the season. Weed emergence, growth, and seed production were monitored in all cover crops.

Cover crop growth and biomass production as well as weed growth and weed seed production were compared in a variety of existing and novel cover crop mixes. This paper reports the results of 9 of 27 mixes. The rotary hoe trial examined the effect of rotary hoeing on weed populations within a legume-rye cover crop.

Table 1. Seeding rates and estimated plant density for three separate cover crop trials.

Trial	Cover crop mix	Seeding Rate (kg/ha)	Seeding density (plants/m2)
Cover crop variety and seeding rate trial	Merced Rye1 1X	90	410
	Merced Rye 3X	270	1230
	Mustard2 1X	11	335
	Mustard 3X	33	1005
	Legume-rye3 1X	112	138
	Legume-rye 3X	336	414
Mixes trial	10% oat, 90% legume4	140	173
	40% oat, 60% legume5	140	259
	10% rye, 90% legume4	140	194
	40% rye, 60% legume5	140	346
	Legume4 + 2lbs mustard2	129	216
	Bell beans (*Vicia faba* L.)	140	32
	Mustard2	11	335
	Cayuse oats (*Avena sativa*)	112	335
	Rye1	90	410
Rotary hoe trial	Legume-rye3	255	315

1 *Secale cereale ('Merced')*
2 61% *Brassica juncea* (L.) Czern. ('Ida Gold'), 39% *Brassica hirta* Moench. ('Pacific Gold') by weight.
3 10% *Secale cereale* L. ('Merced'), 35% *Vicia faba* L., 25% *Pisum sativum* L., 15% *Vicia sativa* L., 15% *Vicia benghalensis* L. by weight.
4 35% *Vicia faba* L., 25% *Pisum sativum* L., 15% *Vicia sativa* L., 15% *Vicia benghalensis* L. by weight.
5 23% *Vicia faba* L., 17% *Pisum sativum* L., 10% *Vicia sativa* L., 10% *Vicia benghalensis* L. by weight.
6 45% *Vicia villosa* (Lana vetch), 45% *Vicia benghalensis* L. (purple vetch) by weight.
7 30% *Vicia villosa* (Lana vetch), 30% *Vicia benghalensis* L. (purple vetch) by weight.

Cover crop canopy development was estimated by holding a 30 by 30 cm quadrat with 64 cross grids above the cover crop canopy and counting the number of grid crosses above cover crop plants. Weed seed production was estimated by vacuuming the soil surface of 0.5 m2 quadrat from each plot. A crust had formed on the soil surface allowing removal of weed seeds and surface debris with minimal soil disturbance. The weed seeds were separated from soil and organic residue by passing each sample through a 1.7 mm sieve and then floating the seeds in water. All data were analyzed in SAS (Cary, NC) with the PROC GLM procedure and Tukey's or leasts squares means comparisons. Only the first year of multiple year studies is presented.

Results and Discussion

*Cover crop variety and seeding rate trial. Chickweed (*Stellaria media *(L.) Vill.) comprised the majority of the weed biomass. Weed biomass production was significantly affected by cover crop variety and seeding rate throughout the cover cropping period (Figure 1). The legume-rye 1X cover crop achieved 100% ground cover more slowly than any other cover crops and had significantly less biomass production early in the season. Mustard and rye 3X produced the most cover crop biomass early in the season. By early spring (March) there were no significant differences in cover crop biomass production (data not shown). Weed biomass was inversely proportional to early season cover crop biomass. Weed biomass in the legume-rye 1X increased by more than eight fold from November to January when it was 11 times higher than the average weed biomass in all other treatments.*

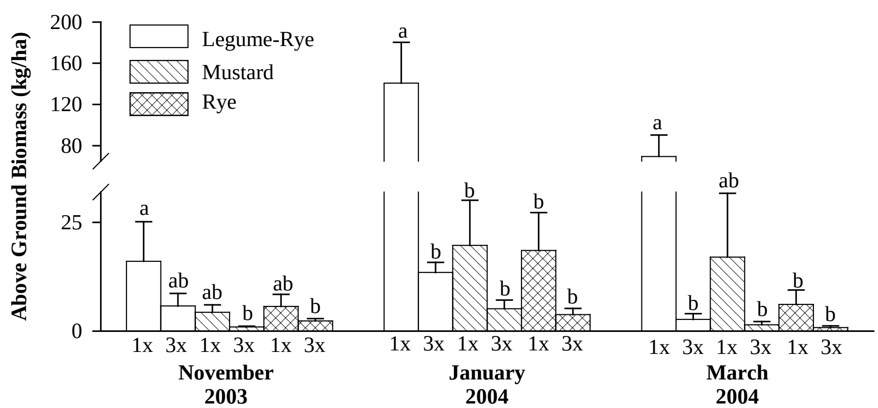

Figure 1. Weed dry biomass production on 3 harvest dates in the cover crop variety and seeding rate trial. Bars are mean ± SE. Within each date, bars topped with different letters are significantly different at < 0.05.

Chickweed seed production was also influenced by cover crop variety and seeding rate (Figure 2). The greatest chickweed seed production occurred under the legume-rye 1X (224 seeds/m2) and the least occurred under the legume-rye 3X (3 seeds/m2). Cover crop seeding rate did not influence chickweed seed production in mustard or rye.

Rotary hoe trial. One pass with the rotary hoe in the legume-rye cover crop reduced chickweed and shepherd's purse seedlings by 64 and 91%, respectively. At 36 days after planting (DAP) there were a total of 474 emerged weeds/m2 in the no rotary hoe treatment. A single pass with the rotary hoe 14 DAP reduced total weed density by 69% to 148 weeds/m2. An additional pass with the rotary hoe did not further reduce weed density. One pass with the rotary hoe reduced seed return by 81% for chickweed and 93% for shepherd's purse (Figure 3).
A second pass with the rotary hoe had no additional affect on weed seed return.
Mixes trial. Ground cover, above ground cover crop and weed biomass and weed seed production were compared for a variety of cover crop mixes. Chickweed was the predominate weed. In single component cover crops the lowest weed seed production occurred in mustard followed by rye (Table 2). Oats and all other legumes examined in this trial were less competitive. Increasing the cereal component of a mix, and consequently its density, decreased

weed seed production (Table 2). Adding mustard to a legume mix reduced weed seed production and survival of the legume component (Table 2). Weed biomass was highly correlated with early season ground cover measurements taken 43 DAP.

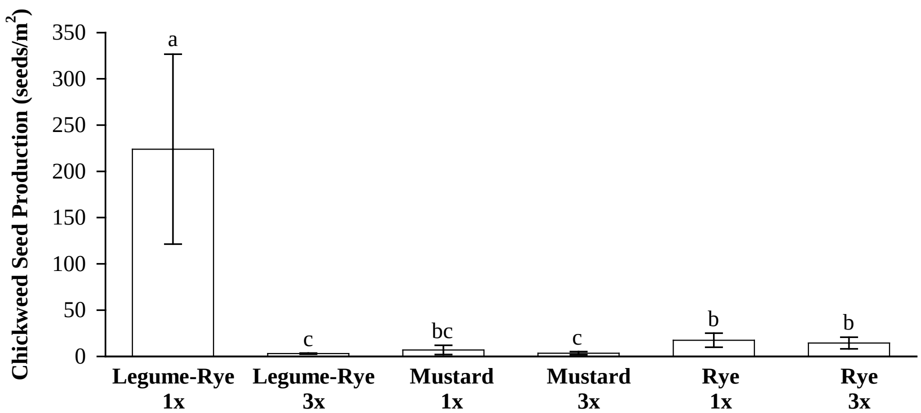

Figure 2. Chickweed seed production by the final cover crop harvest in March, 2004 of the cover crop variety and seeding rate trial. Bars are mean ± SE. Within each date, bars topped with different letters are significantly different at *P* < 0.05.

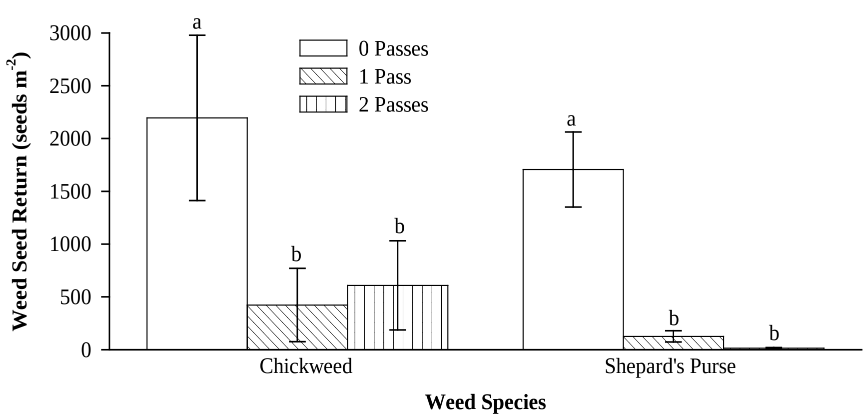

Figure 3. Weed seed return by chickweed and shepherd's purse 134 DAP following 0, 1, or 2 passes with the rotary hoe. Bars within the same weed species with different letters are significantly different at *P*<0.05.

Table 2. Winter chickweed seed production within various cover crop mixes in the mixes trial.

Cover Crop Mix	Chickweed Seed Production
10% oat, 90% legume[1]	1074 a[2]
40% oat, 60% legume	850 ab
10% rye, 90% legume	855 ab
40% rye, 60% legume	435 bc
Legume + 2lbs mustard	90 c
Bell beans	1568
Mustard	46
Cayuse oats	802
Merced Rye	310

[1] For further information on the cover crop mix please see table 1.
[2] Values followed with different letters are significantly different at $P<0.05$. Single components were not compared statistically.

The differences in weed suppression by the cover crop varieties and seeding rates in these studies is partially explained by differences in canopy development early in the season. As expected, increasing the seeding rate or the cereal component of legume-cereal mixes markedly improved their weed suppressive abilities. However, increasing cover crop seeding rate to improve weed suppression in legume mixes often suppresses both weeds and less competitive components like legumes (Brennan and Boyd, unpublished data). With single component cover crops, increasing the seeding rate may provide ‘cheap insurance’ against weeds, considering that cover crop seed accounts for a relatively small part (≈25%) of total cover cropping costs (Klonsky et al., 1994). Alternatively, the rotary hoe may obtain sufficient weed management in poorly competitive cover crops without increasing the seeding rate.

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PREIRRIGATION IMPACTS ON SUBSEQUENT WEED EMERGENCE

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INTRODUCTION

On the Central coast of California direct-seeded vegetables such as broccoli and lettuce are grown on raised beds. Extensive tillage is the norm in this production system with the objective of creating a smooth seedbed that is suitable for the planting of small-seeded vegetable crops such as lettuce (Ryder 1999, Fennimore and Jackson 2003). During dry weather, creating a smooth seedbed for planting requires irrigation of the raised beds, followed by drying to the appropriate soil moisture before the final tillage (Masiunas et al. 1997). We tested the hypothesis that lengthening the time interval between pre-plant irrigation and crop planting may improve weed control by allowing time for more weeds to emerge so that they can be removed with pre-plant tillage. Because irrigated vegetable fields often have the option of several irrigation systems such as sprinkler and furrow irrigation, we compared these two major preplant irrigation systems. The study objectives were: 1) to compare short versus long time intervals between pre-plant irrigation and tillage, and 2) to compare the level of preplant weed germination stimulus with sprinkler and furrow irrigation.

METHODS

Site description. In field studies conducted at the USDA-ARS station at Salinas, CA, spring lettuce was planted at Spence farm and fall lettuce was planted at Hartnell farm. Soil at Hartnell farm is an Antioch sandy loam, and at Spence farm is a Chualar loamy sand. Cropping history included vegetable crops such as lettuce, broccoli, and winter cover crops of oats and mustard at Spence and Hartnell farm, respectively. These two sites are about 5 miles apart and vary in their weed species richness and diversity; Hartnell farm had fewer weed species but higher weed densities than Spence farm.

Pre-irrigation studies were conducted on 40-in raised beds and treatments included; furrow irrigation 1 and 2 weeks prior to planting, sprinkler irrigation 1 and 2 weeks prior to planting, and a control with no pre-plant irrigation. Experimental designs in the 2002 spring planting were 3 by 3 Latin square block design for the pre-irrigation, each block was 100 ft long by 16 beds wide. Blocks were split for the two time intervals (7 or 14 days) and further split between three preemergence herbicide rates (pronamide 0, 0.6 and 1.2 lb ai/A), applied to two beds in each block one day after crop seeding. Furrow irrigation was used to water the beds to near saturation. Sprinkler irrigation plots were watered for approximately 7 hrs during which time about 1.75 in of water was applied.

Plots were seeded with romaine (var. green tower) in two planting lines with 2-inch in-row spacing. After lettuce seeding, pronamide was applied on the bed tops in a 22-inch band using a CO2 tractor mounded sprayer. Following pronamide application, all plots were sprinkler irrigated for 3 hrs (equivalent to 0.75-inches of rain).

The fall 2002 and both spring and fall 2003 pre-irrigation studies had a randomized complete block design with three to four replicates, with block size of six 40-inch beds wide by 100 ft long, similar to the spring 2002 study. After the initial pre-irrigation and seeding, all plots were subjected to uniform horticultural practices common for lettuce production in the Salinas Valley such as sprinkler irrigation, hand weeding and cultivation, and fertilizer application (Ryder 1999).

Weed counts were performed before bed shaping, prior to crop thinning 21 days after crop seeding, and before any hand weeding or cultivation. Weed densities were measured in two 2.7 ft2 sub-samples per treatment (one per each center bed); weeds were identified and recorded by species. The time required for hand weeding during lettuce thinning was recorded. Lettuce yield was evaluated by harvesting one 10 ft seed line in each of the two center beds. Number of lettuce heads and fresh weights were recorded.

Statistical analyses. All data analyses were performed on the averages of the two sub-samples. Data were subjected to arcsine, logarithmic or square root transformation as required after consideration for normality and heterogeneity. Data were subjected to a two way block-designed ANOVA with interaction, using proc. mixed in SAS. When blocks had no significant effect, data were tested again with a two way ANOVA with interaction, for the effect of the different pre-irrigation and herbicide treatments, using proc. GLM in SAS. Single degree-of-freedom (df) linear contrasts were used to compare efficacy of different time intervals (7 vs. 14 d), pre-irrigation methods, and herbicide rates at P = 0.05 (SAS 1991).

RESULTS AND DISCUSSION

Post-plant weed evaluations. All studies demonstrated that pre-irrigation followed by preplant tillage reduced weed densities during the crop establishment period, i.e. approximately the first 21d after crop seeding (Table). These early season weeds present the highest risk for yield lost in many leafy vegetable (Roberts and Stokes 1965, Roberts et al. 1977, Shem-Tov and Fennimore 2002). Insufficient time interval between pre-plant furrow irrigation and bed shaping did not improve weed control and even increased weed densities in spring plantings (Table). Lonsbary et al. (2003) also demonstrated the importance of time interval between pre-plant irrigation and cultivation of stale-seedbed as a method to improve weed control in cucumbers. If a short pre-plant interval is to be used, sprinkler pre-plant irrigation is the recommended method.

Spring experiments. In both 2002 and 2003 planting, late season rain occurred after bed listing. However only in the 2003 study did weed emergence occur after bed listing. Weed densities were reduced by most pre-plant irrigation treatments; in some cases pre-plant irrigation with the long time interval of 14 d had similar or better weed control than the non pre-irrigated control treated with 1.2 lb/A pronamide (Table). The level of control demonstrated by the 14 d pre-irrigation may be sufficient for organic production of sensitive crops with no good herbicides. Weed densities in the spring 2002 planting, without pre emergence herbicide application, were: 124, 142, 68, 66 and 46 weeds m-1 for the no pre-irrigation control, furrow 7 d, furrow 14 d, sprinkler 7d and sprinkler 14d pre-plant irrigation, respectively. The weed densities measured 21d after crop seeding in the spring 2003 planting were: 225, 450, 213, 313 and 216 weeds m-1 for the non pre-irrigated control, furrow 7 d, furrow 14 d, sprinkler 7d and sprinkler 14d pre-plant irrigations, respectively. While the 2002 study demonstrated a good weed control provided by the pre-plant irrigation alone, the 2003 study showed improved weed control only in combinations of herbicide and pre-plant irrigation treatments (Table). In the 2003 study, pronamide did not improve weed control in plots that were not pre-irrigated.

Fall experiments. A high weed density in the fall 2002 planting demonstrated the importance of the pre-plant irrigation. Pre-plant irrigation alone reduced the weed densities from 575 weed m-1 to 477, 378, 409 and 472 weeds m-1, in the furrow 7 d, furrow 14 d, sprinkler 7d and sprinkler 14d pre-plant irrigated plots, respectively (Table). Similar reduction was noted in time required for hand weeding the plots. The combination of pre emergence herbicide application and pre-plant irrigation reduced the hoeing time by up to 50%. The first hand weeding, during thinning, and pre emergence herbicide application costs for romaine lettuce costs are 15% and 5%, respectively of the cultural practice costs (Tourte and Smith 2001). Orthagonal contrasts in both years, demonstrated significant differences in the weed densities and the hoeing time between the two time intervals (7 and 14 d) under sprinkler pre-plant irrigation, and between weed densities in plot pre-irrigated with furrow or sprinkler under the long time interval of 14d (data not shown). In the 2003 fall planting, lower weed densities were recorded, yet both pre-plant irrigation and pronamide rates had a significant effect on weed control and the time required for hoeing and hand weeding. The long pre-plant interval of 14 d had the best weed control and pre emergence herbicide application supplemented the pre-irrigation to achieve up to 80% weed control (Table). Orthagonal contrasts revealed a significant effect of the two time interval (7 and 14 d) and these differences were noticeable under the sprinkler pre-irrigation but not under the furrow pre-plant irrigation (data not shown). The two pre-plant irrigation methods (sprinkler and furrow) had a significant effect on the total weed densities (data not shown).

Lettuce yield. In general all the spring pre-plant irrigation treatments had similar fresh weights and head size, as the control. However, during the fall planting reduced yield mass and quality was noted in the no pre-irrigation control (data not shown). This reduce quality could be attributed to nitrogen phytoxicty caused by the fertilizer injected to the soil during bed listing, while part of the nitrogen applied to the pre-plant irrigated plots was lost before seeding and therefore did not show such response (Ajwa personal communication). This was not a problem for the spring planting since beds were exposed to few natural rainfalls that occurred between bed listing and the initiation of the study.

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Table: Weed densities, and the hoeing time required to thin and hand weed the 2002-3 lettuce plantings 21 d after planting.

Pre-irrigation treatment	Herbicide rate	Spring 2002		Fall 2002		Spring 2003		Fall 2003	
		Weed density	Hoeing time	Weed density	Hoeing time	Weed density	Hoeing time	Weed density	Hoeing time
	Lb ai/A	no. m-2	Sec 30 ft-1	no. m-2	Sec 30 ft-1	no. m-2	Sec 30 ft-1	no. m-2	Sec 30 ft-1
None	0	124	254	575	186	225	176	126.1	159
None	0.6	96	170	272	124	281	136	99.4	111
None	1.2	66	124	335	127	218	122	86.0	101
Furrow 7d	0	142	NA	477	158	450	173	68.6	109
Furrow 7d	0.6	36	NA	102	92	348	119	26.9	75
Furrow 7d	1.2	31	NA	94	96	167	97	25.8	80
Furrow 14d	0	68	159	378	146	213	164	75.1	158
Furrow 14d	0.6	109	124	106	95	157	113	37.5	99
Furrow 14d	1.2	38	95	122	91	161	105	33.7	85
Sprinkler 7d	0	66	NA	409	187	313	147	58.5	134
Sprinkler 7d	0.6	54	NA	242	126	135	96	35.2	86
Sprinkler 7d	1.2	28	NA	87	107	86	89	20.0	82
Sprinkler 14d	0	46	131	472	145	216	136	66.0	93
Sprinkler 14d	0.6	49	125	96	93	156	96	24.8	89
Sprinkler 14d	1.2	26	103	148	102	145	96	34.6	82
LSD 0.05		46	13	77	27	74	36	2	28

a- The time (sec.) required for thinning and hand weeding a 30 ft long bed of lettuce, data were analyzed as averages of the to sub-samples (paired beds).

CALTRANS STRUCTURAL VEGETATION MANAGEMENT SOLUTIONS FOR ROADSIDES

Jennifer A. Malcolm, 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. This document focuses on the "structural" method for vegetation control. Historically, structural applications have been the most expensive and least utilized method at Caltrans, but currently structural methods show the most promise for Caltrans' future.

When choosing an appropriate vegetation management strategy, Caltrans considers safety for our highway maintenance workers, safety for the traveling public, and increased mobility. Structural methods can also decrease sight distance concerns. Generally, structural methods involve higher costs during initial installation, but they lead towards reduced maintenance needs and costs in the long run. Structural elements can also help Caltrans with its herbicide reduction goals. Hardscaping can unify and tie elements together while also being aesthetically pleasing – due to the wide variety of treatments, colors and patterns available.

Hardscaping and Structural methods can be interchangeable terms. Basically, hardscaping is the use of hard inert material surfaces such as asphalt, concrete and rock – in comparison to living soft material surfaces such as organic mulches and plants. Caltrans typically utilizes ten different highway hardscaping treatments. Last year I covered three products in detail – fiber weed control mats, polyureas, and rubber weed control mats. Today, I will cover two products in detail –CRMCrete and Cullet.

CRMCrete is short for Crumb Rubber Modified Concrete. CRMCrete is a concrete-based product that includes recycled scrap tire crumb rubber material and homopolymer polypropylene high performance reinforcing fibers, all blended into a slurry. Placement is similar to that of concrete and stamped concrete. Typical installation includes pouring CRMCrete into place, tamping and leveling as necessary. Applications may also include adding a stamped texture to the top finish or including a concrete color stain to match nearby items.

CRMCrete benefits include:

- Wide variety of colors to match soil colors by utilizing concrete stains
- Formwork is not always necessary
- Higher daily production rates – faster than other surface treatments
- Fairly easy installation
- Uses standard equipment and concrete mixes
- Reduces the number of tires going into landfills

CRMCrete limitations include:

- Consistency of mix may limit its use on slopes
- Limited history of maintainability and life cycle costs
- Repairs are difficult to match to the original color, if you use a concrete stain
- It is rigid and requires a 150 millimeter gap between the product and nearby guardrails/sign posts

Product will be crash-tested this year

Caltrans then decided to combine two vegetation control methods together by installing a 'Mowable Median Project with CRMCrete'. The site originally had many obstructions in the median such as raised drop inlets, culvert pipes sticking out, survey monuments, signage, posts and pullboxes. There were many obstacles that obstructed the efficiency of the mowing crew. This project made everything flush with the existing finish grade by relocating all of the obstructions and resetting them with CRMCrete. By placing CRMCrete around the appurtances, chemical spraying was also reduced. The mowers can now swath the median easily and quickly while also reducing the amount of time our employees spend in a dangerous location, thus improving our safety.

The next product is known as Cullet. Cullet is the professional term used for recycled glass mulch. Cullet is applied like you would apply wood mulch. It is recommended to lay some sort of a barrier between the soil and the recycled glass mulch (just in case you ever need to remove it). We have tried Visquene and the typical black weed fabric. Caltrans has also installed cullet in one location (under the guardrail) that doesn't have any underlayment underneath it. Then you dump the glass mulch on top and spread it out evenly.

Cullet Benefits include:

Shimmers and sparkles

Works great for flat areas

Does not decompose, since it is glass

There are a wide variety of sizes available from the glass recycling companies

Cullet comes in a wide variety of colors – practically every color is available

Cullet also reduces the amount of waste going into our landfills

Cullet Limitations include:

Never use it on a slope

Reflective – glare issue and reflects the underlayment

Tumbling is required

A border may be necessary

Clear glass tends to look white

Costs or maintainability in the long-term are unknown

Heat and soil temperatures are unknown

ABSTRACT FOR CA WEED SCIENCE SOCIETY PRESENTATION
AQUATIC SPECIES SESSION:
MULTI-YEAR CONTROL OF ARUNDO DONAX IN SANTA CLARA COUNTY WATERSHEDS

Presenter: Rick L. Austin

The Santa Clara Valley Water District has implemented a multi-year program to control *Arundo donax* in Santa Clara county streams. The goal of the project is to control 125 acres of the target species over a ten year period. The program is currently in Year 3 with an accomplishment to date of 33.5 acres removed from various creeks, mostly in the southern part of the county. The removal efforts are being done under contract by Clean Lakes, Inc. The focus of the presentation is methods tried, lessons learned, and process improvement.

Arundo is a large perennial grass that propagates vegetatively by rhizomes. There is no evidence of propagation from seed in CA. The plant is native to Southeast Asia and was introduced in the early 1800's as a building material. Arundo has been used as a windbreak, for erosion control, and as an ornamental. More recently it was commercially used for reeds in woodwind instruments. It has been considered for pulp production and as fuel for biomass generators.

Arundo is found throughout Santa Clara County Creeks though the largest infestations are in four watersheds. The program's goal is to remove125 acres of from county watersheds over a ten year period as part of the District's stream maintenance program. The primary focus is riparian restoration in the infested areas.

The program to date has had a number of challenges. Most infestations are located in hard to access areas that require very labor intensive control methods. Most of the locations are in very environmentally sensitive areas that have high levels of regulation.
Endangered Species Issues, Water Quality, Pesticide Use, and Archeological sites are some of the potential issues that add to project complexity. Biological surveys and training are required due to multiple endangered species that inhabit project areas.

The valley floor is entirely built out and people are not sensitive to issues in the creeks. The project sites have hundreds of owners with their own agendas. Often other projects have other goals that conflict with these project goals. Project is highly political.
The work window, with all regulations in place, is approximately 14 weeks. Any work outside this period requires additional regulatory clearance. The compressed work window adds a huge amount of complexity and cost to the project.

Effecitive control of the plant requires herbicide use. The Bay Area is very environmentally conscious and there are many critics of pesticide use. The project is an ongoing educational challenge. Access is one of the most critical challenges. Many places do not have room for any equipment. All work must be done by hand. Biomass has to be hauled long distances. Most times the project is accessed through someone's back yard.

Disposal is always an issue because of the huge amounts of biomass. We have tried various disposal methods including burning, chipping or grinding on site, and hauling to landfills.

Project cost varies depending on the site and your project parameters. Labor is a huge element of the project so the more expensive the labor, the higher the cost. The access and regulatory issues add a lot of cost to the project.

The project requires specialized technology. GPS mapping technology allows for both initial assessment and long term monitoring of each site.
NPDES permit requires water quality monitoring and reporting for in-stream pesticide application. We have a consultant perform these tasks. Close coordination is required for all project elements.

UVAS SITE (Year 1)
This project site had large single owner parcels and much of the infestation away from the channel. There was significant space to stockpile biomass. Mechanical mowing or mulching was limited due to large amounts of debris mixed in with the Arundo.

Los Gatos Creek
The project area was highly urban with no access. A trail system located along one side meant a high level of public use and project visibility. Most clumps were very small but there were numerous clumps. The stream is a steelhead creek that required a softer touch. Numerous homeless issues.

UVAS CREEK (Year 2)
Access required coordination with multiple property owners. “Ag folks” took more convincing to allow into properties. The contractor skipped a large section in center of project because the calendar forced us to pull out of the creek. Heavy autumn rains and farming operations made disposal a problem.

LLAGAS CREEK AND UVAS CREEK (Year 3)
All of the work was in-stream which made removal much more difficult and all spray work required NPDES sampling.
The project site had more than 50 landowners to coordinate with. County of Santa Clara proved most challenging. An initial mowing trial on Uvas Creek was highly successful.

In summary, the early years of the project have produced mixed results. This is attributable to the varied nature of project locations but also the complexity associated with highly regulated work in riparian areas. Santa Clara County is densely populated and very little access to project areas requires more time, planning, and resources to effectively implement the project. Future project goals are to maximize the use of mechanical equipment where possible, negotiate site specific resource protection with regulatory agencies to expand work practices and work season, and investigate more cost effective disposal methods. The project will also closely monitor timing of cutting and herbicide treatments to determine the most effective matrix of control methods to reduce re-growth.

UPDATE ON CDFA REGULATORY AQUATIC WEED PROGRAMS

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The California Department of Food and Agriculture's (CDFA) Division of Plant Health and Pest Prevention Services' Integrated Pest Control Branch has three programs that are involved with weed control. They are the Weed Program, the Hydrilla Program and the Biological Control Program. In addition, there is a statewide coordinator for the many local Weed Management Areas. The Hydrilla Program is primarily responsible for the aquatic weeds.

California's weed rating system is based on distribution within the state. "A" rated weeds are of limited distribution, "C" rated weeds are generally widespread and "B" rated weeds are in between the two in distribution.

"A" rated weeds are prohibited entry into the state and sale within the state, and are subject to eradication.
"B" rated weeds are prohibited from nurseries and sale by nurseries, can be prohibited and eradicated at the county level at the discretion of the county Agricultural Commissioner.
"C" rated weeds can be prohibited from sale and eradicated at the discretion of the county Agricultural Commissioner.
"Q" rated weeds, are temporarily treated as "A" rated weeds, subject to review for a permanent weed rating.

The primary aquatic weed projects are:
Hydrilla
Salvinia
Purple Loosestrife
Alligatorweed
South American Spongeplant

In 2004 there were some aquatic weed rating changes:

Four new "Q" rated weeds were added - Alternanthera sessilis - Sessile joyweed
- Ceratopteris thalictroides - Watersprite
- Hygrophila polysperma - Indian smartweed
- Lagorosiphon major - Curly waterweed

New "A" rated weeds - Limnobium laevigatum - South American Spongeplant
- Hydrocharis- morsus - Frogbit
- Salvinia auriculata complex - Giant salvinia

New "B" rated weed - Piatia stratiodes - Water lettuce

New "C" rated weeds - Bacoppa monnieri - Water hyssop
- Eichhornia crassipes - Water hyacinth
- Myriophyllum spicatum - Eurasian watermilfoil

STATEWIDE GENERAL NPDES PERMIT FOR THE DISCHARGE OF AQUATIC PESTICIDES FOR AQUATIC WEED CONTROL IN WATERS OF THE UNITED STATES

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On March 12, 2001 the Ninth Circuit Court of Appeals decided that the discharge of aquatic pesticides to waters of the United States (U.S.) required coverage under a National Pollutant Discharge Elimination System (NPDES) Permit. In response to the ruling, the State Water Resources Control Board (State Board) adopted an emergency General NPDES Permit for discharges of aquatic pesticides to waters of the U.S. That permit expired on January 31, 2004. On May 20, 2004 State Board adopted two General NPDES permits. General Permit No. CAG 990005 covered the discharge of aquatic pesticides for aquatic weed control and General Permit No. CAG 990004 covered the discharge of aquatic pesticides for vector control. Basic requirements of the General Permits include: 1. The applicator must follow all pesticide label instructions and any Use Permits issued; 2. The discharger must be licensed by DPR or work under the supervision of someone who is licensed if the aquatic pesticide is considered a restricted material; 3. The discharger must comply with effluent limitations including developing and implementing an Aquatic Pesticide Application Plan (APAP); 4. The discharger must comply with applicable receiving water limitations; and 5. The discharger must comply with monitoring and reporting requirements. To seek coverage under the General Permits, a Notice of Intent must be completed and submitted to the Regional Water Quality Control Board, along with the filing fee, APAP, map(s), and other supporting documents, if any. Copies of the General Permits and additional information regarding the program are posted on the State Board website at www.waterboards.ca.gov.

ORIENTATION OF GRAPEVINE ROWS AFFECTS WEED GROWTH

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Introduction

Black nightshade (*Solanum nigrum* L.) is a common vineyard weed. It may be effectively controlled with herbicides, but farmers are increasingly seeking alternatives to chemicals. In fact, many California grape growers wish to develop management practices that are economically and environmentally sustainable (Dlott et al. 2002). Sustainable weed control is likely to require a multifaceted approach that includes the design of weed suppressive cropping systems. Such systems may shade weeds to reduce their fitness, but this concept has been developed for annuals and has not been extended to perennial systems such as vineyards.

Canopies of trellised vines may intercept more sunlight in rows oriented north-south (NS) compared to rows oriented EW, but variables including latitude, time of year, canopy architecture, and cultural practices such as pruning style, can all have pronounced effects on canopy light interception, so experimental comparisons of actual systems are needed. Even so, these contrasting row orientations would be expected to affect the quantity and quality of light available to weeds under the canopy. Shade may decrease fitness of some weeds by reducing their photosynthetic capacity and by causing changes in dry matter partitioning that favor vegetative, rather than reproductive, structures (Begna et al., 2002). Therefore, row orientation might serve as one part of an integrated weed management (IWM) strategy for new vineyards.

The objectives of this study were to test the following.

- Effect of row orientation on light environment in the weed canopy zone (WCZ).
- Effect of light environment on weed photosynthesis.
- Effect of row orientation on weed growth and seed production.

Materials and Methods

In April 2003 and 2004, uniform black nightshade seedlings growing in separate, 8-liter, black polyethylene pots were randomly assigned to row orientation treatments and moved to a vineyard at the Kearney Agricultural Center, Parlier. The vineyard was established in 2000 and featured rows oriented NS and EW in a randomized complete block design with four replicates. 'Selma Pete' grapevines were spaced about 2 m within rows and 3.6 m between rows, with guard rows surrounding each experimental row. The length of the vine row was 20 m. The vines were trained to quadrilateral cordons on a Y-shaped open-gable trellis (Figure 1). Similar vine and row spacing, and training and trellis systems, are used commercially for raisin and table grape production in California.

Photosynthetically active radiation (PAR) was measured three times a day (0900, 1200, and 1600 hrs) each week with a ceptometer positioned parallel to the vine row and straddling each pot, about 0.5 m above the vineyard floor in the WCZ. Photosynthetically active radiation was also measured hourly between 06:30 and 19:30 hrs on one day during each experiment. On May 20, 2003, and on June 10, 2004, a single leaf of each nightshade was selected and subjected to photosynthesis measurements under ambient light conditions at about 09:30 and 12:00 hrs using a portable photosynthesis system.

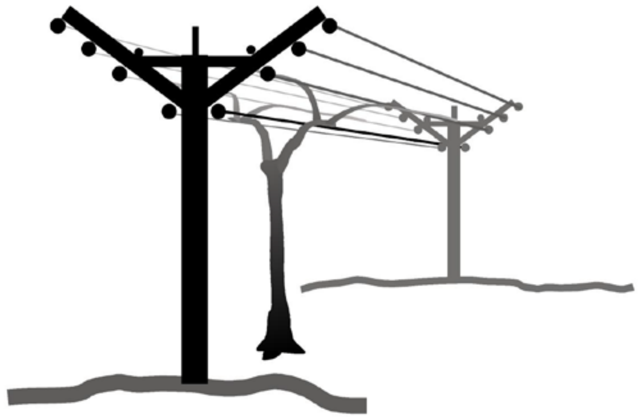

Figure 1. An open-gable trellis system.

Height (stem length from the soil surface in the pot to the shoot apex) of each nightshade was recorded weekly. After about 7 weeks, each plant was harvested and divided into leaves, stems, berries, and roots. Growth media was washed from the roots. Leaf area was measured with a leaf area meter and the total stem lengths of the plants were also measured. The number of berries in each nightshade plant was counted. Leaf, stem, berry, and root dry weights were determined after drying the samples to a constant weight in an oven. Ten berries from each plant were randomly sampled after drying and the seeds contained in each berry were extracted and counted. Leaf area ratio (LAR), leaf weight ratio (LWR), and specific leaf weight (SLW) were calculated as total leaf area/total plant dry weight, total leaf dry weight/total plant dry weight, and total leaf dry weight /total leaf area, respectively.

All data were subjected to analysis of variance. Replication and year by replication interaction were considered random effects. There was a main effect ($P<0.05$) of year on most of the variables measured. However, data were combined for the two years as there was no year by treatment interactions for the variables.

Results and Discussion

Irradiance beneath grapevine canopies in NS rows was bimodal, with peaks occurring at about 09:30 and 16:30 hrs (Figure 2), when the angle of the sun was such that some direct light passed between the canopies of adjacent vinerows. At those times, irradiance at the WCZ in NS rows increased rapidly from about 35 µmol • m-2 • s-1, in both years, to peaks of about 500 µmol • m-2 • s-1, in 2003, and to about 700 µmol • m-2 • s-1, in 2004 (about 30 to 40% of full sun, data not shown). In contrast, the WCZ beneath grapevines in EW rows was characterized by low irradiance throughout the day (Figure 2) due to shade cast from vines within the rows or from vines in the southern guard rows, depending on the time of day. Thus, the WCZ in EW rows received about 80% less light than that in rows oriented NS (based on the difference in the areas under the curves; data not shown). The difference in light levels of each row orientation and time of day resulted in greater photosynthetic rates for the leaves of plants in NS rows compared to those in EW rows, in the morning, but the leaves of plants in both row orientations had similar photosynthetic rates at midday (Table 1).

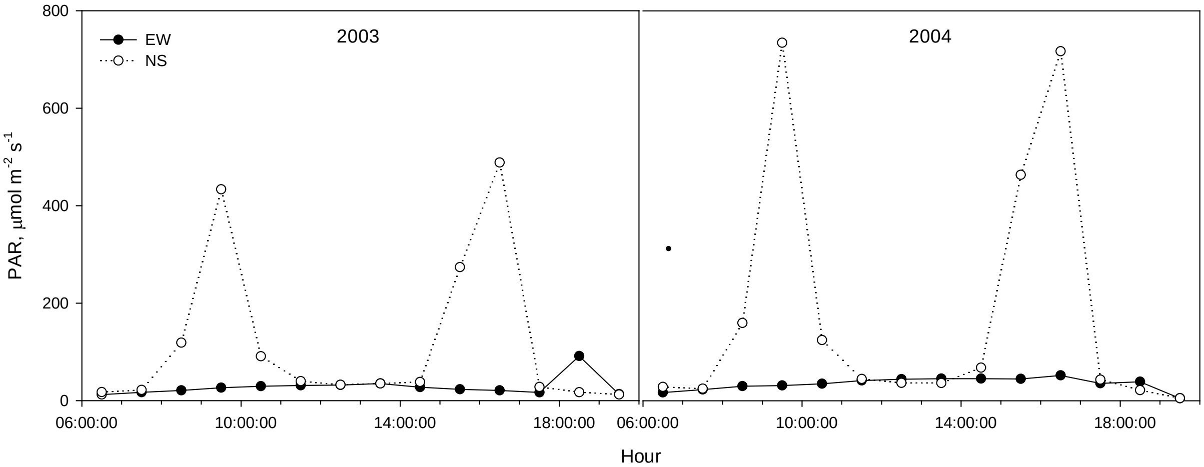

Figure 2. Incident photosynthetically active radiation (PAR) beneath grapevine canopies in rows oriented north-south (NS) or east-west (EW) measured hourly between 06:30 and 19:30 hrs on Julian day 161, 2003, and on Julian day 144, 2004, Parlier, CA.

Table 1. Incident photosynthetically active radiation (PAR) on leaves of potted nightshade plants grown under grapevine canopies oriented East-West (EW) or North-South (NS), and net CO2 assimilation (A) of those leaves. Measurements were made at about 1030 hrs and 1200 hrs on 12 June 2003 or 14 June 2004.

	Time of day							
	1030 hrs				1200 hrs			
	Year 2003		Year 2004		Year 2003		Year 2004	
	PAR	A	PAR	A	PAR	A	PAR	A
Row orientation	---(µmol • m-2 • s-1)---							
EW	24a	1.18	13	0.17	22	0.88	12	1.08
NS	659	9.00	798	6.84	19	0.69	16	0.72
P Valueb	0.007	0.0001	0.04	0.05	0.38	0.37	0.07	0.99

aValues are treatment means, n = 4.
bSignificance level for treatment comparisons within columns

Plants in both EW and NS rows were of similar height at harvest, but row orientation had a marked effect on other plant morphological variables. The total number of leaves per plant was not affected by row orientation, but nightshades growing in the EW rows had bigger and thinner leaves than those in the NS rows as shown by the differences in the total leaf area, 22% greater in EW vs NS, and SLW, 21% lesser in EW vs NS (Table 2). Plants in EW rows also partitioned more resources to leaves at the expense of other organs as evidenced by their greater LAR and LWR compared to NS plants, i.e. 31% and 18% greater, respectively in EW vs NS (Table 2).

Table 2. Average (2003 and 2004) total leaf number, leaf area, stem length, leaf area ratio (LAR), leaf weight ratio (LWR), and specific leaf weight (SLW) of the black nightshade plants as affected by vineyard row orientation.

Row orientation	Total leaves	Total Leaf area	Total Stem length	LAR	LWR	SLW
	No. plant-1	cm2 plant-1	cm plant-1	cm2 kg-1	kg-1 kg-1	g-1 m-2
East-West	178.5	2376.9	307.6	180.9	0.33	1.8
North-South	171.0	1843.4	297.7	124.0	0.27	2.3
P Valuea	.4543	<.0001	.7970	<.0001	.0002	<.0001

aSignificance level for the treatment comparisons within a column.

Specifically, plants in the EW rows partitioned less dry matter to berries and to roots compared to those in the NS rows (Figure 3). Number of berries, average number of seeds per berry, and total seed return per plant was 16%, 7%, and 20% lower respectively, in the nightshades in EW compared to NS rows (data not shown). Such reductions in seed return could have long term implications for plant population dynamics and future weed management. The low root:shoot ratio of nightshades in EW rows may make that these plants more vulnerable to moisture and nutrient stress than those in the NS rows. A smaller root biomass may also facilitate uprooting the weeds by hand or by mechanical cultivation. Further, a higher leaf area and lower root mass might influence the degree of susceptibility of plants to herbicides (Ipor and Price, 1994).

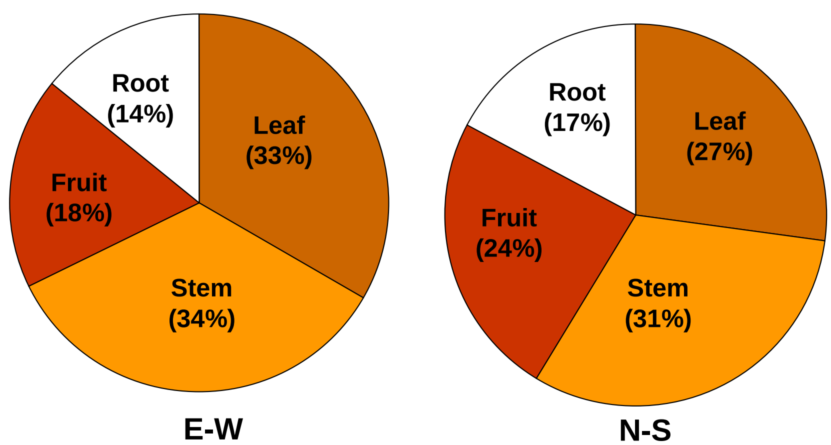

Figure 3. Proportion of dry mass allocated to roots, leaves, stems and fruit of black nightshades grown under 'Selma Pete' grapevines in rows oriented east-west (E-W) or north-south (N-S), Parlier, CA, April to June, 2003 and 2004.

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WEEDS AS ALTERNATE HOSTS OF PIERCE'S DISEASE: THEIR ROLE IN PLANT DISEASE

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The plant disease triangle summarizes the complex conditions required for Pierce's disease (PD): insect vectors, the plant pathogenic bacteria *Xylella fastidiosa*, a susceptible crop, and other environmental factors, including weeds that are insect breeding hosts or alternate hosts for the bacteria. *X. fastidiosa* multiplies to high populations (up to 10 million live bacteria per gram of plant material) in plant xylem and is acquired by insect vectors, primarily sharpshooters, during feeding. Vectors can acquire *X. fastidiosa* in a single feeding and remain infective for the rest of their adult lives. Control of PD focuses on reducing vector populations through targeted insecticide sprays and habitat modification to keep vectors from entering vineyards.

The severity and distribution of PD depends on the sharpshooter species present. In the north and central coast, blue-green sharpshooters (BGSS), breeding on certain riparian plants spread PD to vineyards adjacent to streams. In the Central Valley, red-headed (RHSS) or green sharpshooters (GSS) cause disease adjacent to irrigated pasture or weedy alfalfa fields. The glassy-winged sharpshooter (GWSS) is established in southern California and multiplies on citrus and irrigated ornamentals. In the north coast, guidelines for habitat modification to reduce blue-green sharpshooter breeding habitat are available (http://nature.berkeley.edu/xylella/north/info.htm).

Weeds serve as both insect breeding and feeding hosts as well as reservoirs for *X. fastidiosa*. Plants such as wild grapevine, Himalayan blackberry, and periwinkle that are both breeding hosts of the BGSS and support systemic bacterial populations are of particular importance. In greenhouse and field tests, *X. fastidiosa* survives to some degree in many riparian plants (Purcell and Saunders) and ornamentals (Wong and Costa). We tested common vineyard weeds in Central Valley vineyards to identify likely hosts in areas newly-infested with GWSS. Weeds were greenhouse-grown and sampled 1, 3, and 9 weeks after inoculation to obtain population data over time. Eight of 29 species tested (horseweed, sunflower, sacred datura, fava bean, annual bur-sage, poison hemlock, common cocklebur, and common morning glory) were frequently infected by sharpshooters in the greenhouse. Another 19 species were inconsistently or rarely hosts. In general, populations peaked at 6 weeks at 1.9 million live bacteria per gram of plant tissue.

When plants that had been sharpshooter-inoculated were grown concurrently in the field and in the greenhouse, fewer field-grown transplants maintained detectable infections compared to greenhouse-grown weeds, and field plants had lower *X. fastidiosa* populations in both summer and winter.

PD control begins with identifying the diseased area, the insect vectors, and their habitat in your area, by monitoring with sticky traps. Insects enter vineyards or orchards from outside vegetation. Where sharpshooters are endemic, remove plants that are spring breeding hosts for the insects. Host lists generated in greenhouse studies are a good first screen but should be used with caution since *X. fastidiosa* survives at much lower rates in the real world, and the risk posed by a particular plant depends on how often and when sharpshooter vectors feed on it as does the ability of the plant to host *X. fastidiosa*.

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Purcell Lab Web Site: www.nature.berkeley.edu/xylella
Riparian Vegetation Management Guide: http://nature.berkeley.edu/xylella/north/info

ECONOMICS OF CONTACT VERSUS RESIDUAL WEED CONTROL IN WALNUTS AND PISTACHIOS

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Weed pressure and competition for water and nutrients significantly impact pistachio and walnut growth during the first 5 to 7 years after planting. In walnuts, for example, if weeds are allowed to grow next to the trees, they will not attain the necessary 8 feet of growth the first year to be able to head them at 6 to 6.5 feet tall. Consequently, the grower will have to cut them back to 2 buds and start over, or compromise their heading height and wind up with the primary branches to low to avoid damage from tractors and harvesters. In pistachios, drip and fanjet emitters are placed close to the base of pistachio trees, making gopher damage a problem, especially when yellow nutsedge is present. If not controlled during orchard establishment, growers will find that the cost of herbicides is far cheaper compared to the loss of trees from gopher damage. In walnuts, growers furrow irrigate the first 2 years after planting, which promotes rapid weed growth in the furrows and potential for waterlogged walnut roots, leading to tree decline or death.

Weeds are also known to host economic insect pests in tree nuts. Knotweed, spotted spurge, and London rocket host false chinch bug, which can kill young trees in late April or early May when the weeds dry down. Russian thistle, clovers, and birdsfoot trefoil are hosts for lygus and stink bugs. These insects attack nuts in the soft and hard shell stages, causing epicarp lesions and kernel necrosis.

Herbicides play a necessary role in walnut and pistachio production. If herbicides are not used following planting, growers resort to cross-disking to destroy the vegetation. This can lead to tree damage by debarking or cutting off tree roots, a cause of crown gall infection. Tree canopy development and shading is slower to develop in pistachio than walnut orchards, increasing the need for herbicide use for a longer period of time in pistachios.

While several herbicides are available in pistachios and walnuts (table 1), soil residual herbicides are essential for the first 5 to 7 years after planting to reduce the negative impacts associated with weed growth. Soil residual herbicide selection in pistachios is limited, but if properly used, can significantly reduce problems associated with allowing weeds to grow before treating with contact herbicides. Although contact herbicides are generally less expensive than soil residual herbicides (table 2), there are significant problems that can arise if they are relied upon solely, particularly in the first years following planting. Selecting an herbicide program based solely on cost or economics to save a few bucks early on less expensive postemergence sprays should not be the reason for herbicide choice, since it will cost at least $7,000 an acre to establish the trees for the first 6 years.

Contact programs begin to have greater potential in mature orchards where: (1) several years of soil residual treatments will limit the weed population and reduce the likelihood of new weed seed introduction, (2) the weed spectrum will be narrowed, (3) the additional postemergence spot treatments during the season required to substitute for not applying soil residuals do not exceed the cost of the preemergents, and (4) lighter equipment, such as ATV sprayers, can be used instead of more expensive boom sprayers used for soil herbicide applications.

Table 1. Herbicides registered in pistachios and walnuts in California in 2004

Soil residual herbicides	Pistachio	Walnut
Dichlobenil (Casoron)	Not registered	Bearing and non-bearing
Diuron (Karmex, Direx)	Not registered	Established at least 1 year
EPTC (Eptam)	Not registered	Bearing and non-bearing
Napropamide (Devrinol)	Bearing and non-bearing	Bearing and non-bearing
Norflurazon (Solicam)	Not registered	Established at least 1.5 years
Oryzalin (Surflan)	Bearing and non-bearing	Bearing and non-bearing
Oxyfluorfen (Goal)	Bearing and non-bearing	Bearing and non-bearing
Simazine (Princep)	Not registered	Established at least 1 year
Trifluralin (Treflan)	Not registered	Bearing and non-bearing
Isoxaben (Gallery T&V)	Non-bearing only	Non-bearing only
Pendimethalin (Prowl)	Non-bearing only	Non-bearing only
Thiazopyr (Visor)	Non-bearing only	Non-bearing only
Contact herbicides		
Glufosinate (Rely)	Not registered	Bearing and non-bearing
Glyphosate (Roundup)	Bearing and non-bearing	Bearing and non-bearing
Paraquat (Gramoxone)	Bearing and non-bearing	Bearing and non-bearing
Sethoxydim (Poast)	Non-bearing only	Bearing and non-bearing
Sulfosate (Touchdown)	Non-bearing only	Bearing and non-bearing
2,4-D (Weedaxe, etc.)	Established at least 1 year	Established at least 1 year
Clethodim (Prism)	Non-bearing only	Non-bearing only
Diquat (Reglone)	Non-bearing only	Non-bearing only
Fluazifop (Fusilade)	Non-bearing only	Non-bearing only
MSMA	Not registered	Non-bearing only

Several problems are associated with relying primarily on less expensive contact herbicides for weed control during orchard establishment:

1. Weeds that are already established are obviously competing for essential water and nutrients, taking away from early tree growth and development. Since the trees are planted during the dormant period, it may be difficult for the grower to be able to enter the field under rainy and wet conditions in a timely manner before these weeds get too large for control or produce seed. In the spring and summer, nutsedge becomes quite competitive, which can become a real problem if growers allow it to develop beyond the 4th or 5th leaf stage so that new tubers are formed and perpetuate the problem, even if burned down with foliar herbicides

like paraquat or glyphosate. If hairy fleabane and marestail are present, a more expensive contact herbicide like glufosinate, should be used. It is expensive (about $20/acre), but has excellent activity on these and other weeds that glyphosate and paraquat miss.

2. Young trees are sensitive to injury from postemergence herbicides like glyphosate and paraquat; very common from accidental contact or drift, especially when weeds are tall at the time of treatment. While these herbicides may not kill the trees, growth is severely hindered. In the case of pistachios, paraquat damage can stop the rootstock from growing, harden off the bark, and make it difficult to successfully bud in July or August. Additionally, pistachios are very sensitive to leaf loss as a result of low lying foliage from unbudded rootstocks.

3. Many times growers select to plant their orchards in fields formerly planted to annual crops like cotton or corn, where the weed spectrum can be extensive. Without using combinations of soil residual herbicides, it is often difficult to get adequate control with postemergence sprays if the weed spectrum is diverse. This usually requires additional trips through the field with contact sprays to keep the population under control.

Table 2. Cost comparison of some typical soil residual and contact herbicides in 2004

Soil residual	Lb a.i./A	Product/A	Product cost ($)	Cost/Acre ($)*
Goal 2XL	1.0	2.0 qt	90/gal	14.21
Surflan AS	4.0	4.0 qt	70/gal	22.11
Princep Caliber 90	2.0	2.2 lb	3.60/lb	2.50
Karmex DF	2.4	3.0 lb	3.55/lb	3.36
Prowl 3.3	1.2	3.0 pt	30/gal	3.60
Contact herbicides				
Roundup UltraMax	1.0	1.6 pt	45/gal	3.00
Glyphosate (generic)	1.0	1.6 pt	25/gal	1.58
Rely	1.0	1.0 gal	65/gal	20.53
Gramoxone Max	0.5	1.6 pt	38/gal	2.53
Touchdown	1.0	2.6 pt	42/gal	2.80

*Assumes treating pistachios on a 6' band on a row spacing of 19' and does not include cost of application

For many growers, the question is whether or not soil residual herbicides pay now that contact herbicides, generic glyphosate in particular, can be purchased for about $25 per gallon. At a cost of $1.58/acre (based on a strip spray of 6' on 19' row spacing), it is understandable why growers find this appealing. In contrast, a tank-mix of oryzalin plus oxyfluorfen as a soil residual program may cost more than $36/acre.

Using soil residual herbicides during the first 6 or 7 years of orchard establishment will help avoid many of the major problems associated with relying on contact sprays as mentioned previously. Rather than allowing grassy weeds to become established at planting then spraying with a contact herbicide, a tank-mix application of pendimethalin plus oxyfluorfen in the winter will provide excellent broad-spectrum weed control down the tree row, reducing competition from established weeds. A timely contact spray can then be used to pick up any weeds escaping treatment. A typical preemergence program like this in non-bearing orchards will cost about $20/acre, but provide several months of residual control. Continuing this program for several years can significantly reduce the weed population, making control with contacts much easier and valuable. If nutsedge is known to be present, it would be beneficial to use an herbicide like thiazopyr during the non-bearing years to reduce or eliminate the population. This reduces the likelihood of promoting additional nutlet production due to delayed postemergence sprays.

There are more soil residual herbicides available in walnuts than in pistachios. A fall or winter strip-spray application of diuron at 3 lbs/acre plus simazine at 2 lbs/acre in a walnut orchard established at least 1 year will eliminate most weeds that may be present at an affordable cost of about $6/acre (not including spray equipment). Add an additional cost of $3/acre for a contact spray, like glyphosate or paraquat for small weeds that may be present and it's not hard to see why this program should be very attractive where costs are a concern.

Applying soil residual herbicides for 4 to 5 consecutive years following planting will provide a better opportunity to be flexible in future herbicide choices and use patterns. For example, if an extensive rainy period is anticipated in the fall and early winter months (results in rapid herbicide degradation), consider delaying treatment with oryzalin and oxyfluorfen until late-January or early-February to lengthen residual activity during the summer. An application of oxyfluorfen plus glyphosate applied in the fall, when weeds are small, will often keep the tree rows clean until the residual herbicides can be applied.

Whether or not a grower decides to eliminate their soil residual herbicide program in favor of a contact one is dependent upon several variables that must be considered. Although appealing, one should not base their weed control decisions solely on the ability to purchase contact herbicides cheaply. Pistachio and walnut orchards are a long-term and expensive investment. Although soil residual herbicides are generally more expensive than contact ones, properly selecting and using soil residual herbicides early during orchard establishment will help reduce the likelihood of weed-related problems experienced in contact-only programs.

WEED RESEARCH PROJECTS IN ALMOND AND GRAPES

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Both winter and summer, annual and perennial weeds can be very problematic in grapes and almonds. Weeds compete for nutrients, water and sunlight. Weeds are most competitive during the first couple of years of establishment, but once established heavy densities of weeds, especially perennials, can interfere with irrigation increase damaging rodents and insects, reduce yields and quality and interfere with harvest. Although there are a number of pre and post emergence herbicides registered for use in almonds and grapes (Table 1 & 2) hairy fleabane and horseweed have become severe problems. Currently registered herbicides have effectively controlled most annuals, but have been erratic in control of hairy fleabane and horseweed. Consequently, in most situations there has been a weed shift to these two species. Studies were conducted in 2002, 2003 and 2004 to evaluate the efficacy of various per and post emergence herbicides. All tests were conducted in a randomized complete design and were applied with CO2 backpack sprayer delivering spray volumes of 20 and 40 GPA, depending upon test.

Almonds

Evaluations of hairy fleabane and common groundsel control in 2002, 78 days after treatment (Table 3) indicated 99 to 100 percent control with Chateau tank mix with Roundup at both the 6 and 12 oz. rate of Chateau. The Goal, Visor treatment was also exhibiting 100 percent control. Goal, by itself, and in combination with either Surflan, Shark or Rely was providing 88 to 96 percent control. At 128 DAT, 100 percent hairy fleabane control was being achieved with the 12 oz. rate of Chateau. Reduced control was exhibited by all other treatments.

Evaluations in 2003 (Table 4) indicted 96 to 100 percent control of hairy fleabane, common groundsel and barnyardgrass with both Chateau and Goal in combination with Surflan and Rely, and all rates of E9628 in combination with Roundup.

No injury from any treatment was observed on the almonds in all years tested.

Grapes

Evaluations in 2003 (Table 5 & 6) in grapes indicated excellent control of hairy fleabane with Chateau alone or in combination with Roundup. At 140 DAT (Table 5) E9636 at 4 and 8 oz. in combination with Roundup control ranged from 89 to 95 percent. Goal, Surflan combinations were only providing 65 to 70 percent control. Chateau by itself at 12 and 24 oz. and Chateau at 12 oz. in combination with Surflan at 4 qts. was providing 100 percent control of hairy fleabane at 150 DAT (Table 6). Goal in combination with Visor or Surflan was only providing 70 percent control.

In 2004, E9638 at all rates in combination with Roundup was providing 98 to 99 percent control of hairy fleabane at 38 DAT and 90 to 96 percent control at 103 DAT. Chateau in combination with Surflan was providing 92 to 94 percent control at 38 DAT and 84 to 90 percent control at 103 DAT. Goal by itself and in combination with either Roundup or Surflan + Roundup was only providing 22 to 75 percent control at 103 DAT. Barnyardgrass control with E9638 at 2 and 4 oz. in combination with Roundup was poor, but increased to 98 percent when tank mixed with Karmex.

No injury was noted in the grapes with any herbicide treatment in all years tested.

Conclusion

Both Chateau, a Valent herbicide, and E9636, a DuPont herbicide, provided excellent control of hairy fleabane in almonds and grapes. Once registered, these herbicides will provide growers with an effective means of controlling hairy fleabane and many other winter and summer annuals.

Soil Applied Residual Herbicides

Table 1.

	Common Name	Grapes	Almonds
Casoron	Dichlobenil	X	
Devrinol	Napropamide	X	X
Eptam	EPTC		X
Gallery*	Isoxaben	X	X
Goal	Oxyfluorfen	X	X
Karmex, Direx,	Diuron	X	
Kerb	Pronamide	X	
Princep (others),	Simazine	X	X
Prowl*	Pendimethalin	X	X
Solicam,	Norflurazon	X	X
Surflan, Oryzalin	Oryzalin	X	X
Treflan	Trifluralin	X	X
Visor*	Thiazopyr	X	X

* Non Bearing Only

Foliar Applied Herbicides

Table 2

Brand Name	Common Name	Grapes	Almonds
2,4-D	2,4-D	X	X
Fusilade*	Fluazifop-p	X	X
Gramoxone	Paraquat	X	X
MSMA*	MSMA	X	
Poast	Sethoxydim	X	X
Prism*	Clethodim	X	X
Rely	Glufosinate	X	X
Reglone*	Diquat	X	X
Roundup	Glyphosate	X	X
Sempra. Sandea	Halosulfuron-methyl		X
Touchdown 5	Sulfosate	X	X

Non Bearing Only

Almond Weed Control Study – 2002

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Table 3.

Treatment	Product/Acre	78 DAT		128 DAT
		Groundsel	Fleabane	Fleabane
1. Goal	1 gallon	91	92	77
2. Visor	1.5 pt	84	84	71
3. Goal + Visor	2 qt + 1.5 qt	100	100	89
4. Goal + Surflan + Roundup Ultra	2 qt + 1 qt + 1 pt	92	100	84
5. Shark + Goal + Agridex	0.8 oz + 2 qt + 1%	96	96	90
6. Prowl	4.8 qt	75	75	88
7. Chateau 4F + Roundup Ultra	6 oz + 1 pt	99	99	94
8. Chateau 4F + Roundup Ultra	12 oz + 1 pt	100	100	100
9.Rely + Goal + COC	1 gallon + 2 qt + 1%	88	88	83
10. Untreated Control		0	0	0

Almond Weed Control Study – 2003

Ron Vargas, Brent Holtz, Tomé Martin-Duvall & Eric Hoffman
University of California Cooperative Extension, Madera County

Table 4.

Treatment	Product/Acre	78 DAT		128 DAT
		Fleabane	Common Groundsel	Barnyard grass
1. Chateau + Surflan + Rely	6 oz + 1 gallon + 3 qt	100	100	100
2. Chateau + Surflan + Rely	12 oz + 1 gallon + 3 qt	100	100	100
3. Goal + Surflan + Rely	2 qt + 1 gallon + 3 qt	96	99	100
4. E9636 + Roundup + Agridex	2 oz + 1 qt + 1%	99	100	100
5. E9636 + Roundup + Agridex	4 oz + 1 qt + 1 %	99	100	100
6. E9636 + Roundup + Agridex	8 oz + 1 qt + 1%	99	100	100
7. Untreated Control		0	0	0

Grape Weed Control Study – 2003

Ron Vargas, George Leavitt, Tomé Martin-Duvall & Eric Hoffman
University of California Cooperative Extension, Madera County

Table 5.

Treatment	Product/Acre	Fleabane	
		65 DAT	140 DAT
1. Chateau + Surflan + Rely	9 oz + 1 gallon + 3 qt	92	75
2. Chateau + Surflan + Rely	12 oz + 1 gallon + 3 qt	86	66
3. Goal + Surflan + Rely	2 qt + 1 gallon + 3 qt	86	65
4. Goal + Surflan + Roundup Ultra Max	2 qt + 1 gallon + 25.6 oz	95	70
5. Goal + Roundup Ultra Max	2 qt + 25.6 oz	92	76
6. E9636 + Roundup + Agridex	2 oz + 1 qt + 1%	94	82
7. E9636 + Roundup + Agridex	4 oz + 1 qt + 1 %	100	95
8. E9636 + Roundup + Agridex	8 oz + 1 qt + 1%	98	89
9. Untreated Control		0	0

Grape Weed Control Study – 2003

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Table 6.

Treatment	Product/Acre	Hairy Fleabane Control			
		30 DAT	60 DAT	90 DAT	150 DAT
1. Chateau	3 oz	96	96	94	95
2. Chateau	6 oz	98	99	99	99
3. Chateau	12 oz	100	100	100	100
4. Chateau	24 oz	100	100	100	100
5. Goal + Visor	5 pt + 3 pt	65	50	60	70
6. Goal + Visor	5 pt + 4 pt	75	70	60	70
7. Goal + Surflan	5 pt + 8 pt	60	65	75	70
8 Chateau + Surflan	6 oz + 8 pt	97	99	98	98
9. Chateau + Surflan	12 oz + 8 pt	100	100	100	100
10. Untreated Control		0	30	30	40

Grape Weed Control Study – 2003

Ron Vargas, George Leavitt, Tomé Martin-Duvall & Eric Hoffman
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Table 7.

Treatment	Product/Acre	Fleabane		BYG
		38DAT	103 DAT	
1. Chateau + Surflan + Rely	9 oz + 1 gal + 3 qt	94	90	100
2. Chateau + Surflan + Rely	12 oz + 1 gal + 3 qt	92	84	100
3. Goal	2 qt	82	22	89
4. Goal + Glyphomax Plus	1 qt + 1 qt	93	75	45
5. Goal + Surflan + glyphosate + NIS	2 qt + 1 gal + 1 pt + 6.4 oz	81	50	100
6. E9636 + Roundup + Agridex	2 oz + 1 qt + 0.25%	98	96	58
7. E9636 + Roundup + Agridex	4 oz + 1 qt + 0.25%	99	90	50
8. E9636 + Roundup + Agridex	8 oz + 1 qt + 0.25%	99	96	89
9. E9636 + glyphosate + Karmex + NIS	4 oz + 1 pt + 2 lb + 6.4 oz	98	91	98
10. Untreated Control		0	0	0

* BYG - barnyardgrass

INTEGRATED MANAGEMENT TECHNIQUES FOR PERENNIAL PEPPERWEED

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Introduction

Perennial pepperweed is a long-lived herbaceous perennial capable of forming large monoculture populations in a wide range of environments, including floodplains, irrigation channels, rangeland, riparian areas, brackish marshes, and crop fields (Young et al. 1998, Renz 2001). Both the California Department of Food and Agriculture (CDFA) and California Invasive Plant Council (Cal-IPC) list perennial pepperweed as a noxious weed of great ecological concern in California. Over the past 10 years, it has spread rapidly throughout the west especially in flood plains and riparian habitats (Miller et al. 1986). The rapid spread is associated with the ease in which perennial pepperweed roots and seeds move downstream during periods of flooding or high water (Blank and Young 1997). This characteristic also increases erosion along heavily infested streambanks (Wilson et al. 2004). Large perennial pepperweed populations negatively impact nesting habitat for wildlife, interfere with willow re-generation, and reduce alfalfa and irrigated pasture productivity (Young et al. 1995). Dense infestations also reduce plant diversity and increase soil surface salinity (Blank and Young 1997).

Established perennial pepperweed populations are difficult to control and require multiple years of intensive management (Wilson et al. 2004). Suppressing the extensive root system is critical for successful control. Management plans should include prevention, monitoring, and treatment of satellite populations before plants develop extensive roots. Several post-emergent herbicides control perennial pepperweed, but repeat applications are necessary to treat re-spouting shoots and seedlings. Non-chemical controls (mowing, tillage, burning, and grazing) are useful in removing accumulated thatch, suppression, and/or preparing a site for re-vegetation, but they do not provide effective control since plants quickly re-sprout from vast root reserves.

In an effort to improve current perennial pepperweed management techniques, a study was established in Lassen County to evaluate herbicides and integrated control strategies. The study also evaluated methods for re-vegetating areas heavily infested with perennial pepperweed. Treatments were chosen to increase control options for the diverse array of sites perennial pepperweed infests including waterways, irrigated pasture, and upland range.

Methods

Sites were located at the CDFG Honey Lake Wildlife Area and Mapes Ranch in Lassen County. Both sites were heavily infested with perennial pepperweed and had significant litter (thatch) accumulation from old stems. Perennial pepperweed cover averaged 50% at Honey Lake Wildlife area and 71% at Mapes Ranch in July 2002 before treatments were initiated. Both sites had less than 5% desirable vegetation cover before treatments were initiated. The experimental design was a split-split-plot design with four replications. The treatments are listed below.

Whole plot treatments- (120 ft x 60 ft)
1. untreated (no alteration to the site)
2. winter burn
3. spring mowing at flowering
4. winter grazing
5. tillage (disking)

Sub-sub-plot treatments - (30 ft x 30 ft)
- a. untreated
- b. drill seed native grass mix

Sub-plot treatments- (30 ft x 60 ft)
- A. untreated
- B. chlorsulfuron at 1.5 oz ai/A
- C. 2,4-D ester at 1.9 lb ae/A
- D. glyphosate at 3 lb ae/A

Initial burning, mowing, cattle grazing, and tillage were conducted before herbicides were applied. The burn was conducted in the winter between February and April. A winter burn was preferred because of the lack of burning restrictions and desired perennial grasses are dormant. The objective was to burn perennial pepperweed litter to prepare the site for seeding with a drill. Winter grazing consisted of fencing cattle at a high stocking rate (100+ cows per whole plot) with supplemental feed (alfalfa and grass hay). The purpose of grazing was to trample and break apart the perennial pepperweed litter layer and graze coarse grasses such as tall wheatgrass. Spring or summer grazing was not used since cattle preferentially graze desirable grasses over perennial pepperweed. Spring mowing (flail mower) was conducted after perennial pepperweed flowered. The purpose of mowing was to cut and break apart the litter layer and change perennial pepperweed's growth pattern to increase herbicide efficacy. Fall disking was used for the tillage treatment. Although disking is not recommended because it spreads perennial pepperweed root fragments, tillage incorporates litter into the soil and prepares an optimal seedbed for drill-seeding. Burning, mowing, and grazing were repeated in 2004.

In spring 2003, chlorsulfuron, 2,4-D, or glyphosate was applied when perennial pepperweed reached the flower-bud stage. In mowed plots, the herbicide application was delayed until September to allow mow plants to re-grow to the flower-bud stage. In disked plots, glyphosate and 2,4-D were re-applied in September to control perennial pepperweed root fragments whose buds re-sprouted subsequent to the spring herbicide application. All herbicides were applied at 20 gallons per acre with recommended surfactants using a CO2 backpack sprayer.

In March 2004, selected plots were seeded with a cool season, perennial grass mix using a no-till drill. Re-vegetation in winter grazing plots consisted of broadcasting seed a week before grazing to allow livestock to trample the seed into the soil. Grass species included *Leymus triticoides*, *Phalaris arundinacea, Leymus cinereus,* and *Pascopyrum smithii*.

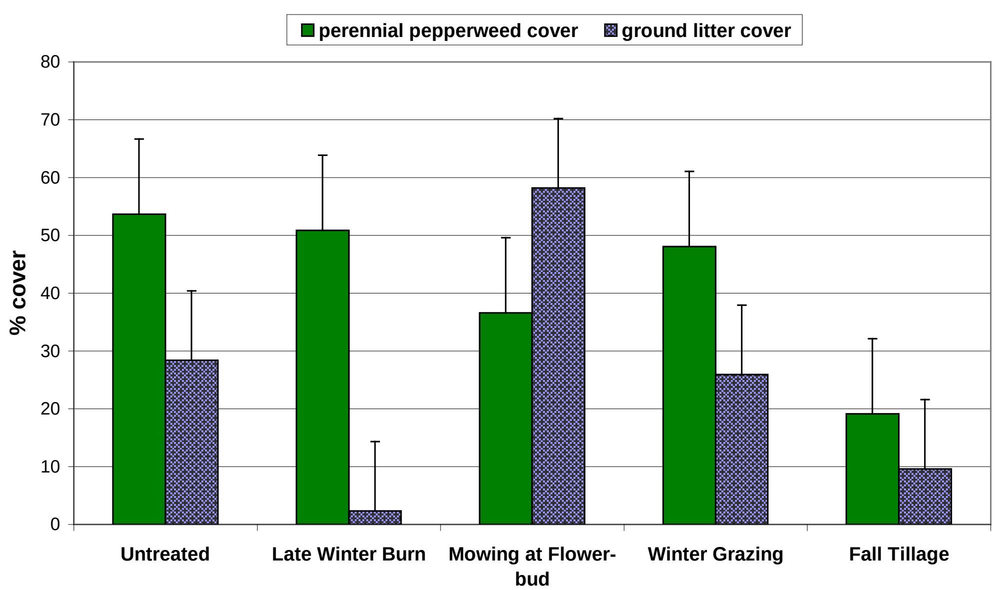
Percent cover of all plant species, bare ground, perennial pepperweed standing thatch, and ground litter were measured in spring and fall 2003 and 2004 to determine treatment effects. Perennial grass density and cover were recorded in spring and fall 2004 to access seeded grass establishment and vigor. Data was collected in three, randomly placed 1 m2 quadrats in each sub-plot.

Results

Preliminary results suggest integrating non-chemical controls with herbicides can provide effective management of perennial pepperweed. Burning and tillage were successful at removing accumulated thatch before herbicide treatment (figure 1), and mowing and tillage significantly reduced perennial pepperweed cover compared to untreated, burned, and grazed plots the year of herbicide application (figure 2). Several treatments provided effective control of perennial pepperweed one year after herbicide application. At both sites, all herbicide treatments significantly reduced perennial pepperweed cover compared to the control (figure 3). Overall, integrating non-chemical controls (burning, grazing, mowing, or tillage) with herbicides did not influence herbicide efficacy on perennial pepperweed (figure 3). In a few cases, burning and mowing decreased herbicide efficacy, but the effect was dependent on site conditions. For example, burning reduced chlorsulfuron efficacy at the Mapes site but had no effect on herbicide efficacy at the Honey Lake wildlife area (figure 3). The reason for decreased control at the Mapes site is unknown, but is likely due to high soil organic matter and the large amount of ash left after the burn. At both sites, tillage commonly decreased herbicide control (figure 3).

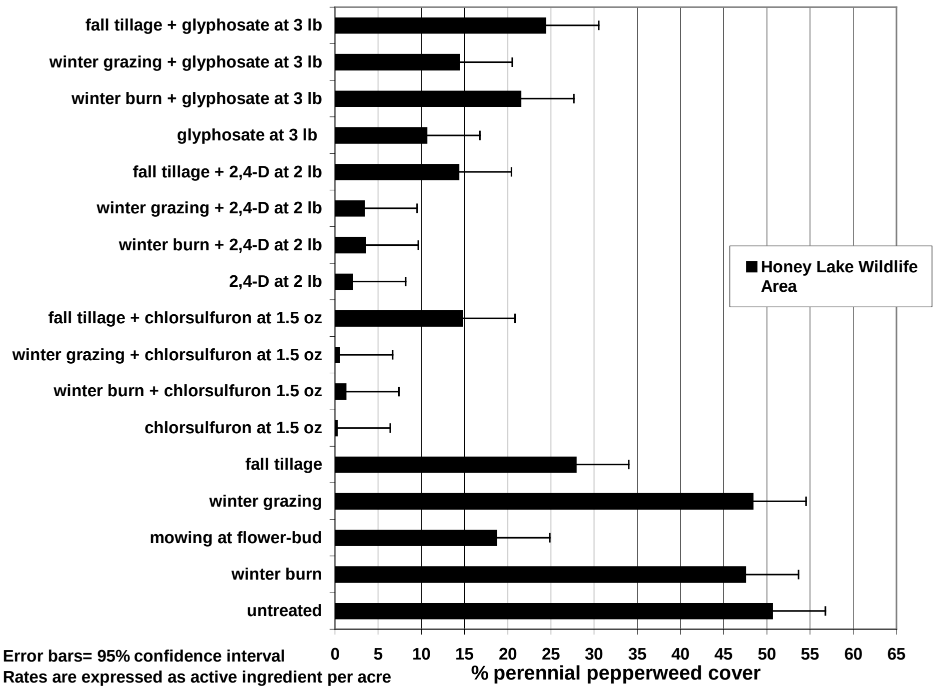
Drought conditions during spring 2004 provided inadequate moisture for perennial grass establishment. For this reason, plots will be re-seeded in March 2005. Although perennial grass establishment was poor, visual evaluations suggest integrating non-chemical and chemical control strategies significantly improves perennial grass establishment (figure 4). At the Mapes site, the following treatments improved perennial grass establishment compared to plots treated with herbicides or non-chemical controls alone: tillage plus 2,4-D, tillage plus glyphosate, winter grazing plus 2,4-D, and winter burning plus 2,4-D. The reason for improved grass establishment with these treatments is likely due to two factors: 1) tillage and burning did an excellent job at removing perennial pepperweed litter allowing exact seed placement with the drill; 2) 2,4-D and glyphosate suppressed perennial pepperweed re-growth allowing perennial seedlings to utilize all available soil moisture. Future results will provide a better understanding of the long-term success of integrating control strategies for perennial pepperweed management.

Figure 1. The Influence of Burning, Cattle Grazing, Mowing, and Tillage on Perennial Pepperweed and Ground Litter Cover Immediately Before Herbicide Application (averaged between sites)



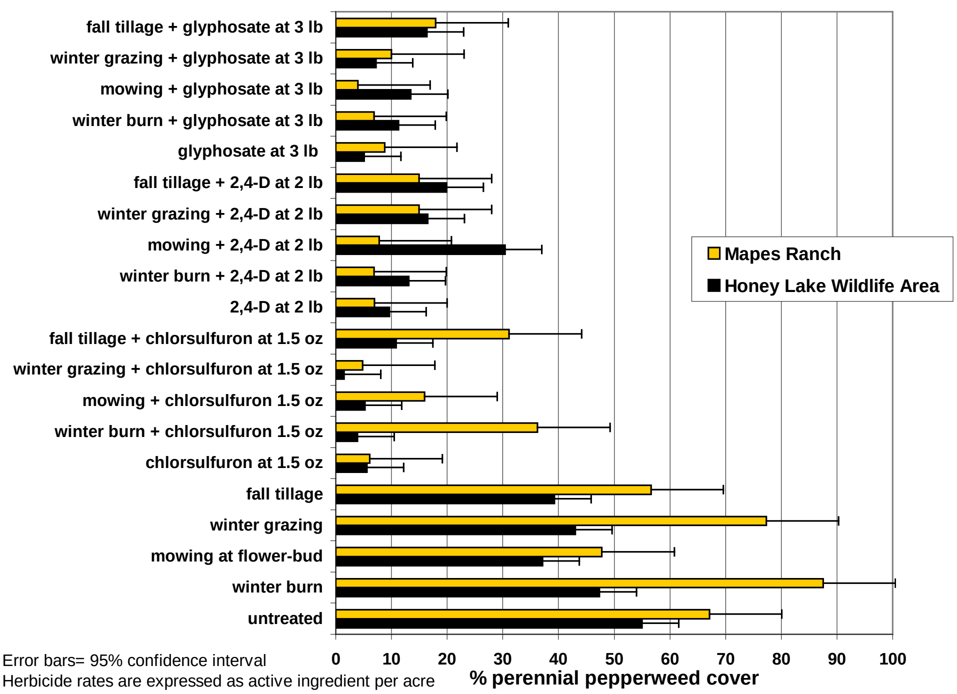
error bars= 95% confidence interval

Figure 2. The Effect of Control Methods on Perennial Pepperweed Cover August, 2003 (2 Months after Herbicide Treatment)



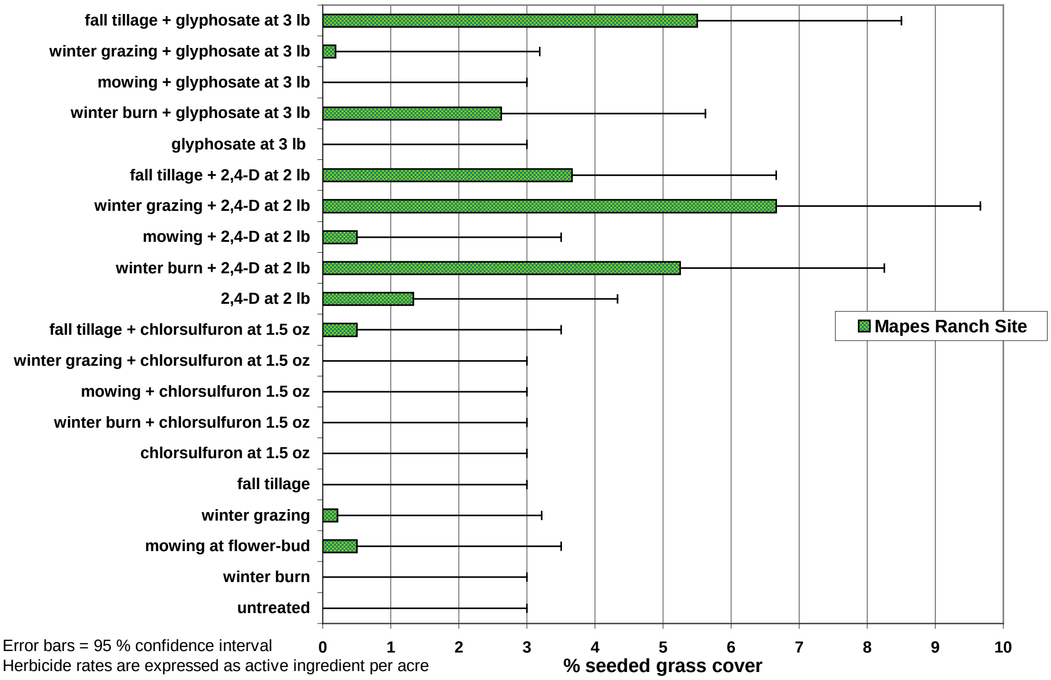
Error bars= 95% confidence interval
Rates are expressed as active ingredient per acre

Figure 3. The Effect of Control Methods on Perennial Pepperweed Cover June 2004 (1 Year after Herbicide Treatment)



Error bars= 95% confidence interval
Herbicide rates are expressed as active ingredient per acre

Figure 4. The Influence Integrating Non-chemical and Chemical Controls on Perennial Grass Establishment (6 months after treatment)



Error bars = 95 % confidence interval
Herbicide rates are expressed as active ingredient per acre

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NASA IMAGERY PROJECT PROVES PRESCRIPTION WEED CONTROL AND PREDICTS THE FUTURE

Presented by Frank Aulgur
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The invasion of perennial pepper weed (tall whitetop) along the Truckee River and Pyramid Lake area of Nevada, north of Reno, is a prime example of how non-indigenous invasive plant species pose a major threat to ecosystems.

However, on a positive note, comprehensive land management activities in the area prove that invasive noxious weeds can be economically controlled with thorough planning and a prescription of mechanical, biological, and chemical measures.

"Tall whitetop simply forces out all other native plants. This land was so engulfed in noxious weeds that people thought it could never be restored to agricultural uses," says Bill Inman, S Bar S Ranch manager.

Inman initiated prescriptive weed control programs on the S Bar S Ranch near Wadsworth, Nevada. The ranch operation was overseen by the College of Agricultural, Biotechnology, and Natural Resources of the University of Nevada, Reno. The university operated the ranch under a trust fund until the end of 2003.

"We set out to change opinions with actual results instead of conducting weed symposiums," Inman says. "We proved what would work by writing prescriptions for land management from our experience, what we saw, what we knew about livestock grazing and what herbicide attributes were necessary. We herded cattle, sheep and goats, set controlled fires, drove mowers and strapped on backpack sprayers to show real results."

The herbicide portions of the prescriptions were developed with the support of DuPont vegetation management representative, Frank Aulgur. DuPont™ Escort® XP and Telar® DF herbicides had the best fit for tall whitetop control and were provided by DuPont as research demonstration material.

The results that Inman and ranch employees achieved along a section of the Truckee River were dramatic. That area became an oasis where tall whitetop was controlled in the midst of a desert of tall whitetop that had invaded the S Bar S Ranch plus adjacent ranches and Paiute tribal property.

"We had no choice but to wage war against the noxious weeds because invasion of these non-indigenous plants had diminished our productive pastures and fields from 287 acres to 47 acres," Inman said.

By the end of 2003, Inman had expanded his noxious weed control demonstration beyond the S Bar S Ranch onto the neighboring Copeland Ranch. A total of 620 acres were in different phases of restoration to agricultural use, and the noxious weed area had been reduced to 30 percent of the total acres.

This effective tall whitetop control caught the attention of more than the local ranchers and Paiute tribal leaders. The tall whitetop control was even obvious from outer space.

National Aeronautics and Space Administration (NASA) satellite imagery recorded the difference as part of research into remote sensing for mapping invasive weed species.

The project was done as part of DEVELOP, which is a collaboration between NASA, other federal agencies, state and local governments, academia and industries. College and high school students in the DEVELOP program conduct earth science application projects that benefit communities. Authors of the DEVELOP research report for the Truckee River and Pyramid Lake project are Douglas R. Gibbons, Utah State University, Jeremiah V. Knoche, Oregon State University, and NASA project coordinator Cindy Schmidt.

The project synopsis noted that, "The DEVELOP students at NASA, Ames Research Center, developed a methodology for the utilization of NASA's Earth Science Enterprise satellite imagery to measure the extent of tall whitetop (Lepidium latifolium) invasion within the Pyramid Lake Paiute Indian Reservation and created a predictive model of future tall whitetop spread."

In general, the model compares Inman's results against allowing the tall whitetop to go untreated and progressively spread to engulf more and more acres.

The synopsis further states, "As expected, the untreated scenario resulted in continued drastic spread of the weed over a five-year period. Alternatively, the treated scenario demonstrated that the weed could be virtually eliminated over a fairly short period of time, but only if done on a comprehensive basis."

The full report explains, "The evaluation of S-S [S Bar S] management practices offers useful insight. The S-S ranch management outlined an 18-month course of action, which has virtually extirpated monocultures of tall whitetop, returning them to irrigated crop and pasturelands."

Tall whitetop is an aggressive competitor with native grass species. The plant grows a taproot that can reach water 15 feet below the surface. It destabilizes riverbanks and increases salinization of infested soils.

The explosive spread of tall whitetop along the lower Truckee River began in 1997 when the area was subjected to a flood. Tall whitetop seed and rootstock came from the upper river channel and settled flooded land along the river. Not only has it had devastating effects on agriculture, wildlife habitat, fisheries, scenic views and recreation, but also Indian culture and traditions.

Inman and his crew had to take control of the situation when the productive S Bar S Ranch land was so drastically reduced.

Inman outlines the basic methodology for tall whitetop weed control as follows:

1) Remove the dead weed matter by one or more options:
    - Hay cattle in the winter so that cattle hooves break up the thatch on the soil surface or any standing weed dry matter.
    - Mechanical mowing.
    - Controlled burning.
2) Grazing of new growth by sheep or goats.
3) Apply 2,4-D and Escort® XP at a rate of 1 2/3 ounces per acre in combination with spring and summer grazing.
4) Continue grazing or manually remove the biomass, especially in those areas close to water where only 2,4-D herbicide applications are made.
5) Fall apply 2,4-D, Escort® XP and Telar® DF when the plants are drawing reserves to their roots.
6) Plant competitive, desirable plant species.

Inman said it is necessary to take down the tall whitetop to uncover hidden obstacles. The plant grows four to eight feet tall and easily hides such things as abandoned cars, farm equipment, and washouts. It is not safe to implement mowing in some areas until all objects and obstacles are located.

"If a half-hearted or minimal effort is put into tall whitetop control, you can actually cause release of it to spiral into a much larger problem by encouraging its spread," Inman said.

Burning alone without complementary control methods is an example because the tall whitetop grows more vigorously after burning than before, which means grazing sheep and goats become even more important. The number of sheep and goats has to be sufficient to properly graze the designated area.

In addition, disturbing soil, such as by disking, where tall whitetop is growing can cause the rhizomatous root system to sprout new tall whitetop plants.

Inman didn't stop at controlling tall whitetop. His efforts to remove noxious weeds also included management of purple loosestrife, salt cedar, and Russian knapweed.

Per state law, it is the responsibility of landowners to control noxious weeds, but much of the western areas are Federal lands where noxious weeds are spreading rampantly. Also, funding for enforcement is not available.

"The paranoia of herbicides has limited some noxious weed control programs. People are very concerned when we mention herbicide control, and that is why we started with demonstrations," Inman explains.

Several tours and site presentations have been made at the S Bar S Ranch to all levels of local, regional, and Federal officials.

Inman sees limited herbicide use in a prescriptive approach, along with biological and mechanical control, as being the necessary, proven answer.

"Unfortunately, the Native Americans do not have the economic resources to combat tall whitetop, and there also has not been a model to follow in accomplishing long-term tall whitetop control," Inman said.

He sees hope in the near future as Cooperative Weed Management Areas (CWMA) are being formed through state, federal and county cooperation to pool funding for larger impact weed control programs. Forming such a CWMA for the area along the Truckee River and Pyramid Lake is extremely important.

As the NASA final report synopsis says, "Economic impacts are potentially severe for the Pyramid Lake Paiute tribe and other irrigators utilizing the Truckee River as a primary water source. Any degradation of the river channel and water resources has far reaching implications for the tribe."

Between the satellite imagery mapping and the demonstrated success of Inman's project, there can be a path forward. The synopsis concludes by saying, "The treated scenario demonstrated that the weed could be virtually eliminated over a fairly short period of time, but only if done on a comprehensive basis. These short-term predictions along with accurate maps of real distribution are very useful in determining the effectiveness of particular management methods, and for helping to coordinate local and regional interest groups policy and management strategies."

Inman's experience and philosophy have led him to establish his own vegetation management consulting and project management company, Preferred Natural Resources. He stresses the management strategies proven at the S Bar S Ranch in addressing noxious weed problems.

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# # #

Always read and follow all label directions and precautions.

BEYOND YELLOW STARTHISTLE: MAKING SURE IT DOESN'T COME BACK

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During the last decade, increased attention to yellow starthistle has resulted in development of a number of effective control strategies such as prescribed burning, treatment with clopyralid, and integrated techniques (DiTomaso *et al.* 1999a, 1999b; DiTomaso *et al.* 2002). Control techniques have been put into use by land managers, agencies, weed management areas, and transportation districts, often resulting in near eradication of local yellow starthistle populations. Two years of preventing new seed production may be enough to reduce the yellow starthistle seedbank by more than 99% (Benefield *et al.* 2002). Large-scale studies have shown that a prescribed burn during early summer of the first year followed by application of clopyralid during winter of the second year is an effective two-year treatment (DiTomaso *et al.* 2002).

However, if even a fraction of a percent of the original seedbank remains – or if another seed source exists nearby – yellow starthistle can rapidly reinfest a site. At Sugarloaf Ridge State Park in Sonoma County, we used prescribed burns to prevent seed production for 3 consecutive years (DiTomaso *et al.* 1999a), then monitored the site for four years following the final burn (Kyser and DiTomaso 2002). The burn treatments reduced the yellow starthistle seedbank to 0.5% of the untreated control (approximately 50 seeds/m2 as compared to 10,000 to 13,000 seeds/m2 in controls) and resulted in a 3- to 4-fold increase in cover of native broadleaf plants and a 50% increase in species diversity. However, following the final burn, the surviving yellow starthistle seedbank launched a reinvasion of the site which brought the seedbank back to 80% of pre-burn levels four years later. Native forb cover and species diversity dropped correspondingly. "Nearly complete" control was not sufficient to restore the Sugarloaf grassland in the long term.

Consequently, follow-up monitoring and control are critical in restoration after yellow starthistle management. After two years of preventing new seed production, the number of new plants emerging each year may be manageable by hand or with spot treatments. For example, at Fort Hunter Liggett in Monterey County, we conducted a large-scale yellow starthistle control project using burning followed by clopyralid (Miller 2003). During the summer after the clopyralid treatment we were able to hand-pull all escapes in about 30 person-minutes per acre, preventing any new seed recruitment. It should be noted that during the following winter a new dirt road was graded across this field, disturbing the soil and apparently releasing some buried yellow starthistle seed. This resulted in a new population along the road. Thus, it may be advisable to avoid disturbing the soil during the follow-up period.

A dense, long-term starthistle infestation can reduce diversity of other plant species (DiTomaso *et al.* 1999a). Under-represented components of the grassland system should be reintroduced to enhance grassland utility and biodiversity, resistance to reinfestation, and – possibly – ecosystem stability. Revegetation may include vigorous forage species such as wheatgrass and clovers, or predominantly native species, depending on management goals. In dryland range in California, establishing plants from seed can be problematic: at sites in Fresno and Yolo counties seeded with a mix of perennial native species in fall 2002, seeds germinated at planting then failed during a 5-week dry period from November to December. Using a rangeland drill and planting during winter can improve chances of seedling survival.

In a trial at UC Davis we established populations of different kinds of native grassland plants to evaluate which species, or combination of species, might be best at resisting infestation by yellow starthistle. We established plots of *Elymus glaucus*, *Grindelia camporum*, *Elymus* + *Grindelia*, and mixed native annuals for one year before seeding with starthistle. We monitored soil moisture down to 180 cm using neutron probe tubes in each plot. We expected that *Grindelia* would occupy a similar niche to yellow starthistle, compete strongly for below-ground resources, and perhaps exclude starthistle. Indeed, *Grindelia* and yellow starthistle showed similar soil moisture use patterns, using more water and from deeper levels than

Elymus alone. However, *Elymus* was much more effective at preventing starthistle establishment. In the summers two and three years after overseeding with yellow starthistle, *Elymus* plots had 4% and 2% yellow starthistle cover, respectively, while *Grindelia* plots had 19% and 8% cover. *Elymus* plots were resistant to invasion probably because *Elymus* allows so little light to reach the soil surface, especially in early spring. We have shown previously that reduced light availability early in the season has a dramatic effect on yellow starthistle root and rosette growth (DiTomaso *et al.* 2003). In contrast to the perennial species, populations of native annuals were quickly invaded.

Establishment of perennial grasses as the first stage in revegetation may give the additional advantage that if soil disturbance by drill-seeding results in release of buried yellow starthistle seed, the restorationist can use clopyralid or other selective broadleaf herbicides to control starthistle.

Recovery from a yellow starthistle infestation has three major components. First, seed production must be prevented on a broad scale for at least two years. Ideally, the final year treatment should not be a burn or other disturbance. Second, the site should be monitored for a few succeeding years and escaped yellow starthistle plants should be removed before seed production. Finally, the site should be revegetated to help withstand reinfestation. Perennial grasses appear to provide effective suppression of yellow starthistle seedlings, and they also allow use of selective herbicides for yellow starthistle control. Drill-seeding in winter gives the best chance for establishing seedlings on dryland range in California.

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MEDUSAHEAD CONTROL

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Medusahead (*Taeniatherum caput-medusae*) is native to the Mediterranean region of Europe and is well adapted to the semi-arid climate predominant in the western United States. It germinates in fall, which is followed by rapid root development during the winter (Sheley et al. 1993) and seed maturation in late spring to summer.

Medusahead was first introduced to Oregon as a seed contaminant around 1887 (George 1992, Young 1992). It rapidly spread north into Washington and throughout the Great Basin, into Utah and Idaho. As recently as 1950, medusahead was reported from only six counties in northwestern California. In the early 1990s, the species occurred in more than 20 counties, and was reported as far south as Riverside County (Young 1992). It continues to expand its range in California and we estimate that medusahead occupies more than a million acres of annual-dominated grassland, oak woodland, and chaparral communities in the state.

Medusahead is an aggressive non-native annual grass causing severe undesirable effects throughout western rangelands. It is an invasive species that has the ability to change the condition and nature of grassland ecosystems over a substantial area. It not only increases the fire frequency within an area, but can also lead to substantial litter accumulation that can suppress the establishment of native or other more desirable species.

Medusahead consists of very high silica content (>10% dry wt) (Bovey et al. 1961), which can reduce forage by as much as 75 to 80% in infested rangelands (George 1992, Hironaka 1961, Major et al. 1960). High silica content in plant tissues can also reduce the rate of tissue decomposition (Hironaka 1994) and can lead to 2 to 5 inches of litter build-up that may remain intact for two or more years (George 1992). The thatch layer does not impact medusahead germination and establishment, but excludes other species (Evans and Young 1970), leading to monotypic stands. Furthermore, accumulated medusahead litter increases the frequency of wildfires, thus eliminating the native shrub component from infested communities (Peters and Bunting 1994). Young (1992) hypothesized that medusahead litter build-up was the greatest threat to biodiversity of natural vegetation in the Great Basin.

Management Strategies

Although there are several well-documented management strategies for selective management of yellow starthistle, few options exist for selectively removing undesirable annual grasses from grasslands. Methods of controlling medusahead have been explored and implemented since the 1950s, but with limited success or inconsistent results.

In many cases, control programs are often based on the differential phenology of medusahead and desirable forages. In a Mediterranean climate, most range plants fully mature and disperse their seed by early to mid-June. In contrast, medusahead matures about 2 or more weeks later than most range species (George 1992), creating a time period when control methods, such as prescribed burning, can be selectively implemented.

Mechanical

Previous reports indicated that the competitive ability of medusahead in annual grasslands was primarily due to the slow breakdown of its thatch (high in silica) and that the thatch was the main component responsible for suppressing other competing species. Removing the thatch by either tillage or mowing in the fall can reduce the competitiveness of medusahead and provide better than 50% reduction in medusahead the following year. In addition, thatch removal can dramatically improved the efficacy of imazapic (not yet registered in California), regardless of whether the removal technique is through burning, tillage, or mowing.

Grazing

In a study designed to determine the effects of grazing on beef production, George et al. (1989) found that two years of intensive grazing significantly reduced medusahead from 45% of the total species composition to only 10%.

While the palatability of medusahead to livestock is low, earlier studies have shown that sheep will graze medusahead in all vegetative stages (Lusk et al. 1961). As plants matured, sheep preference declined as they selectively avoided medusahead. However, at high stocking rates sheep uniformly grazed medusahead-infested grasslands in all vegetative stages (Lusk et al. 1961). In an ongoing study in Yolo County, we intensively grazed medusahead with sheep in early-spring (March) and/or mid-spring (April-May) and monitored the cover of the annual grass in summer. Preliminary results indicate that mid-spring grazing reduced medusahead by greater than 80% with or without an early spring-grazing, but early spring grazing alone was ineffective.

Prescribed Burning

Medusahead and other long-awned invasive grasses (e.g., downy brome, ripgut brome, red brome, barb goatgrass) rely on animal dispersal for seed dissemination. Consequently, the seeds remain attached in the inflorescence longer than most desirable perennial and annual grasses. Medusahead matures a couple of weeks to more than a month later that most annual species, including grasses (Dahl and Tisdale 1975, Young et al. 1970). This directly exposes seeds to intense heat of fire flame when the senesced vegetation of other species or medusahead litter provides adequate fire fuel.

Effective control of medusahead with prescribed burning (>90%) was demonstrated as far back as 1953 (Furbush 1953). In contrast, Young et al. (1972) found that repeated annual burning in mid-summer increased medusahead infestations while decreasing the population of more desirable annual grasses. These inconsistent results suggest that burn timing may be critical to the success of this strategy. Murphy and Lusk (1961) and McKell et al. (1962) showed that the best timing for burning medusahead was in late May to early June before seed dispersal and before the seed moisture is below 30%.

In a more recent study in Yolo and Fresno counties, we have shown that prescribed burning conducted in late spring or early summer, before seed drop, is a very effective treatment, providing 99% and 87% control of medusahead after a single burn and over 99% control after two consecutive burns (DiTomaso et al., unpublished). This level of control in only two years suggests that seed longevity of medusahead in the soil is relatively short.

Despite the potential success of burning, it is not widely accepted because of air quality and liability issues that are exacerbated by construction of residential structures in rural areas.

Chemical Control

Currently registered herbicides are not a practical option in most cases since the extensive application of herbicides is difficult in rough terrain and selective herbicides are not yet registered in California for control of specific annual grasses.

Of the currently registered compounds, glyphosate can be an effective control method when applied in early spring to young medusahead plants. However, it is non-selective and can damage desirable broadleaf or grass vegetation, including native perennial grasses. Although not yet registered in California, imazapic has proven to be very effective on medusahead and other annual grasses. Imazapic is an imidazolinone herbicide registered for use in other states for the management of noxious annual grasses in rangelands, grasslands, and wildlands. We have shown that this new herbicide controls most invasive annual grasses in California without significantly injuring seedlings of many native perennial grass or broadleaf species. However, our data also indicates that imazapic ties up in the thatch layer, thus reducing its availability to germinating and developing medusahead seedlings (DiTomaso et al., unpublished). For example, in Yolo County we found that imazapic provided nearly complete control of medusahead in plots cleared of all thatch, but no significant control compared to untreated plots when the thatch was still present. Thus, it will be difficult for land managers to accurately determine the proper rate to apply if they have some level of thatch within their application site.

Imazapic does not injure most members of the Fabaceae (pea family) and Asteraceae (sunflower family). In some of our plots, this led to the selection of Asteraceae species including members of the genus *Hemizonia* (tarweeds), *Hypochaeris* spp. (catsears), and *Lactuca serriola* (prickly lettuce). Such species may not be desirable in a rangeland, where the goal is to improve the forage quality and quantity.

Integrated Approaches

Although the timely use of consecutive prescribed burns can be a very effective tool for medusahead control, this option is not always available to land managers. Other strategies for the selective control of medusahead are limited. In two sites in California (Yolo and Fresno County), we evaluated the effectiveness of a two-year integrated program using prescribed burning and the herbicide imazapic, either alone or in combination. At each site, we tested the response of five different treatments included two consecutive years of prescribed burning (May or June), two consecutive years of imazapic, a first year burning followed by a second year imazapic treatment, or a first year imazapic treatment followed by a second year burning.

In Fresno County, the medusahead cover in the untreated site averaged 45%, and in the Yolo County site it averaged 71%. As previously described, a single year of burning gave 98% control in Fresno County and 86% in Yolo County, and after a second year burn the control was better than 96% at both sites. By comparison, the combination of a late spring burn (which removed the thatch) followed by a fall imazapic treatment nearly always gave 100% control of medusahead the following year. Thus, it is possible to achieve complete control of this annual grass in a single season using the combination of prescribed burning and imazapic.

Conclusion

Preliminary results (DiTomaso et al., unpublished) indicate that the best approach for medusahead management is the use of prescribed burning. However, when thatch layers can be reduced by late season grazing, disking, mowing or burning, a fall application of imazapic can further reduce the medusahead population. In addition, an integrated approach combining late spring prescribed burning followed by fall imazapic treatment can provide excellent control of medusahead and may even provide complete control.

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RECENT DEVELOPMENTS IN THE MANAGEMENT OF PROBLEM FOREST WEEDS

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Competing vegetation has the most critical influence on plantation establishment and growth. Inevitably, some species are harder to control than others, and for decades have posed a challenge to foresters. Advances in product development and application technologies have increased both efficacy and efficiencies in chemical vegetation management. However, for years certain species have continued to be problematic, especially in established plantations where due to phytotoxicity issues, chemical choices are more limited.

Golden chinquapin, snowbrush and tanoak have predominately been the most problematic species of concern. Triclopyr and 2,4-D have provided short-term control, but due to re-sprouting one to two years after treatment, multiple treatments are usually necessary. With the registration of imazapyr in California, finally a treatment option was available to control these species without any re-sprouting problems. However, ponderosa pine, Douglas fir, and white fir have a very low tolerance to imazapyr and applications were limited to site preparation treatments. Often after logging, the vegetation is too disturbed to use chemical treatments prior to planting. The result is that vegetation treatments revert back to release mode and exclude imazapyr from the equation. Simply, a more effective way of treating the vegetation was required.

The answer to effectively controlling these problematic weeds was found in chemically treating the vegetation one to two years prior to logging. Pre-harvest chemical applications have proven to be the most effective and efficient method in providing cost effective long-term control of problematic species. The applications are primarily applied by ground, but there is potential for aerial applications.

There are many benefits to treating the vegetation in this fashion. The vegetation is in an undisturbed state, with full crowns and undamaged root systems. Efficacy and chemical efficiencies are both maximized. The vegetation is also in a semi-stressed state due to shading of overstory conifers. Although there is no quantitive proof, it appears that vegetation in an understory setting is easier to control than open grown brush.

A second advantage is that conifer tolerance is not a large issue due to the length of time between treatment and planting. This allows for all chemicals registered for forestry use to be considered. Imazapyr products can now be used to effectively achieve long-term control of difficult species. Overall, the forester can target the competing vegetation with the most effective chemical prescription without the worry of conifer injury.

Third, labor costs are extremely cheap compared to release applications. The hand crews do not have to worry about spraying seedlings accidentally and can apply the product in a broadcast fashion. Several methods of application can be employed. Waving wand, floodjet and conventional broadcast applications can be utilized in stands where there is a minimal risk of interception by non-target understory conifers. When understories are crowded with small sub-merchantable conifers or have many pockets of larger brush which may cause shadowing on other target brush, directed applications or a combination of directed and broadcast applications can be utilized. With imazapyr, low volume (3 to 5 gallons per acre) treatments can be used, reducing costs even further.

The most important benefit from pre-harvest treatments is the reduction in follow-up treatments needed. By being able to utilize chemicals that completely control tough to kill vegetation and eliminate sprouting, release treatments in the long-term are dramatically reduced.

Pre-harvest treatments are also not limited to brush species. Mature hardwoods can also be effectively controlled with hack and squirt applications, usually with imazapyr. Labor costs are usually cheaper with hack and squirt applications compared to treating re-sprouts in a release application. Usually one year after treatment is required before cutting treated hardwoods to insure no re-sprouting occurs.

An indirect advantage of using imazapyr as a pre-harvest treatment is that there is usually (depending on soil type and rainfall) a fair amount of soil residual activity. The lingering effect produces varying levels of grass and forb control as well as inhibiting seed germination of competing brush species. Hence, this allows for reductions in the rates of post-logging residual herbicides such as hexazinone, atrazine or sulfometuron.

Another indirect effect applies to units where fall planting is planned. Controlling the vegetation prior to logging allows for a completely clean and vegetation free site once the logging is completed. Where fall planting is planned, logging can be scheduled early in the season to allow treated units to sit fallow through the summer, thereby maximizing the amount of available soil moisture. Significant differences have been noticed between units that were pre-treated and units that were not as far as the amount of soil moisture retained at the end of the growing season.

There is also potential for aerial applications in a pre-harvest setting. To date, aerial applications have been fairly limited to under-stocked stands that are fairly open and have large heavy brush which is too difficult to walk through. Shadowing effects from standing conifers can be minimized by cross-flying the stand in two directions. Operational efforts to date have been extremely successful. Logging must be completely within several months of application however, to reduce the potential for blue stain in ponderosa pine.

Imazapyr alone and imazapyr/glyphosate tank mixes are the most versatile and effective treatment for most vegetation complexes in the sierra cascade region. In all cases with imazapyr, esterified seed oils are required to increase efficacy of applications. The esterified seed oils have proven to be the most effective adjuvant when compared to non-ionic or silicone based surfactants when treating evergreen brush with imazapyr (Ditomaso et. al, 2004). Formulation of imazapyr used is critical to efficacy depending on the species treated. Evergreen brush should be treated with Chopper which is both oil and water soluble. Arsenal, the water soluble formulation of imazapyr is mainly used for hack and squirt treatments. Either formulation may be used for deciduous brush. Pre-harvest treatments are also not limited to imazapyr or glyphosate. Other products may be more desirable depending on target vegetation present. The primary goal is to use the most effective product for the species present.

The use of pre-harvest site preparation does have its complicating factors. Logistical planning with the logging side is critical. Treatments must be planned to coincide with logging schedules. Another complication is road access. Road construction and re-construction associated with harvest plans must be done earlier in the process to allow access to the hand crews. Any special treatment areas such as stream protection zones, habitat retention areas and archeological sites have to be flagged out ahead of time if understory vegetation is to be retained. Fuel loading is also a concern. The stands will be logged with a completely dead understory of dry brush. Fire starts due to logging activity may be of concern.

In conclusion, pre-harvest site preparation has solved some difficult vegetation management problems. While controlling hard to kill species, pre-harvest treatments have also decreased application costs, reduced the overall chemical use, increased available soil moisture and solved several conifer tolerance issues. The most important factors to consider when planning pre-harvest applications are logging schedules, road access, chemical prescriptions, application method, unit and special treatment flagging and obtaining a high quality crew with an experienced foreman. Pre-harvest applications are a recent and vital tool in growing healthy forests.

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BIOLOGY OF NONVASCULAR AND LOWER (SEEDLESS) VASCULAR PLANTS

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With the exception of algae, including seaweeds, all of the organisms that are considered weeds are in the plant kingdom (Kingdom Plantae). Organisms in the plant kingdom can be divided into four categories, each of which includes several Divisions (Phyla):

1. Nonvascular plants (3 divisions)
2. Seedless vascular plants (4 divisions)
3. Gymnosperms (plants with “naked seeds”, 4 divisions)
4. Angiosperms (flowering plants, 1 division)

These four categories are thought to have evolved in the numerical order presented, with nonvascular plants being the most ancient and flowering plants being the most recent to evolve. Within each of the four groups, each division contains anywhere from one to several hundred plant families and each family contains a few to several tens of thousands of plant species. Most weeds are angiosperms, occurring in the single division Anthophyta. However, a few plants in the nonvascular and seedless vascular plant categories can be weedy, as well.

One of the distinguishing features of members of the plant kingdom is a life cycle that includes alternation of generations. That is, during the life cycle of each individual, there is a diploid (2N) stage (sporophyte) and a haploid (N) stage (gametophyte). Over the course of evolutionary time, the diploid stage has come to dominate the plant life cycle so that in angiosperms, the recognizable plant is the diploid stage while the inner organs of flowers comprise the very reduced haploid stage. In the most ancient plants, the nonvascular plants, however, the recognizable plant is haploid and the diploid stage is very small and attached to the haploid stage. Regardless of which stage (haploid or diploid) dominates, in all plants the life cycle consists of the following events—the sporophyte produces haploid spores, which grow into the gametophyte; the gametophyte produces gametes (egg and sperm), which fuse to produce a zygote, which grows into the sporophyte. Spores are very different from gametes (which can fuse) and seeds (which contain embryonic plants). Although they are not particularly hardy, spores are dispersed from the plant and can contribute to its spread.

Haploid organisms have only one copy of each gene and do not possess the level of variation or ability to adapt to a diversity of environments that diploid organisms have. Nonvascular plants also, by definition, have no vascular tissue and therefore cannot transport water or carbohydrates throughout the plant body. While some nonvascular plants are distributed worldwide, they are nevertheless very small and limited in the range of environments they can occupy.

Nonvascular Plants

There are three divisions of nonvascular plants—mosses (Division Bryophyta), liverworts (Division Hepatophyta, named for the resemblance of some to small livers), and hornworts (Division Anthocerotophyta, named for the horn-like appearance of their reproductive structures). Nonvascular plants have no vascular tissue and no organs (stems, roots, leaves, or flowers). Although some appear to have leaves, these are not true leaves because they possess no vascular tissue; rather they are just outgrowths of tissue from the main axis of the plant. Nonvascular plants have no roots; instead, they are lightly anchored to the soil with rhizoids (tissue outgrowths from the base of the plant). These plants consist of parenchyma (generalized) cells, meristems (where cell division occurs), and a cuticle on their top surfaces. In the life cycle the gametophyte is the dominant stage while the sporophyte is very small and not free-living. The gametophyte is perennial, photosynthetic, and can reproduce asexually (without sexual recombination) by vegetative tissue fragments.

There are over 9,500 species of mosses and they are found throughout the world. Mosses can be one of three types—peat mosses (*Sphagnum*), granite mosses, and leafy mosses. Peat mosses are found covering vast acreages in the northern hemisphere where they are harvested for fuel and other commercial uses (including planting mixes). Granite mosses are found at high elevations and are less common than the other two types. Leafy mosses are found throughout the world and in some situations, such as in greenhouses and landscapes, they can be weedy. Like mosses, liverworts are also very small plants. There are approximately 6,000 species of liverworts in the world and all are one of two types—liver shaped (thallose) or leafy. Some liverworts, like some mosses, are weedy in greenhouses, where they can be found growing on the surface of the potting medium. Hornworts are extremely rare and rarely encountered.

Seedless Vascular Plants

There are four divisions of seedless vascular plants, also called lower vascular plants to reflect their less complex anatomy and morphology relative to seed plants (gymnosperms and angiosperms, also called higher vascular plants). These divisions include the whisk ferns (Division Psilophyta), club mosses (Division Lycophyta), horsetails (Division Arthrophyta), and ferns (Division Pteridophyta). Seedless vascular plants arose on land approximately 420 to 500 million years ago as the first vascular plants and are thought to be ancestral to seed plants. In addition to vascular tissue (xylem, which transports water, and phloem, which transports carbohydrates), as a group they possess true stems, roots, and leaves (but no flowers or seeds). In the life cycle of seedless vascular plants the sporophyte is the dominant stage while the gametophyte is very small and free living. The sporophyte is perennial, photosynthetic, and can reproduce asexually.

Whisk ferns are the simplest of the seedless vascular plants, possessing only stems, rhizomes, and sporangia (structures in which spores are produced). They have no true roots or leaves; rather they have rhizomes and leaf-like structures that are just tissue outgrowths from stems. This small division consists of one family and two genera, the most well-known of which is *Psilotum*. Species of this genus grow in the gulf coast states and Hawaii. Club mosses are somewhat more advanced than whisk ferns, possessing stems, rhizomes, sporangia in cones, and true roots (but no true leaves). The most well-known of the three genera in this division is *Selaginella*, some species of which can be weedy in greenhouses. In the Division Arthrophyta are the horsetails, which all occur in one family and one genus of 15 species, *Equisetum*. These plants have stems, rhizomes sporangia in cones, roots, and true leaves (although the leaves are quite small in some species). *Equisetum* plants are known for the high levels of silica in their stems, which give them an abrasive feel and resulted in their use by indigenous people for scouring purposes. These plants can be weedy in some situations.

Ferns are the most advanced and most numerous of all the seedless vascular plants. As a group ferns possess all the plant organs except flowers (stems, roots, and leaves), although in many ferns the stem is not elongated and upright. All ferns are herbaceous and perennial. In most ferns the sporangia are located in clusters (sori) on the underside of the leaves in distinctive patterns, such as rows. There are over 10,000 species of ferns in existence today and they grow around the world in many different habitats. Some ferns, such as bracken fern, can be very weedy.

Summary

Nonvascular and seedless vascular plants are botanically and evolutionarily important. Nonvascular plants represent the simplest and the earliest to evolve land plants. Seedless vascular plants, as a group, represent the steps in evolution from the very simplest vascular plants to the most highly advanced seed plants that possess all the true plant organs—stems, roots, leaves, and in angiosperms, flowers. Although a few of the plants in these two categories can be weeds under certain circumstances, most are an integral part of their natural landscape and do not escape, spread, or cause adverse effects on human activities.

CONTROLLING AND MANAGEMENT OF MOSSES AND LIVERWORTS IN NURSERIES

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Liverworts and mosses are primitive plants that lack true roots; water and nutrients are absorbed by the vegetative organs of the plant. They can be propagated and spread vegetatively or sexually by spores. Spores have been found in air and recycled irrigation water and are likely also in potting mix if stored uncovered near a liverwort or moss infestation. It is unlikely that the common disinfecting systems used in recycling nursery irrigation water (chlorination, bromine injection, ozonation) are effective in killing the spores.

Liverwort is a problem in nurseries because they rapidly cover the container surface and compete with the crop for water and nutrients. Additionally, heavy infestations limit the penetration of water and fertilizer into the growing substrate resulting in the failure of irrigation water to reach the plants' roots. This results in water runoff and additional need for irrigation to keep the plants healthy. An indirect effect of a liverwort infestation is that it they create a favorable environment for fungus gnats to breed. Mosses present the similar problems but the competitive effect is not as pronounced.

The nursery is an ideal environment for liverworts and mosses to become established. Because these plants lack roots, they do not have an efficient method of acquiring water and therefore grow best in areas where water is constantly available. Liverworts are nitrophilous (nitrogen loving), growing best when nitrogen is between 75 and 250 ppm. Nitrogen is often a limiting nutrient in nursery production so it is usually applied at high rates. These two conditions are probably the most significant factors in the establishment of liverwort in a nursery. Nitrogen is not as crucial to moss proliferation but water is necessary for spore fertilization. Therefore an integrated program of irrigation and fertility management, supplemented with physical and chemical controls is necessary to reduce and possibly eliminate liverwort and moss.

Cultural control: It is important to prevent the introduction of liverwort into an area. Covering potting mix components will help prevent the infestation of spores during the canning process or in liner production. Sanitize all greenhouse surfaces with a disinfectant registered for greenhouse or nursery use. Containers that have been infested should be thrown away as it is likely that spores are on the plastic. At the very least they should be sterilized with a disinfectant. Media mixes should also be properly stored to prevent contamination.

Once plants are in the production phase, do not overwater the crop. If at all possible, allow the surface of the growing medium to dry between irrigation cycles or use a coarse mulch which will dry quickly. Subbirrigating will allow the plants to take up water but the potting medium surface will be drier.

Continually monitor fertilizer applications and adjust to use only the amount required by the crop. As noted above, excess N is conducive to liverwort growth. Surface applied fertilizers tend to encourage more liverwort growth than if the fertilizer is incorporated. However, surface applications of slow-release iron sulfate or copper sulfate combined with reduced irrigation levels can decrease liverwort infestations.

Chemical control: There few herbicides registered for control of liverwort and fewer specifically for control of mosses. The label must be consulted carefully to determine if the product can be used in greenhouses or nurseries. Many products are contact herbicides and can damage the crop if not washed off the foliage. Heavy irrigation often reduces the effectiveness of herbicides because they are either diluted or washed away. In general preemergent herbicides containing oxadiazon have been shown to be effective in reducing liverwort pressure. Flumioxazin (Broadstar and Sureguard) are registered for controlling liverwort. In trials conducted in Irvine, CA we found that Broadstar was slow to injure liverwort but effective in the long run. It had much faster activity on moss. Terryacyte was also particularly effective in moss control but is not yet registered in California. Other products which can be effective in some situations include those containing cinnamic aldehyde (Cinnamite). No-Moss is a contact herbicide derived from garlic and clove oil which has shown good control of liverwort of moss. Again, avoid contact the crop foliage to reduce the possibility of phytotoxicity. Hydrogen dioxide (Zero-tol), a disinfectant, can be applied to the potting medium surface twice weekly to control spore germination.

Another product under testing for possible U.S. registration by Crompton-Uniroyal is quinoclamine. In recent studies this material provided excellent liverwort control.

The table below shows the results of a test conducted to examine different cultural and chemical controls for preemergent liverwort management.

Preemergent liverwort control using various cultural and chemical controls 4 and 7 weeks after treatment (WAT).

Treatment	**% cover 4 WAT**		**%cover7 WAT**		**Rate**	
Untreated	10	bc1	28.5	cd		
Broadstar (flumioxazin)	0	a	0	a	2 oz ai/A	
Broadstar	0	a	0	a	1 oz ai/A	
GC Mite (garlic and cinnamon oil)	0.3	a	4	a	6T/gal	
GC Mite	0	a	2.8	a	12 T/gal	
Ironite	2.8	a	6.3	a	50 lb/1000 ft2	
Ironite	10.8	cd	22.5	bc	25 lb/1000 ft2	
Coir mulch_fine	0	a	0	a		
Coir mulch_med	0	a	0	a		
Coir mulch_coarse	1.8	a	3.3	a		
Ronstar 2G (oxadiazon)	3.5	a	2.3	a	100lb/A	(2 lb ai/A)
Ronstar 2G	3.8	a	2.5	a	200lb/A	(4 lb ai/A)

1Means followed by the same letter are not significantly different at the P=0.05 level using SNK means comparison.

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CONTROL OF SILVERY THREAD MOSS *(BRYUM ARGENTIUM)* IN PUTTING GREENS

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Introduction

In the pursuit of faster putting greens and higher levels of surface quality, golf course superintendents often lower mowing heights and reduce fertilizer inputs. Over extended periods of time such cultural practices may lead to an overall reduction in vigor and plant density of bentgrass and *Poa annua* putting greens. Under these conditions moss can easily invade putting green surfaces. Isolated moss colonies can rapidly spread into more serious infestations that can be more difficult to control.

Silvery thread moss *(Bryum argentium)* is a significant problem on golf course putting greens in California and on many golf courses throughout the country. This very competitive moss species creates a fine textured mat on putting green surfaces and under favorable conditions can develop into a thick, dense layer that creates a barrier against air and water movement, ultimately out competing desirable grasses.

Silvery thread moss is adapted to a wide range of environments and can be found growing just about anywhere, from the mortar between patio bricks to the shingles on your roof. Silvery thread moss can grow on either USGA sand profile greens or push-up soil greens and has been observed growing in many different grasses including *Poa annua* and Penncross, Pennlinks, A4 and G2 creeping bentgrass. It is also well adapted to both shade and full sunlight conditions. Silvery thread moss has also been shown to survive long periods of desiccation, in some cases up to two years, and can withstand high temperatures in a dormant state. Research information provided by Dr. Larry Stowell, PACE Consulting, San Diego, California shows that mosses can survive extended periods of dormancy by living symbiotically with blue-green algae. In some ways algae may be viewed as a precursor to moss encroachment.

Mosses exhibit a two-stage life cycle. The green leafy phase most frequently observed on golf courses is called the 'gametophyte'. In this phase a germinating spore gives rise to a green filament called the protonema from which the moss plant with its stems, leaves and rhizoids develops. Upon maturity the production of egg and sperm give rise to a fertilized egg or zygote. With germination the zygote produces a slender stalk with a capsule containing spores. The spores are then released from the capsule and give rise to new moss plants, thus completing the life cycle.

Over the years a significant amount of field research and quality field observations have developed a 'best practices management program' for the suppression or control of silvery thread moss in putting greens. The key concepts within this program are directly primarily toward the enhancement of vigorous turfgrass growth and review of proper agronomic perspectives including drainage, height of cut, fertilizer use, irrigation practices and topdressing programs.

While strong cultural programs are essential to aid in the prevention of moss encroachment, what types of chemical control strategies are available for golf course superintendents who already have significant moss problems? A tremendous amount of university field research has been conducted over the years in the hope of finding a 'silver bullet' for control of moss in putting greens. A wide range of products and program concepts have been reviewed for moss control including the use of iron products such as ferrous sulfate, different fertilizer sources such as ammonium sulfate or urea, soap or fatty acid products, preemergent and postemergent herbicides as well as fungicides. The results of this work have been highly variable. In some cases treatments that performed well in research evaluations did not perform as well under actual golf course management use or the best performing products/treatments for control of moss also exhibited unacceptable injury levels on desirable turf.

Over the last several years field research trials conducted by Professor Thomas Cook at Oregon State have shown high levels of moss control on bentgrass putting greens with multiple applications of JunctionTM (Fore + copper hydroxide: Griffin Corporation). Results of moss control field trials conducted in Southern California by Dr. Larry Stowell, PACE Consulting, have shown acceptable levels of control with the use of Dawn Ultra (2.0 oz/gal) detergent at very high drench volumes (60 gal/M).

TerraCyte (sodium percarbonate: BioSafe Systems, Glastonbury, Connecticut) is a new granular product that has shown potential for moss control in field trials when applied with a drop spreader at rates of 8 to 16 pounds of product/1000 ft2. Field research was conducted on a *Poa annua* putting green at Carmel Valley Ranch Golf Club in Carmel, California by Mark M. Mahady & Associates, Inc. to evaluate the performance of multiple applications of these products for control of silvery thread moss. The key question was: can silvery thread moss be controlled without injuring or reducing the surface quality of annual bluegrass putting greens?

Moss Control Programs on Putting Greens

Three replicated field research trials for moss control on putting greens were conducted at Carmel Valley Ranch Golf Club in Carmel, California from 1999 to 2002. During January of 2002 a new product, TerraCyte (sodium percarbonate: BioSafe Systems), was evaluated in a replicated field trial at Carmel Valley Ranch Golf Club for control of silvery thread moss.

TerraCyte performed well for control of silvery thread moss when applied with a drop spreader at rates of eight to twelve pounds of product per thousand square feet (lb/1000 ft2). Pre and post application irrigation is required for activation of TerraCyte. The three-treatment sequence applied at five-day intervals showed the best level of moss control. Three 8.0 lb./1000 ft2 treatments of TerraCyte applied at five-day intervals showed 66% moss control and three 12.0 lb./1000 ft2 treatments applied at the same interval showed 90% control. Although the 12.0 pound rate showed a higher level of control (90%) with three repeat applications than the 8.0 pound rate (66%), the degree of injury and color loss observed on annual bluegrass at the 12.0 lb./M rate may be too severe for most golf course superintendents. Creeping bentgrass exhibited more tolerance than *Poa annua* to TerraCyte applications.

TerraCyte aids in the suppression and control of moss in annual bluegrass and bentgrass putting greens by dynamically shifting the competitive balance between moss and turf. Unfortunately, TerraCyte is not yet registered in California. Registration is anticipated by spring of 2005. Once registered, TerraCyte will be a very valuable tool to control slivery thread moss in creeping bentgrass putting greens. If TerraCyte is presently not available, what other products and agronomic strategies are available to reduce silvery moss invasion and promote the growth of creeping bentgrass?

Many superintendents have achieved acceptable burn down of moss with soaps such as Dawn Ultra. However, it is illegal to use this product for moss control on putting greens because it is not registered for this use. Soap applications do burn down moss rapidly. Spiking and seeding bentgrass back into these thin areas may speed recovery. Unfortunately, in our experience, soaps do not prevent regrowth of moss or enhance the competitive balance of creeping bentgrass.

Another program option to consider is the use of Daconil (chlorothalonil) Weather Stick. Several researchers throughout the country have reported positive results with multiple treatments of

Daconil applied at 5.3 ounces per 1000 ft2 at seven-day intervals. A minimum of four applications is necessary for effective control. Daconil is effective for algae control with multiple applications and many researchers believe there is a symbiotic relationship between moss and algae. Other researchers have reported that **the key to successful moss control with Daconil is multiple applications during hot summer days (85 degrees+).**

Research from Professor Tom Cook at Oregon State University has shown that multiple applications of copper hydroxide products such as Kocide (copper hydroxide) or Junction (copper hydroxide and mancozeb) reduce infestations following 5 to 7 treatments at two-week intervals. Unfortunately, these products have not performed well in our moss control trials. We are suspicious that the high pH of our well water precipitates much of the copper out of solution, thus reducing efficacy. Professor Cook has also found that multiple applications of Quick Silver (Carfentrazone, FMC**)** selectively injure moss with minor injury potential on creeping bentgrass. Spring use is recommended.

Baking soda (sodium bicarbonate) is not registered for moss control. However, reports show that carefully sprinkling the dry product on moss patches with a small-holed spice dispenser, or mixing 6.0 ounces of product in one gallon of water and spraying with back pack sprayers every 14 days discolors moss (brown) and reduces infestations.

Moss is susceptible to metal ion toxicity. Research has shown that high rates of iron, copper and zinc will discolor moss and reduce infestations. Research conducted by Mark Mahady in 1984 showed that lawn moss could be successfully controlled in the Pacific Northwest by applying 12.0 ounces of ferrous sulfate/1000 ft2 at a spray volume of 4.0 gallons/1000 ft2. During the cool wet winter months from January through March two treatments applied at six-week intervals on home lawns mowed at a cutting height of 2-3 inches provided a very high level of control. Because conditions were cool and wet there was no turf injury and the greening effect on lawns was dynamic within 24 hours.

This concept can be extrapolated to the golf course industry for moss control on greens. Increase spray volumes to a minimum of 4.0 gallons/1000 ft2 in order to reduce the potential for turf injury. TeeJet Turbo FloodJet nozzles (TF-VS10, wide angle flat fan spray tips) set at 40 psi and 20 inch nozzle spacing will deliver 4.5 gallons per 1000 ft2 at a speed of 3 mph. The higher the spray volume the less potential there is for turf injury. If the boom is changed to 10 inch spacing and pressure and speed remain the same the spray volume increases to 6-9 gallons/1000 ft2 depending on the size of the intake hose.

Choose the highest spray volume that can be delivered consistently with a single pass from a standard spray boom system equipped with 10-inch nozzle spacing (6-9 gallons/1000 ft2). Choose two ferrous sulfate rates of 8 and 16 ounces of product/1000 ft2. Conduct a simple evaluation on a <u>practice green</u> at this high spray volume and test these two rates during winter, spring and late summer to evaluate potential turf injury, moss control and surface quality. A 7-day interval is recommended.

Establish a monthly soil and tissue testing program prior to and during the test program. Each test green site should also have an untreated area as a check comparison. Monitor soil and tissue nutrients to ensure that these additional nutrient programs do not detrimentally influence plant growth and surface quality. Always schedule these high spray volume applications when tissue and soil moisture is adequate.

Moss control is in most cases a long-term program. Moss control programs should be a combination of those agronomic practices that encourage vigorous growth of desirable grasses plus a selective suppressant or control product that will place the moss under additional stress.

Today in California there are two program concepts that have shown encouraging potential to control silvery thread moss in Poa annua and creeping bentgrass putting greens. On Poa annua greens three repeat applications of TerraCyte showed by far the best reactive control of silvery thread moss. For bentgrass greens either the TerraCyte program or high rates of ferrous sulfate applied at high spray volumes dynamically reduced moss cover while greatly enhancing bentgrass growth.

The following cultural practices should also be considered to reduce the incidence of moss on putting greens. Check the green surround and green irrigation uniformity. Make sure that the green surround irrigation is not overlapping onto green surfaces. Water deeply. Keep surfaces as dry as possible, while still maintaining adequate moisture for good turf vigor. Hand water hot spots. Increase mowing heights to between 160/1000ths to 170/1000ths of an inch. Maintain sound fertility programs to improve turfgrass vigor. Use hollow tine aeration as frequently as possible to disrupt the surface. Pursue an aggressive light and frequent sand topdressing program. Check sand profile depths in problem greens to determine if variation in sand depth is contributing to moss problems. If wet areas exist around green perimeters use smile drains to enhance water movement away from the green.

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CONTROL AND MANAGEMENT OF HORSETAIL AND FERNS

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Horsetail (*Equisetum arvense*) control is not an easy task. If possible it is best to prevent horsetail from being established. This includes avoiding light tillage in areas where horsetail occurs. If tillage occurs be sure to clean the equipment to assure rhizomes don't get transported to new areas. Also improve drainage in poorly drained areas near ditches, bodies of water and low spots. Mechanical control is difficult. In a study conducted in Quebec Canada, horsetail was removed by hoeing 16 times during one growing season, but this did not have any impact on regrowth.

Horsetail's impact as a weed might be considered marginal as most crops with proper growing conditions and proper drainage can compete with the weed. There are few chemical control options. The lack of efficacy of many herbicides, specifically contact herbicides, is partially due to the fact that horsetail is a perennial with a deep root system complete with rhizomes, and herbicide uptake is minimal because of the lack of leaf area. The siliceous nature of its stem may inhibit the movement of herbicides into the plant. Glyphosate is often used to suppress horsetail, however, regrowth should be expected. Frequently after glyphosate applications horsetail increases since glyphosate often eliminates competing vegetation. Amitrole (Amitrol) is the only postemergence herbicide that will control the plant, however where available, it can only be used in noncrop situations. MCPA and 2,4-D are sometimes used in tolerant crop systems, however, they will only burn the above ground foliage off and have little effect on the root system. Dichlobenil (Casoron) is effective in the Pacific Northwest particularly when applied during midwinter just prior to an anticipated cold rain. Dichlobenil can be used in a number of perennial ornamental species and in many trees and vines. The other two effective herbicides that can only be used on noncropland at the rates required to control horsetail are sulfometuron (Oust) and chlorsulfuron (Telar). Trial results obtained at the Washington State University Mount Vernon Research and Extension Center with both sulfometuron and chlorsulfuron found November applications were more effective in controlling horsetail than those applied in the early summer.

Controlling western brackenfern *(Pteridium aquilinum)* is considerably easier than controlling horsetail. Brackenfern is not a serious weed of most annual row crops. A single mowing is not effective, however, a publication from the University of Minnesota reports frequent mowing throughout the growing season is effective. Frequent tillage is also reported to be effective.

There are several herbicides that will control the plant. In cropland and pastures where the following foliage applied herbicides are labeled: glyphosate, metsulfuron (Ally/Escort/Cimarron) MCPA, and dicamba (Banvel/Clarity) and will control the weed. Picloram (Tordon) will also control brackenfern, but be extremely cautious where it is used. Dichlobenil can be used in certain ornamentals and orchards and vineyards. Asulam (Asulox) has been used successfully in Christmas tree production. Australian information suggests burning the old growth when the plants are dormant and treating the later, new growth when the fronds are fully developed will enhance control. Soil applied dichlobenil will also control the plant and in Michigan, bromacil (Hyvar) applied postemergence has been reported effective.

The best control of either horsetail or brackenfern is to prevent their introduction, and if introduced, to control the plants before they become established. As with most perennial weeds, controlling horsetail and brackenfern before they become established will prevent a lot anguish later on. When the plants are established, control is much more difficult. Once the weeds are established, using an integrated approach of incorporating all the known control methods is more effective then using one method alone to obtain long term control.

WATER QUALITY AND NEW REGULATIONS FOR IRRIGATED AGRICULTURE IN THE CENTRAL COAST OF CALIFORNIA

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On July 9, 2004, the Central Coast Regional Water Quality Control Board adopted new water quality regulations for irrigated lands. The new regulations replace old "blanket" type waivers of Waste Discharge Requirements that were adopted in 1983. The goal of the waiver program is to manage discharges from irrigated lands to ensure that such discharges do not cause or contribute to conditions of pollution or nuisance as defined in Section 13050 of the California Water Code (CWC) and do not cause or contribute to exceedances of any Regional, State, or Federal numeric or narrative water quality standard.

Under the California Water Code, Regional Boards regulate discharges of waste that could affect water quality through issuance of permits called "Waste Discharge Requirements". CWC Section 13269 authorizes Regional Boards to waive Waste Discharge Requirements for a specific discharge or specific type of discharge if the waiver is in the public interest. Section 13269 was amended in 1999, causing all old waivers to expire. All waivers must now be reviewed and renewed or revised at least every five years, must be conditional, and must include monitoring.

The new conditional waiver applies to irrigated crop lands throughout the Central Coast Region. The Central Coast Region encompasses all or part of the counties along the Central Coast from San Mateo to Ventura, and includes all of Santa Cruz, Monterey, San Luis Obispo and Santa Barbara counties, as well as part of Santa Clara and most of San Benito and small portions of San Mateo and Ventura counties.

The conditions of the waiver require all owners and operators of irrigated lands in the Central Coast Region to: 1) enroll with the Regional Board by submitting a Notice of Intent and a checklist of currently implemented and planned management practices, 2) complete fifteen hours of water quality education, 3) develop a farm water quality management plan that addresses, at a minimum, erosion control, irrigation management, nutrient management and pesticide management, 4) implement management practices in accordance with the farm plan, and 5) conduct individual monitoring or participate in a cooperative monitoring program.

The waiver sets forth two categories of waiver. One category (Tier 1) applies to farmers who have already completed the education and farm plan development requirements and have begun to implement management practices for their operations. The other category (Tier 2) applies to those who have not yet completed all the requirements for a Tier 1 waiver. Tier 2 waivers are renewable annually for up to three years, giving farmers time to meet the waiver requirements.

Irrigation Agriculture in the Central Coast

Irrigated agriculture in the Central Coast Region comprises approximately 435,000 acres and more than 100 different crops. There are about 2500 agricultural operations in the region that are required to enroll under this program. Operations range in size from less than ten acres to more than 2000; however, approximately two-thirds of all operations are less than fifty acres. About one-third are less than ten acres. Fewer than 200 operations (less than 8%) exceed 2000 acres. Major crops include vegetable crops (such as lettuce, broccoli, cauliflower, celery, cabbage and spinach), fruits (such as strawberries and wine grapes), cut flowers, and potted plants. Other crops include mushrooms, artichokes, raspberries, asparagus, carrots, onions, snap peas, and many more. Agriculture is concentrated in several major drainages, including the Salinas Valley and upper Salinas watershed, the Pajaro Valley, the lower Santa Maria River, the Santa Ynez Valley and the Santa Barbara coastal area, as well as in numerous small drainages throughout the region.

A number of factors make agriculture in the Central Coast region unique. In general, farming is on a smaller scale than in the Central or Imperial Valleys. The Central Coast climate is unique in California and comprises a "niche" in the agricultural industry that distinguishes Central Coast farm products from other areas. The majority of operations are less than 50 acres. There are no large irrigation districts since most operations use groundwater as their water source. Many properties have been held in families for generations and are leased out rather than sold. The area is considered highly desirable, and growth pressures drive up the price of agricultural rents. There is a mixture of owned and leased lands and many operators own some ranches and lease others. Leases can be either short or long term (one year or more than five years), resulting in varying incentive by lease-holders to implement water quality protection.

Crop prices are primarily controlled by the existing market structure. Consolidation in the food industry has resulted in a smaller group of buyers, giving corporate retailers more bargaining power. In addition, local farmers often compete with products from other countries, where the costs of production may be substantially less. The result is that growers often have little control over the price they are paid even though the costs of producing and delivering products continues to rise. Additionally, issues of food safety are increasingly dictating practices growers must use in order to sell crops, and some recommended food safety practices may run counter to water quality protection practices. Because of these and other factors, the agricultural industry is extremely sensitive to cost increases and management practice requirements.

Existing Water Quality in Agricultural Areas

Information available to the Regional Board, including information used in identifying impaired water bodies within the Region in accordance with Clean Water Act section 303(d), indicates that irrigation return water and storm water runoff from irrigated lands contains waste that has impacted water quality in the waters of the State within the Region.

Over the past five years, the Regional Board's Central Coast Ambient Monitoring Program (CCAMP) has provided information to characterize water quality, support waterbody beneficial use determinations, support waterbody listings for impairment, and to evaluate regional priorities. Under CCAMP, the Region has been divided into five rotational monitoring areas, based on hydrologic units such as the Pajaro River, Salinas River and Santa Maria River. Each rotational area is monitored once every five years. CCAMP performs tributary-based, in-stream monitoring at fixed sites throughout the rotational area on a monthly basis. The same sites are monitored again during the next rotational cycle.

CCAMP data, as well as other data sources, have shown that waterbodies in areas of intensive agriculture often have high levels of nutrients. For example, nitrate in some surface waters is present at levels far in excess of the drinking water standard of 10 mg/L as N (nitrogen). Persistent toxicity has also been documented in some areas of intensive agricultural operations, with its cause being traced to currently applied pesticides. Many surface waterbodies are on the Clean Water Act Section 303(d) list of impaired waters for pollutants associated with agricultural activities, and are scheduled for development of Total Maximum Daily Loads. Of the region's 178 currently listed waterbodies, about 75 designate agriculture as a potential source. In addition, many groundwater basins underlying agricultural areas in the Central Coast Region show elevated nitrate concentrations, in some cases well over the drinking water standard.

Existing Efforts by the Agricultural Industry to Address Water Quality Issues

The Central Coast Region has benefited from the proactive approach taken by several segments of the agricultural industry. Notable examples include the Agricultural Water Quality Program of the Coalition of Central Coast County Farm Bureaus (Farm Bureau Coalition) and efforts to promote sustainable wine growing practices by the Central Coast Vineyard Team and the Central Coast Winegrowers Association. Efforts are also underway to promote sustainable practices by Spanish-speaking farmers through the Rural Development Center and the Agricultural Land-Based Training Association (ALBA) in Monterey County.

The Farm Bureau Coalition has been working to address agricultural water quality impacts in areas that drain to the Monterey Bay National Marine Sanctuary, which represents approximately two-thirds of the region. This is a broadly supported cooperative effort that is implementing the Sanctuary's Plan for Agriculture and Rural Lands. The Sanctuary Plan was developed in cooperation with the California State Farm Bureau Federation and the Coalition of Central Coast County Farm Bureaus, the Regional Board and numerous other partners, including University of California Cooperative Extension, the Natural Resource Conservation Service and local Resource Conservation Districts.

Key components of the Sanctuary Plan implementation strategy include formation of grower working groups, and development and implementation of farm water quality management plans. Technical assistance is provided by Farm Bureau watershed coordinators active in each county, as well as all of the other partners listed above. Farm Bureau watershed coordinators provide the Regional Board with annual reports summarizing practice implementation and self-monitoring results by grower watershed working groups.

A small but significant (and increasing) percentage of growers on the Central Coast are participating in the Farm Bureau Coalition's program. As of late 2004, there were 17 active grower watershed working groups and another 17 in the process of organizing. The Regional Board estimates that active participants represent approximately 10-15% of operations in the region. Participants are often industry leaders who have chosen to be proactive in addressing water quality concerns.

In 1999, the University of California Cooperative Education and the Natural Resources Conservation Service developed and piloted a Farm Water Quality Planning short course in the Central Coast, to provide farmers with the information and resources needed to address water quality issues on their farms. The course provides farmers with information on water quality management practices for irrigation, pesticides, nutrients, and erosion control. Course participants are able to complete a farm water quality management plan by the end of the 15-hour course. In 2001, UC Cooperative Extension and the Farm Bureau Coalition teamed up to offer the short course to members of grower working groups that are implementing the Sanctuary Plan for Agriculture. As of December 2004, more than 600 Central Coast farmers have completed the course. Funding to support farm water quality planning has come from a variety of sources, including a current Clean Water Act Section 319(h) grant from the Regional Board. The Regional Board has been closely involved in the development of the short course. Regional Board staff, along with UC Cooperative Extension, NRCS, local Resource Conservation Districts, California Department of Fish and Game and others, participate in teaching the classes.

Another industry-led effort has been underway for several years to promote sustainable practices by wine grape growers. There are approximately 100,000 acres of grapes in the Central Coast, representing about 16% of the irrigated croplands in the region. Many of the growers have undertaken an evaluation process to assess irrigation, nutrient management, pest management, and erosion control practices through the Positive Point System developed by the Central Coast Vineyard Team (CCVT). CCVT estimates that approximately 75-100 operations have completed the Positive Point System evaluations and are using them to evaluate management practices and identify opportunities for improvement.

Developing New Regulation: Using a Collaborative Approach

In beginning to develop a replacement for the old waivers, Regional Board staff held a number of informal discussions with several agricultural and environmental groups throughout the Region. After hearing comments during several such meetings, staff concluded that the interests of all concerned would be best served by face-to-face meetings among all parties. The Central Coast Region is relatively small, at least compared to the Central Valley Region, California's other major agricultural Region. This feature made it feasible to convene an advisory group of agricultural and environmental representatives from across the Region. Participants included the Ocean Conservancy, the Central Coast Coalition of County Farm Bureaus, Monterey County Farm Bureau, Jefferson Farms, Santa Cruz County Farm Bureau, San Benito County Farm Bureau, the Environmental Center of San Luis Obispo (ECOSLO), the Environmental Defense Center, Monterey Bay National Marine Sanctuary, the Agricultural Land-Based Training Association (ALBA), the Central Coast Winegrowers Association, San Luis Obispo County Farm Bureau and Cattlemen's Association, Santa Barbara County Farm Bureau, Grower Shipper Vegetable Association of Santa Barbara, and Santa Barbara Channel Keeper. Several other organizations that were contacted felt that their interests were adequately represented but expressed a desire to be kept informed.

Panel meetings were conducted as facilitated discussion sessions. The group adopted ground rules and spent time hearing about the interests and concerns of each of the participants. In this way, a foundation of understanding was built that allowed the participants to discuss ideas and propose solutions in a respectful environment. At the second meeting, the panel agreed on a mission statement, which reads, "The goal of the panel is to assist staff in developing recommendations to the Regional Board for a replacement to the expired waivers that will be protective of water quality, the viability of Central Coast agriculture, and comply with state law."

All panel recommendations were developed by consensus. Although the panel did not reach consensus on all aspects of the adopted program, considerable progress was made during the year of panel meetings. The input provided by the panel was very valuable in helping staff develop the waiver program. Perhaps even more importantly, a foundation has been laid for future communication between the agricultural and environmental communities across the Central Coast Region, as well as with the Regional Board.

Among the recommendations of the panel were the education and farm water quality plan development requirements, management practice implementation and reporting through a checklist format, and the tiered structure of the waivers, which offer reduced reporting for those meeting all the requirements. The panel also recommended that monitoring focus on currently applied agricultural constituents, make use of existing monitoring resources wherever possible, and be structured on a regionwide, cooperative basis rather than on individual discharge monitoring, all of which have been incorporated into the monitoring program.

Conclusion

The Regional Board has endeavored to develop a collaborative and cost-effective approach to water quality protection, by focusing on management practice implementation and by developing a regionalized monitoring option that will focus monitoring resources on currently applied agricultural constituents and concentrate monitoring in areas where data already indicates problems associated with agricultural activities. Primary focus during the first waiver cycle will be on performance requirements and use of water quality information to adjust practice implementation. To reduce administrative costs, staff has developed data management options such as direct monitoring data submittals, web-based enrollment and practice reporting, and coordination with pesticide use reporting.

The collaborative process used to develop the waiver has laid a foundation for successful implementation of the waiver program, and ultimately should result in better water quality throughout the agricultural areas of the Central Coast Region. Statewide interest in this process and the success of the program may lead to similar approaches in other parts of the state.

Volatile Organic Compound Emissions from Pesticides

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Background

Volatile organic compounds (VOCs) and nitrogen oxides (NOx) react with sunlight to form ground-level ozone, a major air pollutant. Many active and inert ingredients in pesticide products are VOCs. As required by the federal Clean Air Act, the Air Resources Board (ARB) and Air Pollution Control Districts (APCDs) are the lead agencies for preparing State Implementation Plans (SIPs) to reduce VOCs and NOx. The 1994 SIP requires the Department of Pesticide Regulation (DPR) to reduce VOC emissions from pesticides in five ozone nonattainment areas. Specifically, DPR must reduce the May – October pesticide VOC emissions by the following amounts of the 1990 base year:

South Coast:	20% by 2010
Southeast Desert:	20% by 2007
Ventura:	20% by 2005
Sacramento Metro:	20% by 2005
San Joaquin Valley:	12% by 1999

VOC Emission Inventory

To track and determine compliance, DPR maintains an inventory of VOC emissions from agricultural and commercial structural pesticide products. DPR estimates the VOC emissions for each product based on the VOC fraction (emission potential) of the product multiplied by the amount of product applied (from pesticide use reports). DPR calculates VOC emissions from agricultural and commercial structural applications for all years, beginning with the 1990 base year.

As of 2002, the South Coast and Sacramento Metro nonattainment areas meet their pesticide VOC reductions. As of 2002, the Southeast Desert, Ventura, and San Joaquin Valley nonattainment areas do not meet their pesticide VOC reductions. The San Joaquin Valley is currently out of compliance with the SIP because it does not meet its 1999 target reduction. VOC emissions patterns parallel pesticide use patterns, with areas and time periods of high pesticide use coinciding with high VOC emissions. Fumigants and pesticides formulated as emulsifiable concentrates account for most of the VOC emissions in all nonattainment area. Herbicides that make up a significant fraction of the emission inventory include: methyl isothiocyanate (metam), glyphosate, molinate, acrolein, thiobencarb, EPTC, oxyfluorfen, and trifluralin.

Key Regulatory and Legal Issues

DPR is no longer in compliance with the pesticide SIP for the San Joaquin Valley. Moreover, even if pesticides were in compliance the San Joaquin Valley would need to reduce all VOC emissions by approximately 30% to achieve the federal 1-hour ozone standard. In April of 2004 the U.S. Environmental Protection Agency (U.S. EPA) established a more stringent 8-hour ozone standard. Additional VOC reductions from all sources are needed to meet the new ozone standard by 2010 to 2021, depending on the nonattainment classification. DPR and ARB are also being sued for allegedly failing to meet the requirements of the 1994 SIP.

Current and Future Activities

DPR and ARB are preparing a new SIP to address the 8-hour ozone standard. ARB must submit a statewide SIP to U.S. EPA by June 2007. Research is needed to assist in preparing the new SIP. The following research is needed for the pesticide VOC emission inventory:

Determine emissions of pesticide VOCs under field conditions

Determine the speciation (specific chemical makeup) and reactivity (ability to create ozone) of pesticide VOCs

Research is needed to determine if the following measures reduce pesticide VOC emissions, the magnitude of reductions, and the feasibility:

Integrated Pest Management techniques focused on VOCs

Formulation changes and new pesticides

Application method changes, particularly for fumigants

Application rate reductions

Temporal changes (changing application date outside May – Oct, or night applications)

Research studies to investigate some of these issues will be initiated in 2005.

Due to the 1994 SIP requirements, DPR cannot wait until research is completed to implement regulatory measures. DPR plans to initiate a reevaluation and establish a new registration requirement mandating submittal of emission potential data by registrants. DPR is also considering VOC limits or other reduction measures for certain pesticide products.

UPDATE ON NEW GROUND WATER PROTECTION REGULATIONS

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The California Department of Pesticide Regulation's (DPRs) new ground water protection regulations went into effect on May 27, 2004. The regulations require users to modify the use of seven herbicides that have been found in California ground water due to legal agricultural use -- atrazine, simazine, bromacil, diuron, prometon, bentazon and norflurazon – when they are used in newly defined vulnerable areas called ground water protection areas (GWPAs). The new use modifications and GWPAs are based on an improved understanding of how pesticides move to ground water, how that movement can be minimized, and what constitutes a vulnerable area. For the first time, pesticide users will be required to take actions to prevent ground water contamination before it is reported.

Except in the case of bentazon, the previous ground water regulations only applied in the one-square mile sections of land where the herbicides were detected in ground water. Additional vulnerable areas were identified solely of the basis of additional sampling, which was slow and costly. After a decade of monitoring, enough detections of pesticides were available for DPR to determine whether there was a relationship between detections and soil characteristics, climate and depth to ground water in the contaminated areas. DPR's analysis indicated that most detections occurred in relatively low rainfall areas, in certain soil types, such as coarse and hardpan soils, and at a depth to ground water of 70 feet or less (1, 2, 3, 4). Sections of land with these characteristics were considered vulnerable to movement of certain pesticides to ground water. DPR then developed a procedure to screen all sections of land that hadn't been sampled for pesticides and for which Natural Resource Conservation Service soils data and depth to ground water data were available to determine if they should be identified as vulnerable areas (5). Sections with those characteristics along with sections with actual pesticide detections were then identified as GWPAs.

The previous regulations banned all uses of two herbicides (atrazine, prometon), all noncrop uses of three herbicides (simazine, bromacil, and diuron), and use of norflurazon in recharge areas and inside canal and ditch banks – all within Pesticide Management Zones (PMZs), which were the areas where these herbicides were detected in ground water. These various mitigation measures were based on the best information available at the time and recommendations of a multi-agency committee that formally reviews pesticides found in ground water. However, since these herbicides have similar environmental fate characteristics – they are both mobile and persistent – and are often found in the same wells, DPR believes that they move to ground water by the same mechanisms. One of the problems with banning preemergent herbicides is that users simply switch to alternative preemergent herbicides. Since these alternative chemicals usually have the same mobility and persistence characteristics as the banned materials, they would also be expected to contaminate ground water.

As DPR identified sensitive soil conditions, they also conducted studies to determine how pesticides behave under these conditions. In two studies DPR found that rainfall was insufficient to significantly move simazine residues downward in soil in coarse soils under relatively low rainfall conditions in California (6, 7). In contrast, studies to observe movement of atrazine pre-emergent herbicide residues under various irrigation systems and water application rates showed that over irrigation appears to be the principal mechanism of movement in coarse soils (8). So movement of preemergent herbicides to ground water can be minimized by controlling the amount of irrigation water contacting treated areas in coarse soils.

In hardpan soils, DPR staff took deep soil samples in areas treated with pesticides found in ground water. In contrast to coarse soil areas, DPR found very little pesticide residue, indicating that leaching was probably not the primary pathway to ground water. In a cooperative study involving DPR, pesticide registrants, and the Tulare County Agricultural Commissioner staff, rain runoff entering drainage wells was sampled for preemergent herbicides detected in ground water in hardpan soil conditions. High levels were detected up to 2.5 months following application, indicating that runoff, not leaching, was the principal pathway of movement to ground water in hardpan areas (9).

The new regulations establish leaching GWPAs and runoff GWPAs, and require permits for all agricultural, outdoor industrial and outdoor institutional uses of the seven detected herbicides in GWPAs. In leaching GWPAs, one of the following three management practices must be designated on the permit:
(1) No irrigation for six months following application,
(2) Don't allow irrigation water to contact the area treated for six months following application, or
(3) Irrigate efficiently for six months after application (apply no more than 133% of the net irrigation requirement, as defined).

In runoff GWPAs, one of the following seven management practices must be designated on the permit:
(1) Apply the pesticide as a band treatment immediately adjacent to the crop row so that not more than 33 percent of the distance between rows is treated (for citrus, the band may extend out to the drip line of the tree),
(2) Disturb the soil to be treated that is outside of the 33% band, or outside the dripline in citrus, by using a disc, harrow, rotary tiller, or other mechanical method within seven days before the pesticide is applied (not an option for bentazon),
(3) Incorporate the pesticide on at least 90 percent of the area treated outside of the 33% band, or outside of the dripline in citrus, within 48 hours after the day the pesticide is applied. Incorporation may be by mechanical methods, such as by using a disc, harrow, or rotary tiller, or by sprinkler or low flow irrigation (1/4 – 1 inch of water applied at a rate that does not cause runoff), including chemigation if allowed by the label (not an option for bentazon),
(4) Apply the pesticide between April 1 and July 31,
(5) Retain all irrigation runoff and all precipitation on, and drainage through, the field for six months following the application. If a holding area is used, its percolation rate shall not exceed 0.2 inches per hour,
(6) Channel runoff to a holding area off the application site, under the control of the property operator, that is designed to retain all irrigation runoff and all precipitation on, and drainage through, the treated field and all other areas draining into that holding area, for six months following the application. The percolation rate of the holding area shall not exceed 0.2 inches per hour; or
(7) Manage the runoff so that it runs off onto an adjacent unenclosed fallow field at least 300 feet long that is not irrigated for six months after application, with full consideration of any plant back restrictions, for six months following application.

"Engineered rights of way" are areas within a GWPA that are constructed in a way that results in increased runoff and collection of storm water, such as railroad ballasts and berms, public roadsides, and highway median strips or similar areas, but not canal or ditch banks or utility lines. Use of the detected herbicides is prohibited on engineered rights-of-way in leaching or runoff GWPAs unless one of the following management practices is designated on the permit:
(1) Comply with any of the runoff GWPA management practices
(2) Manage any runoff from the treated right-of-way so that it passes through a noncrop fully vegetated area adjacent, and equal in area, to the treated area,

(3) Comply with any permit issued pursuant to the storm water provisions of the federal Clean Water Act pertaining to the treated area.

In lieu of the management practices specified for runoff and leaching GWPAs, or for engineered rights of way within GWPAs, pesticide users may submit a request to the Director and the Director may approve the following:

(1) An alternative management practice based on scientific data demonstrating its effectiveness in reducing movement of pesticides to ground water; or

(2). Interim use for up to three years, provided the requestor

provides evidence that the available management practices are not feasible for a specific crop or site, and that there are no feasible alternatives for the specific crop or site

submits a protocol that is subsequently approved by the Director for testing an alternative management practice, and

collects the data on a timely basis.

On a statewide basis, the use of these seven herbicides is prohibited below the high water line in artificial recharge basins and inside unlined canal and ditch banks. This prohibition does not apply if water does not contact the treated area for six months after application, or in the case of canals and ditches, the percolation rate is not more than 0.2 inches per hour.

The new regulations also address wellhead protection, which applies to all pesticides mixed, loaded, rinsed, and stored around any type of well, including municipal, domestic, irrigation, drainage, abandoned, and monitoring wells. There are two options:

(1) Wells should be sited so that runoff water from irrigation or rainfall does not move from the perimeter of the wellhead toward the wellhead and contact or collect around any part of the wellhead including the concrete pad or foundation. Alternately, wells should be protected by a berm constructed of any material sufficient to prevent movement of surface runoff water from the perimeter of the wellhead to the wellhead. Application of preemergent pesticides is prohibited between the berm and the wellhead; or

(2) If the well cannot be protected, the following activities are prohibited within 100 feet of a well:

mixing, loading, and storage of pesticides.

rinsing of spray equipment or pesticide containers.

maintenance of spray equipment that could result in spillage of pesticide residues on the soil.

application of preemergent herbicides.

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