The Gadfly

The gadfly buzzes around the animal’s face,
With an irritating sound hoping to be heard.
But the beast just sits, completely content.
To chew its cud with the rest of the herd.

The town’s people pull on the animal’s tether.
There’s work to be done in the fields.
But it is used to the constant tugging,
And their efforts fail to make it yield.

It’s ruminating on its mission statement.
It’s chewing on visions for its strategic plan.
How can it keep its stakeholders promises?
And still get the governor to understand.

Its hide is marked with the bites from other flies,
That made the animal turn his head and look around.
But they were only biting to feed on the animal’s blood.
And it keeps resting on the same piece of ground.

The gadfly lands on the polished data volumes.
It detects decay under the skin.
And it circles and rubs its wings together,
To warn of the “agenda science” that lies within.

Its mandibles cut through the layers of rhetoric.
Its compound eyes see beyond the animal’s view.
It asks the questions that no one wants to answer.
Why not follow the policies like they’re expected to do.

Its legs tickle the soft skin of the beast’s belly.
The fly knows where the vulnerable spots are.
But it won’t selfishly disclose this information.
It knows retaliation will not get it very far.

This fly’s bite can make the animal stand.
Maybe see a better view from its upright position.
Observe the world beyond the pasture fence,
And the town’s people that deserve more recognition.

This could be a symbiotic relationship.
If the advice is not viewed as a reprimand.
Only to support the theory of responsible regulation,
That science and politics can walk hand-in-hand.

The gadfly wants to become a team player.
It wants to gain the animal's respect.
But all flies are associated with filth.
And the fly's motives are always suspect.

The gadfly is at risk from the swishing tail,
That can sweep away promotions and travel per diems.
And memberships on policy committees.
The fly could starve on the leftover crumbs.

The gadflies will come and these flies will go.
They will continue to rise out of all the manure.
Most will bite just to feed on the animal's blood,
But this fly could help the animal endure.

by

David Haskell

CWSS, Weed Science, and the Short-Handled Hoe

Carl E. Bell
President, California Weed Science Society

The theme of the 60th conference of the California Weed Science Society is "Everyone benefits from weed control". I applaud our Vice-President and Program Chair Stephen Colbert for coming up with this theme; in my opinion it is way past time we said this loud and clear. Our general session speakers are presenting the case quite well that there is an economic return on investing in weed control. One of our speakers, Leonard Gianessi, published an excellent paper in the journal Weed Technology in 2007 (volume 21, pages 559-566) that documents much of the information on this subject. I want to make the case, however, for the value of weed science as an important and essential contributor to the theme of the conference and I also want to expand the scope of the theme beyond economics.

At the third California Weed Conference (that used to be our name) in 1951, Paul Sharp, Director of the University of California Agricultural Experiment Station cited 20 years of UC research on weed control. Many of these studies were concerned with the development of selective herbicides; chemicals that could be used to kill weeds in crops without hurting the crop. This may seem routine today, but it was not then when the only truly selective herbicide was 2,4-D. By the 20th conference in 1968, 26 scientists from government, industry, and the universities discussed the use of a large variety of herbicides for weed control in field crops, vegetables, orchards and vineyards, rangeland, along utility corridors, and for noxious weed eradication. At the 30th conference, held here in Monterey and presided over by Floyd Colbert as President (our Program Chair's father), 32 talks were presented by this mix of government, industry and university scientists and weed control practitioners. Every California Weed Conference, from the first one in 1949 to our 60th meeting today, has brought the audience the latest and the most reliable information on weed control. If you add it up, scientists have spoken to members of CWSS about 2500 times for 900 hours on how to control weeds in all of the variety of situations that weeds cause problems throughout this state. In addition, the third edition of our textbook, Principles of Weed Control has over 70 authors and contributors.

In addition to the value of the science benefiting weed control practices and the economic benefits of weed control for society, there is also an important social aspect to what we do, and it relates to the hoe. The ceremonial Robbins Short-Handled Hoe was presented to UC Davis Professor W.W. Robbins at the third conference in 1951 in recognition of his many contributions to CWSS. Walter Ball, with the CA Department of Agriculture, had been given the hoe by Dr. Robbins' widow after his death and established the tradition of passing this hoe down to the current President. In his address to the conference, Walter Ball, speaking about Dr. Robbins said, "In his many talks before farmers he often would bring out the hoe and display it as the time honored tool; that even in his day of magic chemicals, was still the major weapon in the fight against weeds."

From the 1900's through the 1960's, short-handled hoes were the most important tool used to weed vegetables and other row crops like cotton and sugarbeets. Farmers felt that the labor crews worked faster and more accurately if they were closer to the crop. But extended use of short-handled hoes caused permanent lower back injury and these hoes became a rallying cause for farmworkers, especially union members, of their mistreatment. Short handled hoes were banned in California in 1975 by the CA Industrial Safety Board; since then only long-handled hoes are allowed. Fortunately for California agriculture, selective weed control in crops with herbicides was well established by this time. Again, the weed scientists with industry, government, and universities had done the laboratory and field research to develop these herbicide practices. And they typically delivered their information at the California Weed Conference.

The short-handled hoe is still viewed negatively by farmworkers and the groups that support them. At the 59th conference the question was asked, "Why does CWSS have a short-handled hoe as its symbol?" As discussed earlier, it was given to Dr. Robbins to signify his work ethic and dedication to advancing weed control. It is passed on as a reminder of the importance of our endeavors. I personally feel that it is also a symbol of triumph for weed science and weed control in California that the short-handled hoe is no longer needed in our agricultural fields. It may be that we decide as an organization to drop the use of the short-handled hoe as our logo someday because it is no longer appropriate; but I doubt if it will ever be abandoned as our Presidential symbol. I feel honored to have had the hoe in my home for the past year and I feel privileged to pass it to Stephen Colbert.

Economic Considerations in Weed Control

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Economic considerations in weed control include efficacy (impact on yield and quality) and efficiency (cost per unit of production). Weed management costs at the farm level include labor for hand hoeing and tractor operation, materials, and equipment. Equipment costs include fuel and lube for tractors, repairs, insurance and property taxes, and capital recovery on ownership. Weed control alternatives can be compared based on costs per unit of production, resource use, risk, and environmental impacts.

Factors external to the farm impacting the efficiency of weed control practices include the prime interest rate; the cost of materials, equipment, and labor, availability of labor, and the cost of compliance with regulations impacting the use of herbicides. The low interest rates of the past 25 years has encouraged investment in farmland, farm equipment, and perennial crops. Over the last five years the cost of fuel has about tripled and the cost of fertilizer has doubled. In marked contrast the cost of herbicides and insecticides has only increased about ten percent over the past 10 years. Therefore, looking at the relative changes in input costs, the cost of cultivation using heaving equipment is the most highly impacted weed control method followed by herbicide applications and lastly hand hoeing.

When we look at specific crops, weed control represents between 1 and 20 percent of total production costs. For winegrape production weed control is between $50 and $100 per acre and only one percent of total costs. Control typically consists of winter strip spray along the vines, mowing the centers between the vines, and strip spot spray in the summer. The equipment used includes an ATV with a weed sprayer and a small tractor and mower. The difference in costs among vineyards is primarily due to the choice of herbicides used in the strip spray. The cost of vine row weed control for an organic vineyard unable to use herbicides is about $150 per acre using a small tractor and an in-row cultivator.

The cost of weed control in alfalfa in the Sacramento Valley is about $36 per acre. It consists of winter spray of herbicide. Weed control represents about seven percent of total costs and is extremely important to maintain quality hay.

Weed control in high valued vegetables typically includes a combination of herbicide applications, cultivation, and hand weeding. For processing tomato weed control is about $400 per acre and represents 17 percent of total costs. The tomatoes are sprayed about five times, cultivated seven times and hoed by hand between one and three times depending on the weed pressure. The size of the tractors used will vary depending on the size of the fields. For broccoli on the coast, weed control is only about $100 per acre. There is typically only one herbicide application at planting, several cultivations, and one time over with hand hoeing. Organic broccoli cannot use the preplant herbicide and relies more on hand hoeing. Total weed control costs can jump to over $250 per acre, two and a half times the cost for a conventional grower.

Losses and Costs Imposed on California Ranchers by Yellow Starthistle

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ABSTRACT

The substantial ecological damages caused by invasive weeds have been well documented. By comparison, the economic consequences of specific invasive weed species tend to be poorly understood to date. Yellow starthistle (*Centaurea solstitialis* L.) is the most widespread non-crop weed in California, yielding damage to forage on natural range and improved pasture. A survey was administered to California cattle ranchers to investigate infestation rates, loss of forage quantity and value, and control or eradication efforts related to this weed. The results were used to estimate county-wide losses and costs for three focus counties, as well as statewide losses/costs, due to yellow starthistle in California. Total losses of livestock forage value due to this weed on private land in the state of California are estimated at $7.65 million per year, with ranchers' out-of-pocket expenditures on control amounting to $9.45 million per year. Together, these amount to the equivalent of 6-7% of the total annual harvested pasture value for the state. Therefore, while the impacts are relatively small within the statewide total agricultural production system, losses and costs due to yellow starthistle infestation do represent a constraint on California's livestock grazing sector.

The Value of Herbicides in U.S. Crop Protection

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Widespread herbicide use is a relatively recent development in U.S. agriculture in comparison with insecticides and fungicides, which were routinely used in inorganic, naturally derived chemical formulations on U.S. fruit and vegetable crops beginning in the early 1900s. By contrast, widespread use of herbicides to kill weeds did not begin until the introduction of synthetic organic chemicals in the late 1940s. Currently, herbicides are routinely used on more than 90% of the area of most U.S. crops. The importance of herbicides to U.S. crop production can be understood through a historical perspective and examinations of the practices of organic growers.

In the early years of crop production in the United States, human labor was used to remove weeds from fields. As late as 1850, 65% of the population lived on farms and removing weeds was one of the main farm chores. The historical record reveals that herbicides replaced or reduced the use of hand weeding and cultivation for weed control with an associated reduction in cost and increase in yield. The adoption of herbicides was spurred by a desire to reduce weed control costs as labor became scarce and more expensive in the years following World War II.

Use of the short handled hoe was the primary weed control method for most vegetable crops in California from the early 1900s through the 1960s. Weeding of celery took 111 hours/hectare, carrot took 69 hours/hectare, strawberry required 69 hours/hectare. Numerous complaints were received from farm workers who stated that they suffered permanent back damage as a result of using the short handled hoe for extended periods of time. The California Industrial Safety Board issued a regulation that permanently banned the use of the short-handled hoe in 1975. Most growers switched to the use of herbicides which proved to be more economical than the use of workers wielding hoes. The cost of herbicides plus application was $25/hectare in comparison to hand weeding costs of $247/hectare for spinach, $198/hectare for celery, $309/hectare for onion, and $988/hectare for strawberry. The use of herbicides is credited with reducing the use of labor in California onion fields by 297 hours/hectare, which was equivalent to two million hours per year.

For many crops, herbicides substituted for and reduced the practice of cultivation. For example, herbicides reduced the number of tillage trips in California almond orchards by 16 with grower savings of $52/hectare.

For most crops, historical data indicate an increase in yields due to herbicide use .For two crops, corn and soybean, researchers have statistically determined the contribution of herbicides to improved yields. Herbicides accounted for 20% of the increase in corn yields 1964 through

1979 and 62% of the yield increase in soybean 1965 through 1979.Better weed control with herbicides is credited as an important factor in doubling rice yields in the 1960s.

For several crops, including carrot, cotton, and onion, dramatic improvements in yield did not occur following the adoption of herbicides. For these crops, an adequate amount of hand labor had been previously used to remove weeds and prevent yield loss prior to the introduction of herbicides.

Organic crop growers do not use herbicides to control weed populations. The problem of controlling weeds without herbicides has been cited numerous times as the single biggest obstacle to crop production that organic crop growers encounter. Organic rice growers report that weed management is the most difficult part of organic production, and it is the major reason that organic rice yields are 50% lower than conventional yields. Lower yields and higher costs for weed control labor are two of the major reasons that organic cotton must sell with high price premiums.

California organic crop growers rely extensively on hand weeding to control weed populations: almond (17h/ha), apple (50 h/ha), cotton (30 h/ha), cucumber (75 h/ha),grape (20 h/ha),lettuce (45 h/ha),onion (181 h/ha) and tomato (37 h/ha). The problem of farming without herbicides was recently highlighted in an exemption from a farm worker protection rule granted to California organic growers. The State of California banned the practice of using workers to pull weeds by hand in 2004. The California Occupational Safety and Health Standards Board determined that the practice of pulling weeds by hand was more destructive to workers backs than use of the short handled hoe, which had been banned in 1975. Organic crop interests sought and were granted an exemption from the ban on hand weeding, claiming they would incur tremendous yield and profit losses if they were required to use laborers with long handled hoes rather than hand weeders. Organic crop growers reported that workers with long-handled hoes would inadvertently damage or remove some of the vegetable plants while missing some of the weeds.

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Herbicide Mode of Action

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The mode of action of an herbicide includes all aspects related to its uptake, movement, metabolism, and activity at the specific target site. Herbicides that reach their site of action can affect several biochemical responses. While most herbicides initially interfere with a single biochemical reaction, some may be relatively non-specific and interfere with several reactions simultaneously. Of the herbicides used in wildlands, the most common targeted biochemical reactions involve nucleic acid or amino acid metabolism. Most of these compounds fall into the category known as growth regulators, including 2,4-D, 2,4-DP, aminopyralid, dicamba, triclopyr, clopyralid, and picloram. These compounds mimic the naturally occurring auxins found in plants. A second common group of herbicides used in wildlands are the amino acid inhibitors which can either block the activity of the enzyme acetolactate synthase (ALS) or 5-enolpyruvylshikimate-3-phosphate synthase (EPSP synthase). The ALS inhibitors prevent the synthesis of branched chain amino acids and include chlorsulfuron, sulfometuron, metsulfuron, imazapyr, and imazapic, whereas glyphosate is the only EPSP synthase inhibitor and prevents the synthesis of aromatic amino acids. By disrupting any of these biochemical reactions, herbicides may injure or kill the plant.

Growth Regulators

Growth regulator herbicides are compounds which mimic naturally occurring auxins. These can be divided into several groups; indole acids, phenoxy carboxylic acids, benzoic acids, and picolinic acid (also known as pyradines) derivatives. The indole acids include the naturally occurring growth regulator indole acetic acid (IAA). No compounds within this group are commercially available as herbicides. The latter three groups contain many herbicides registered for use in wildlands, including the phenoxy carboxylic acid 2,4-D, the benzoic acid dicamba, and the picolinic acids aminopyralid, triclopyr, clopyralid and picloram (not registered in California). These compounds are often called auxinic herbicides. All of these compounds are active as foliar applied herbicides, and some have excellent preemergence activity, particularly aminopyralid, clopyralid and picloram. They generally translocate through the phloem of the living plant and accumulate at the growing points or other carbohydrate sinks, such as roots and underground reproductive structures (Vencill 2002).

One of the difficulties in studying the mechanism of auxin action is the multitude of different kinds of physiological processes that they appear to control. It has been suggested that there may be many target sites of IAA action or a single target site which unleashes a cascade of events. Auxins seem to be involved in a number of developmental functions, including phototropism, apical dominance, senescence, cell growth and differentiation, and root formation. Although they have been studied for a few decades, their specific mechanism of action is still not well understood. In general, however, the initial response of plants to auxin treatment can be categorized into two phases (DiTomaso 2002). Initially there is a fast response that occurs within minutes of exposure. This is characterized by rapid acidification and loosening of the cell wall. This is due to a weakening of the hydrogen bonds. The loosening of the bonds decreases the resistance of the wall to turgor pressure. More water would move into the cell causing an increase in cell volume and irreversibly stretching the cell wall. As a result, the petiole and stem internodes of treated plants often elongate within hours of treatment. The second phase of the response occurs 30-45 min after treatment, and involves the synthesis of nucleic acids.

Under natural growing conditions, plant tissues respond to auxin treatment by dramatically increasing nucleic acid and protein synthesis, and this effect is closely correlated to cell division and growth. The action of auxin appears to involve specific gene activation at the transcriptional level. Auxin may interact with a binding protein and the auxin-protein complex then interacts with chromatin (filamentous complex of DNA, histones and other proteins constituting chromosomes) to cause an increase in DNA template available for transcription. The result of this action could be altered DNA transcription and quantitative and qualitative changes in RNA synthesis. These RNAs would then serve as templates for the synthesis of the proteins required for the observed physiological responses.

Auxinic herbicides, however, are applied at rates considerably higher than the concentration of IAA in plants. In meristematic tissues, high levels of auxins inhibit RNA synthesis and growth. In contrast, high auxin levels stimulate RNA and protein synthesis is mature tissues causing cells to divide. The abnormal stimulation of cell division by synthetic auxin treatment, in conjunction with the rapid cell wall loosening response, leads to uncontrolled growth and the production of callus tissue. Volume expansion of mature tissues is somewhat restricted by the presence of secondary cell walls and thickened cells, such as collenchyma and fibers. Consequently, excessive cell division in these tissues can cause stem swelling and eventually cellular collapse, particularly in the phloem tissues (DiTomaso 2002).

The phytotoxic concentrations of growth regulator herbicides elicit a variety of symptoms in plants. Among these include leaf chlorosis (yellowing), stem tissue proliferation, root initiation in stem tissue, disintegration of root tissues, and abnormal apical growth. Many of these are secondary effects. The inhibition in cell division in meristematic regions, in conjunction with abnormal stimulation of cell division in mature tissues is the likely causes of plant death (Vencill 2002).

Another characteristic symptom of growth regulator treated plants is a twisting response, known as epinasty. This response is the result of an auxin-induced stimulation in ethylene production. This symptom, in itself, is probably not responsible for the phytotoxic activity of these herbicides.

Amino Acid Inhibitors

Acetolactate Synthase (ALS) Inhibitors

Although the sulfonylurea (chlorsulfuron, sulfometuron and metsulfuron) and imidazolinones (imazapyr and imazapic) herbicides are structurally quite different, they are highly active compounds that inhibit the activity of the same enzyme, acetolactate synthase (ALS), also called acetohydroxyacid synthase (AHAS). ALS catalyzes the first step in the synthesis of the branched-chain amino acids valine, leucine and isoleucine. ALS-inhibiting herbicides block the synthesis of branched-chain amino acids (DiTomaso 2002). The exact mechanism of plant death is unknown, and has been suggested to be either due to the buildup of a substrate of ALS, called α-ketobutarate (LaRossa and Van Dyk 1987), or to a depletion of the pool size of the essential amino acids. Although cell division and plant growth can he inhibited very soon after exposure to these herbicides, death occurs slowly. The rate of death is probably linked to the total pool size of the branched-chain amino acids available to the plant tissues. Thus, older plants and particularly woody species with large amino acid reserves will survive longer than younger plants.

ALS inhibitors are typically applied preemergence, but can have excellent postemergence activity in some plants. Their symptomology includes the rapid inhibition of root and shoot growth, vein reddening, chlorosis, and meristematic necrosis (Vencill 2002). Young developing tissues can often appear disfigured.

More weed species have developed resistance to the ALS inhibitors than to any other herbicide group. In most cases, this is due to selection of an altered ALS that is insensitive to these herbicides. In some cases, however, resistance in plants is due to an enhanced ability to metabolize or degrade the herbicide to non-phytotoxic components.

EPSP Synthase Inhibitor

Glyphosate was identified in the late 1960's in a Monsanto discovery program that initially produced the sugar cane ripener glyphosine. Glyphosate inhibits the activity of the enzyme 3-phospho-5-enoylpyruvateshikimate (EPSP) synthase in the shikimic acid pathway. This enzyme is essential to the synthesis of the aromatic amino acids phenylalanine, tyrosine, and tryptophan (Gresshoff 1979). These essential amino acids are important for protein synthesis and other biosynthetic pathways critical to growth. Inhibition of this biosynthetic pathway results in an unregulated accumulation of shikimate to very high levels in the plant. In fact, following glyphosate treatment, as much as 10 to 20% of the plant's total soluble carbon can be found to accumulate in shikimate. Although not completely known, the apparent death of treated plants is the result of the unregulated accumulation of carbon in that intermediate.

Like the ALS inhibitors, the rate of plant death depends on the amount of stored amino acids in the plant tissues. Thus, small plants may die within a week to a month, whereas larger plants, such as shrubs or trees, may require a year or more to be fully controlled.

Glyphosate is a foliar applied herbicide that translocates in the living phloem of treated plants. Although it does not inhibit chlorophyll synthesis, symptoms can include interveinal chlorosis (Vencill 2002). This may be due to the high buildup of shikimate in the chloroplast. Accumulation of this organic acid can alter the pH balance of the chloroplast and cause loss of membrane integrity and chlorosis.

Glyphosate also interferes with normal carbohydrate translocation in plants. It has been shown to inhibit the import of sucrose to sink leaves, the export of sucrose from source leaves, and the net starch accumulation in source leaves. This disruption in carbon metabolism would eventually starve the plant of compounds required for growth. The appearance of a red coloration on leaves and stem of treated plants is due to the accumulation of the pigment anthocyanin. Anthocyanin accumulation is a typically symptom of an interference in carbon metabolism. Interestingly, anecdotal reports indicate that wildlife prefer to forage on glyphosate treated plants. This may be due to the increased levels of carbohydrates in the foliage.

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Herbicide Resistance Management

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Herbicide-resistant weeds generally occur where the same herbicide or herbicides with the same site of action are used repeatedly. To prevent the appearance of herbicide-resistant weeds, you must know in which chemical family an herbicide belongs and which herbicides have the same site of action. Table 1 lists weeds resistant to herbicides in California, along with the site of action grouping, chemical name, and trade names. Herbicide families that have the same site of action are the same group number. An herbicide program to prevent resistance does not use herbicides from the same group more than once in 3 years.

Management can prevent or delay the appearance of herbicide-resistant weeds. The following practices can be used with the information on herbicide families provided in the table to form an herbicide resistance management strategy.

Prevention

Herbicide rotation —Avoid year-after-year use of herbicides that have the same site of action. At one time this meant not using herbicides from the same chemical family, but this is no longer the case. For example, two chemically different groups of herbicides, the sulfonylureas and imidazolinones, have the same site of action, ALS inhibitors. For another example, Prism and Poast belong to different chemical families but kill susceptible grasses in the same way.

Avoid repeated application of herbicides —Repeated applications within a growing season of an herbicide with no soil activity (e.g., glyphosate) has resulted in weeds resistant to the herbicide.

Crop rotation —Because different crops may require different herbicides, rotating crops can increase herbicide rotation. But with glyphosate resistant crops, crop rotation alone may not be enough to avoid weed resistance.

Cultivation/Hand weeding —In row crops, orchards, and vineyards cultivation can be an effective tool for eliminating weed escapes that may represent the resistant population. Tillage or hand weeding controls herbicide-resistant and herbicide-susceptible weeds equally as long as seedlings of the two biotypes emerge at the same time.

Accurate record keeping — To have an effective herbicide rotation or tank-mix system to prevent resistance, you must know which herbicides have been used in the past, at what rate, and how often.

Integrated weed management —This concept is important for all weed control, not just management of herbicide-resistant weeds. Integrated weed management uses all the tools available to control weeds, including cultural, mechanical, and chemical methods. An integrated approach to weed management, whether it is in crop or noncrop land, is an important environmental and economic consideration.

Monitor fields for weed escapes —Weed escapes are not necessarily resistant, but they may be. A resistance problem may not be visible until 30 percent or more of the weeds are no longer controlled. See whether escapes are only one species or a mixture. If only one species, the problem is more apt to be resistance, especially if the herbicide controlled the species in the past and if the same herbicide has been used repeatedly in the field.

Keep weeds from spreading —Prevent known resistant weeds from flowering and producing seed. After using machinery in fields or areas with known or suspected

Table 1. Weeds resistant to herbicides in California

Group Type and Site of Action[1]	**Weed**	**Chemical**	**Trade names**
Group A/1 Acetyl CoA carboxylase	Late Watergrass (*Echinochloa phyllopogon*)	fenoxaprop-p-ethyl	Puma, Whip, Acclaim
(ACCase) inhibitors	Barnyardgrass (*Echinochloa crus-galli*)	cyhalofop-butyl, fenoxaprop-p-ethyl, molinate, thiobencarb	Clincher, Whip, Ordram, Bolero
	Early Watergrass (*Echinochloa oryzicola*)	cyhalofop-butyl, fenoxaprop-p-ethyl, molinate, thiobencarb	Clincher, Whip, Ordram, Bolero
	Little Seed Canary Grass (*Phalaris minor*)	Fluazifop, fenoxaprop-p-ethyl, sethoxydim, clethodim	Fusilade, Whip, Poast, Prism, Select
Group B/2 Acetolactate	Perennial Ryegrass (*Lolium perenne*)	sulfometuron-methyl	Oust
synthase (ALS)	Smallflower Umbrella Sedge (*Cyperus difformis*)	bensulfuron-methyl	Londax
inhibitors	California Arrowhead (*Sagittaria montevidensis*)	bensulfuron-methyl	Londax
	Redstem (*Ammania auriculata*)	bensulfuron-methyl	Londax
	Ricefield Bulrush (*Scirpus mucronatus*)	bensulfuron-methyl	Londax
Group B/2 Acetolactate	Long-Leaved loosestrife (*Ammania coccinea*)	bensulfuron-methyl	Londax
synthase (ALS) inhibitors	Russian Thistle (*Salsola iberica*)	chlorsulfuron, sulfometuron-methyl	Telar, Oust
Group O/4 Synthetic auxins	Smooth Crabgrass (*Digitaria ischaemum*)	quinclorac	Facet
Group N/8 Lipid	Wild Oat (*Avena fatua*)	difenzoquat	Avenge
synthesis inhibitors	Late Watergrass (*Echinochloa phyllopogon*)	thiobencarb	Bolero
but not ACCase	Early Watergrass (*Echinochloa oryzicola*)	thiobencarb	Bolero
inhibitors	Barnyardgrass (*Echinochloa crus-galli*)	thiobencarb	Bolero
Group G/9 EPSP	Rigid Ryegrass (*Lolium rigidum*)	glyphosate	Roundup, Touchdown, etc
synthase inhibitors	Horseweed (*Conyza canadensis*)	glyphosate	Roundup, Touchdown, etc
	Hairy Fleabane (*Conyza bonariensis*)	glyphosate	Roundup, Touchdown, etc
	Junglerice (*Echinochloa colona*)	glyphosate	Roundup, Touchdown, etc

[1] Mode of action classification based on Herbicide Resistance Action Committee (HRAC) and Weed Science Society of America systems.

infestations of herbicide-resistant weeds, thoroughly clean the equipment to reduce the spread of resistant weeds from one field or area to another.

Change crops and tillage systems —Crop rotation and altered tillage practices can affect the weed populations. Alternating spring and winter crops means that the field will be tilled at different times each year. During one of the field preparation operations, resistant as well as susceptible weeds will be killed.

Change herbicide program —If weed resistance occurs, herbicides with other sites of action and other weed management practices must be used.

Control of Roundup Resistant Ryegrass in Almonds

Ryegrass (*Lolium multiflorum or rigidum*) has been reported to be resistant to glyphosate (Roundup) in Sacramento Valley of California. An experiment was conducted in a mature almond orchard, located on the Pante Farm, near Durham, California, (N39º38.545, W121 º46.027) to assess ryegrass control.

Experimental plots were arranged in a randomized complete block and replicated 6 times. Individual plots were 10 ft. wide by 27ft. long, with a single almond tree in the center of each plot. Treatments were applied on November 22, 2006, using a CO_2 powered backpack sprayer. Visual evaluations of ryegrass control were made at 1, 2, 3, 4, 6, 12, and 20 weeks after application. Additionally, overall weed control was assessed at 20 weeks and 30 weeks after treatment.

At one week after treatment, ryegrass control was over 90% if Gramoxone was included in the treatment (Table 2). The addition of other herbicides with Gramoxone did not influence ryegrass control. Weather was relatively cool during the week after application and activity of the systemic herbicides was much slower. By two weeks after treatment, the Gramoxone treatments were still providing the best control, but other treatments were starting to show more activity, particularly the Chateau treatments. By three weeks after treatment, Roundup plus Poast treatments were also providing 90% control, with the exception of the Roundup plus Poast plus Princep treatment. The addition of Princep, a wettable powder, may have caused some binding of the active herbicide molecules, and thus a reduction in activity of both the Roundup and Poast, as has been reported previously.

By 12 weeks after application, all treatments except Roundup alone, were providing 90 percent or better ryegrass control. Roundup alone provided about 50% control, which probably represents the portion of the ryegrass population which was sensitive to glyphosate. The addition of Poast, Surflan, Princep, or Chateau, to Roundup, resulted in about 50% better ryegrass control.

In summary, Roundup alone would not be an effective treatment in situations where glyphosate resistant ryegrass was present. The addition of Poast can help to control the ryegrass. Gramoxone was effective against established ryegrass, but a residual material would help to improve residual weed control. Princep should not be added to Roundup treatments as antagonism would likely reduce activity.

Table 2. Ryegrass control (%) relative to herbicide treatment and evaluation date.

Treatment	11/29	12/6	12/13	12/20	1/2	2/12	4/13
Roundup 1.5 lb/A	3	22	42	48	53	51	48
Roundup 1.5 lb/A + Poast 0.375 lb/A	7	38	90	91	94	97	97
Poast 0.375 lb/A	1	13	26	42	79	97	94
Roundup 1.5 lb/A + Poast 0.375 lb/A + Surflan 4 lb/A	4	31	90	92	99	99	100
Poast 0.28 lb/A + Surflan 4 lb/A	2	10	25	48	88	99	98
Roundup 1.5 lb/A + Poast 0.375 lb/A + Princep 2 lb/A	2	12	53	70	90	97	92
Poast 0.375 lb/A + Princep 2 lb/A	4	10	22	37	75	98	97
Roundup 1.5 lb/A + Chateau 5.1 oz/A	6	52	72	82	97	96	96
Roundup 1.5 lb/A + Poast 0.375 lb/A + Chateau 5.1 oz/A	39	62	94	96	99	99	99
Gramoxone 1.0 lb/A	93	94	94	95	93	90	90
Gramoxone 1.0 lb/A + Surflan 4 lb/A	96	97	96	96	99	99	99
Gramoxone 1.0 lb/A + Poast 0.375 lb/A + Surflan 4 lb/A	94	98	96	98	99	99	99
Gramoxone 0.75 lb/A + Princep 2 lb/A	96	99	98	99	100	99	99
Gramoxone 0.75lb/A + Poast 0.375 lb/A + Princep 2 lb/A	93	96	99	99	99	99	99
Untreated	0	0	0	0	0	0	0
LSD .05	13	13	16	18	15	10	11

Residential Turf Weed Control

Dennis Penner
Abate-A-Weed, Bakersfield, CA

Weeds compete for the following in turf: water, nutrients, light, carbon dioxide, space. The best defense for weed control in turf is to build a healthy turf stand. Identifying weeds correctly in turf is required in order to select the proper herbicide. Applying the herbicide properly is essential for good weed control. The pre emergent herbicides (Dimension, Pendulum, Gallery) and post emergent herbicides (Trimec Turf, Weedhoe, Sedgehammer, Turflon) are chosen based on the type of existing weeds.

Weed control is an environmental craft. As professional pesticide applicators, we are improving the beneficial state of the environment. We help protect infrastructure, human health, safety, and natural resources.

Application Temperature Impacts on Herbicide Effectiveness

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Winter annual broadleaf weeds are common problems in turfgrass. Application of herbicides in cool weather is generally thought to be less effective than treatments applied during warmer conditions. It has been suggested that products containing carfentrazone may be effective for broadleaf weed control in winter or early spring. Carfentrazone is a contact broadleaf herbicide sold by itself as QuickSilver. It can be added to systemic herbicides and is also available in the prepackaged mixes Powerzone and Speedzone.

The objective of this research was to compare the effectiveness of carfentrazone applied alone or in combination with systemic broadleaf herbicides for turf weed control. A combination product containing sulfentrazone was also included in the research conducted.

Two identical trials were conducted in order to determine the efficacy of carfentrazone applied alone (0.016 lb ai/A), Speedzone (carfentrazone plus 2,4-D plus MCPP plus dicamba at 0.020, 0.67, 0.2 and 0.06 lb ai/A, respectively), Speedzone Southern (carfentrazone plus 2,4-D plus MCPP plus dicamba at 0.020, 0.26. 0.10, and 0.025 lb ai/a, respectively), Powerzone (carfentrazone plus MCPA plus MCPP plus dicamba at 0.018, 0.97, 0.19, and 0.10 lb ai/A respectively), Surge (sulfentrazone plus 2,4-D plus MCPP plus dicamba at 0.024, 0.57, 0.20, and 0.09 lb ai/A, respectively) compared to Trimec Classic (2,4-D plus MCPP plus dicamba at 0.80, 0.22, 0.22, and 0.09 lb ai/A, respectively) on winter broadleaf weeds.

The first trial was conducted in well-maintained tall fescue (*Festuca arundinacea* Schreb.). The cool weather treatment was applied at 46 F and the warm weather application was made at 67 F. Control of ivyleaf speedwell [*Veronica hederifolia* L.], common chickweed [*Stellaria media* L. Vill.], and henbit [*Lamium amplexicaule* L.] was determined. The second trial was conducted in a stand of dormant common bermudagrass. The cool temperature treatment was applied at 44 F while the warm temperature application was made at 64 F. Along with ivyleaf speedwell and common chickweed, control of purple deadnettle [*Lamium purpureum* L.] and wild garlic [*Allium vineale* L.] was determined.

In trial one, warm weather applications resulted in greater initial control at 5 days after treatment (DAT) than cold weather application. However, by approximately 17 DAT, similar results were seen between cool and warm temperature applications of each herbicide. At this time, all herbicides applied in both weather conditions with the exception of Trimec Classic provided 92% or greater control of ivyleaf speedwell and 82% or greater control of henbit. Trimec Classic provided less than 50% control of both ivyleaf speedwell and henbit. At both temperature regimes, Trimec Classic and carfentrazone controlled common chickweed about 55% at this time. Common chickweed control with Surge, Speedzone, Speedzone Southern, and Powerzone at both application timings was similar, ranging from 68% to 78%.

At 34 DAT in both temperature regimes, all herbicides provided 96% or greater control of ivyleaf speedwell and 84% or greater control of henbit, with the exception of Trimec Classic (approximately 58% control of ivyleaf speedwell at both temperatures and 34 and 68% henbit control for warm and cold temperature applications, respectively). Common chickweed control with a given herbicide was similar at both temperature regimes. All treatments except carfentrazone provided good to excellent control of common chickweed.

At approximately 2 months after treatment, all treatments at both temperatures gave 97% or greater control of ivleaf speedwell and henbit, except for Trimec Classic, which gave about 85% control of ivyleaf speedwell and about 60% henbit control. All treatments except carfentrazone gave excellent common chickweed control.

In trial two, similar control trends were observed, although overall weed control was lower than in the first trial. At 7 DAT, warm weather treatments resulted in generally greater weed control. At 14 DAT, control of ivyleaf speedwell was similar between warm and cold temperature applications for a given herbicide. Control of common chickweed and purple deadnettle tended to higher with warm applications compared to cold applications for all treatments except Surge.   By approximately 37 DAT, generally similar control was seen when comparing the effectiveness of a given herbicide applied at cold versus warm temperature application. Powerzone and Speedzone were the overall most effective treatments in the second study.

Application of these herbicides under warm conditions resulted in faster symptom development in broadleaf weeds, but long term control was generally similar between warm and cold temperature applications for a given herbicide. Better weed control in the first trial may be the result of younger plants (treated in mid-December) and competition from tall fescue. Trial two was in an area not regularly mowed and weeds were older and more mature (trial treated in early March). In general, Speedzone and Powerzone were more effective than Trimec Classic, which could be due to the presence of carfentrazone and/or due to the use of an ester form of 2,4-D and MCPA in Speedzone and Powerzone, respectively, compared to an amine form of 2,4-D in Trimec Classic. The addition of carfentrazone may provide an additive or synergistic effect. Using ester forms of 2,4-D (Speedzone) and MCPA (Powerzone) should improve effectiveness over an amine form of 2,4-D (Trimec Classic). Carfentrazone combinations with systemic broadleaf herbicides are effective for winter broadleaf weed control under cold weather conditions.

Postemergence Nutsedge Management in Turf

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Yellow nutsedge is a common turf weed throughout the 48 contiguous states. Purple nutsedge is an occasional turf weed in the southern half of the US. Both species primarily spread vegetatively by rhizomes and tubers but both do produce seed. Several new herbicides have been introduced to the turf industry for control of sedges, among other weeds. Mesotrione is an herbicide that causes bleaching in susceptible species. Sulfentrazone is a contact herbicide that is available alone and in combination with prodiamine.

In the first trial, sulfentrazone was applied post for yellow nutsedge control at 0.25, 0.3125, 0.375 lb ai/A (0.28, 0.35, 0.42 kg ai/ha) to established perennial ryegrass, for comparison, halosulfuron was applied at 0.047 lb ai/A + X-77 nonionic surfactant. Injury symptoms following sulfentrazone application was observed 1 day after treatment (DAT) while injury symptom development was much slower with halosulfuron. By 20 DAT, sulfentrazone controlled yellow nutsedge 74, 80 and 90% at 0.25, 0.3125, 0.375 lb ai/A, respectively while halosulfuron provided 97% control.

Repeat applications of sulfentrazone were evaluated for purple nutsedge control. Sulfentrazone was applied once at 0.125, 0.188, 0.25, or 0.375 lb ai/A. An additional set of plots were treated with sulfentrazone at 0.25 lb ai/A followed by 0.125 lb ai/A at 28, 35, or 42 days after the first application. Sulfentrazone caused a rapid burn in purple nutsedge but control never exceeded 55% with single or repeat applications. Halosulfuron controlled purple nutsedge 100% at 21 DAT, although control decreased to 71% at 41 DAT.

Mesotrione was applied at 0.125 or 0.25 lb ai/a (0.14 or 0.28 kg ai/ha) once or repeated 14 days later for postemergence control of yellow nutsedge. At 9 DAT, mesotrione controlled yellow nutsedge 78 and 98%, respectively, at 0.125 and 0.25 lb ai/A. Yellow nutsedge regrew when mesotrione was only applied once but two applications at 0.125 lb ai/A gave good control with excellent control seen with two applications at 0.25 lb ai/A 41 DAT.

Sulfentrazone and mesotrione were compared to halosulfuron and trifloxysulfuron in another trial for postemergence control of yellow and purple nutsedge. Sulfentrazone injured both sedge species approximately 20% at 3 DAT. AT 17 and 32 DAT, yellow control with sulfentrazone increased to approximately 60%, depending on rate, but decreased at later rating dates. Sulfentrazone provided no control of purple nutsedge at 32 DAT. A single application of mesotrione at 0.25 lb ai/A controlled yellow nutsedge 50% at 39 DAT, with lower injury seen in purple nutsedge. Halosulfuron and trifloxysulfuron provided approximately 75% control of both sedge species at 39 DAT.

Sulfentrazone was compared to the sulfonylureas foramsulfuron, halosulfuron, trifloxysulfuron, flazasulfuron, and sulfosulfuron for postemergence yellow and purple nutsedge control. Sulfentrazone caused approximately 15 to 20% injury in both sedge species at 1 DAT while injury symptom development was much slower with the sulfonylurea herbicides. By 49

DAT, sulfentrazone caused 35 to 71% reduction in yellow nutsedge shoot fresh weight and 14 to 28% reduction in purple nutsedge shoot weight, depending on application rate. Foramsulfuron did not provide acceptable control of either sedge species. Halosulfuron, trifloxysulfuron, flazasulfuron, and sulfosulfuron all provided excellent control of both yellow and purple nutsedge.

Sulfentrazone provides rapid burning of yellow and purple nutsedge but provides much better control of yellow compared to purple nutsedge. Thus, repeat applications are needed to maintain control. It can cause temporary injury to bermudagrass, tall fescue, perennial ryegrass but injury disappeared by 2 weeks after application. Mesotrione was slower acting than sulfentrazone and also provided better control of yellow compared to purple nutsedge. Two applications of mesotrione provided much better yellow nutsedge control than a single application. The sulfonylureas halosulfuron, trifloxysulfuron, flazasulfuron, and sulfosulfuron are effective on both yellow and purple nutsedge.

Successful Control of English Lawn Daisy *(Bellis perennis)*

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Introduction

English lawn daisy or English daisy (*Bellis perennis*) is the most troublesome and difficult to control broadleaf turfgrass weed in California. English daisy continues to flourish in turf stands and frustrate turf managers due to its ability to adapt to a wide range of cultural practices, and to resist and tolerate many of the presently registered broadleaf herbicides.

English daisy is a fibrous rooted perennial with basal leaves and a prostrate, spreading growth habit. The leaves are nearly smooth or loosely hairy, entire margined or variably toothed, broad above, and narrowed at the base to a long stalk. Flower heads are white or pinkish with yellow centers. Flower stalks generally exceed the leaves in length.

This aggressive and troublesome weed spreads through a rapidly advancing rhizome system, and exhibits the potential to root and produce new plants at each node along individual rhizomes. English daisy also appears to be a prolific seed producer. Germinating seedlings have been observed in Northern California from April until late September. Once established in turf this dual propagation system contributes to the rapid spread and invasion of English daisy in adjacent turfgrass areas. English lawn daisy was introduced from Europe as a garden plant and today there are thought to be at least six known biotypes in California.

Field Research 1992-2008

Applications of chloro-phenoxy herbicides have historically exhibited poor control of English lawn daisy. In the past when English daisy populations were extreme, golf course superintendents would often make three to five applications per year of 2,4-D and related products with poor results. The greatest benefit of chloro-phenoxy applications was short-term flower removal and suppression.

With the registration of quinclorac (Drive 75DF: BASF) in California the potential to control English daisy improved. Although quinclorac alone never exhibited high levels of English daisy control in our field trials when used as a stand-alone application, it did appear to enhance the performance of other products when used in tank mix combinations. Three-way tank mix combinations of SpeedZone Southern (2,4-D, MCPP, dicamba, carfentrazone: PBI Gordon), Drive 75DF (quinclorac: BASF) and Vanquish (dicamba: Syngenta) exhibited improved activity on English daisy. In rough areas three applications of this three-way tank mix showed 75-80% English daisy control and in fairways 50-60% control.

Over the last 16 years Mark M. Mahady & Associates, Inc. has conducted 15 replicated field research trials for the control of English daisy in cool season grass fairway and roughs areas. To date 31 products and 90 different product combinations have been evaluated. Those products screened for English daisy suppression and control include Trimec Classic, Trimec Amine, Confront, Gallery, Turflon, Drive, SpeedZone, Vanquish, 2,4-D, 2,4-DP, Lontrel, Greenor, Roundup Pro, Scythe, Prograss, Dissolve, Triplet, TriPower, Triamine II, Lesco 3-Way, MSMA, MCPP, MCPA, Momentum, Millenium, Chaser, Carfentrazone, Spotlight, XDE-565, Mesotrione and Penoxsulam.

To date the best performing product reviewed for selective postemergent control of English daisy in cool season grasses has been Penoxsulam. Penoxsulam is manufactured by Dow AgroSciences and exhibits the following classifications and characteristics:

- Sulfonamide herbicide classification
- Postemergence herbicide, ALS (acetolactase synthase) inhibitor
- Mobile, but not persistent
- Low volatility
- Reduced risk pesticide due to its favorable human health risk profile

Since 2004 five replicated field research trials and two superintendent applied split fairway demonstration trials have been conducted on golf courses in the Monterey Peninsula in order to evaluate the performance of Penoxsulam for English daisy control. The key take home messages from these trials are as follows:

- Late summer/early fall is the best time period for efficacious applications of Penoxsulam. Apply the first application on approximately September 25 with a second application 21 days later.

- At application rates of 0.02 lb. ai/A no injury to cool season grasses has been observed in our trials. Some golf course superintendents have reported slight and short term yellowing on *Poa annua*. No long-term reduction in surface quality has been observed. At very high rates (0.08 lb. ai/A) injury to some varieties of perennial ryegrass has been observed.

- A minimum of two sequential applications at 0.02 lb (9 grams) ai/A is required for high levels of control. Single applications are much less effective with dynamic regrowth of English daisy often appearing.

- With late summer/fall timing two sequential treatments applied at a 21-day interval will provide high levels of control (95%+). In a replicated field trial conducted on a golf course fairway in 2006-2007, two late summer treatments of Penoxsulam applied at 0.02 lb (9 grams) ai/A resulted in 96% English daisy control 345 days after the second application. In a replicated field trial conducted on a golf course fairway in 2007-2008, two late summer treatments of Penoxsulam applied at 0.02 lb (9 grams) ai/A resulted in 100% English daisy control 70 days after the second application.

- If spring applications are planned a third sequential application will be required for high levels of control.

- Use a non-ionic surfactant at standard label rates with all applications.

Penoxsulam is an exceptional new tool for English daisy control in cool season turfgrasses. California registration is expected during the summer of 2008.

Acknowledgements

Over the last 16 years many product development companies have graciously provided funding to support English daisy field research.

We would like to thank Dow AgroSciences, The Northern California Golf Course Association, BASF, LESCO, PBI Gordon, DuPont, Syngenta, Rancho Canada Golf Club and Mark M. Mahady & Associates, Inc. for their generous financial support.

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Pendimethalin phytotoxicity and leaching in container media and field soil

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Weed management in container nursery production relies primarily on hand weeding and preemergence herbicide application. Dinitroaniline herbicides are commonly-applied to container-grown plants for preemergence weed control. Previous research has shown these herbicides can affect root development of container-grown nursery crops.

Container trials were conducted to determine the importance of leaf versus root uptake of pendimethalin by azalea. The emulsifiable concentrate form of pendimethalin was applied at 3.34 kg ai/ha to 'Tradition' azalea shoots, the growing medium (pine bark), or shoots plus the growing medium. Initial plant height and root volume were recorded. Plant height was recorded 2, 4 and 8 weeks after treatment (WAT). Azalea root and shoot growth was evaluated at 4 and 8 WAT. After 4 WAT, azalea height in shoot-only and shoot plus growing medium exposure treatments increased by 17% and 25%, respectively, while height in growing-medium only exposure and in the untreated control increased by 34%. All treatments reduced azalea shoot fresh weight when compared to the untreated control. At 4 WAT, azalea root development in the shoot only exposure was similar to that seen in the untreated plants, while root growth was reduced in the growing medium and growing medium plus shoot exposures.

Experiments were conducted to evaluate depth of pendimethalin movement in container media and field soil at two different irrigation volumes, as indicated by a large crabgrass bioassay. Soil columns were constructed from polyvinyl chloride pipe, with a 5 cm internal diameter and a 35 cm length. A Tetotum silt loam soil was compared to 100% pine bark. An emulsifiable concentrate form of pendimethalin was applied at 3.4 kg ai/ha. Media in the soil columns were separated into 0 to 3 cm, 3 to 6 cm, 6 to 9 cm, 9 to12 cm, 12 to 18, and 18 to 24 cm depths after completion of the simulated irrigation events and seeded with large crabgrass. Large crabgrass root weight and root length were recorded 2 weeks later. After 18 cm of irrigation, pendimethalin leached into the 6 to 9 cm depth in pine bark, while the silt loam field soil displayed no detectable herbicide movement past the 0 to 3 cm depth. Doubling the irrigation volume did not increase the depth to which pendimethalin leached in pine bark or field soil. Large crabgrass root weights significantly increased as pine bark depth increased from the 0 to 3 cm, 3 to 6 cm, 6 to 9 cm and 9 to 12 cm depths, indicating most of the herbicide remained near the medium surface. There was no significant difference in large crabgrass root weights among the 9 to 12 cm, 12 to 18 cm and 18 to 24 cm depths in pine bark. By mass, approximately one half of the particle size of pine bark was 2 mm or greater, while none of the field soil particles were 2 mm or greater. Pine bark had a drastically greater volume of air space (41%) compared to the silt loam soil (4%). The bulk density of pine bark was much less than that of field soil, while water percolation rates were much higher for pine bark than field soil.

Sprayed applications of pendimethalin can directly reduce azalea shoot growth, while exposure of root systems to pendimethalin results in reduced root growth. Root suppression is due to pendimethalin leaching into the 6 to 9 cm zone below the pine bark surface. Pendimethalin moves downward in pine bark much more readily than in field soil as pendimethalin did not leach below 3 cm in field soil.. The differences in physical properties between pine bark and field soil may account for the greater leaching depth in a soil-less growing medium. The greater leaching in pine bark is probably due to the higher percolation rate and higher amount of air space in this growing medium compared to field soil. Growers need to ensure adequate root development prior to application of a dinitroaniline herbicide to containers.

Japanese Dodder Detection and Treatment

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Japanese dodder, *Cuscuta japonica* is listed as both a California and federal noxious weed, and as such is subject to eradication when found in the state. In California, *C. japonica* seed was initially detected at a retail business in Redding, in 2004. The confiscated seed was not sterile and was destroyed under USDA, (United States Department of Agriculture) authority. Subsequent to this interception, in June 2004, a specimen of dodder from Shasta County was submitted to the California Department of Food and Agriculture (CDFA), Botany Laboratory. This specimen was tentatively identified as *C. relfexa*, giant dodder, a closely related noxious weed, also from the eastern Asian seaboard. Each of these weeds belongs to a group of dodders known as 'giant dodder' because of their robust stems, unlike other dodders that are thin stemmed. In October 2005 a specimen from Shasta County, growing on citrus was submitted to the CDFA Botany Laboratory. This specimen had well-developed flowers and was positively identified as *C. japonica*. Subsequent surveys found no other infested properties. The infested citrus tree was removed and disposed at an approved landfill. In the spring of 2005, the initial residential site was re-inspected for evidence of any return of the dodder. As no evidence of the plant was found, it is thought that it succumbed to winter temperatures since this is not a cold tolerant species.

In its native range, Japanese dodder is an annual parasitic plant that uses specialized roots called haustoria that allow the plant to obtain water and nutrients from its host. *C. japonica* can infect a wide variety of hosts. In its native tropical range it grows, sets seed, and dies in a single season. Japanese dodder plants are robust, rapidly growing plants that can survive for prolonged periods without a host. In addition to its wide host range, some cultivation by certain ethnic groups is possible. Flowering of *C. japonica* has been observed in California, but seed production has not. Seeds pose an extreme threat to California as they can live in excess of 20 years. In California it is unknown if the plant will adapt and establish in the varying climates found in the state. In late 2005, the CDFA decided to survey areas in the state where Japanese dodder was likely to occur. These surveys detected one site in Los Angeles County. In 2006, a sharp increase of *C. japonica* sites were detected throughout. Emergency funds were made available and the Japanese Dodder Survey and Eradication Protocol was developed. The six components of the protocol are detection, eradication, post-treatment monitoring, outreach and education, and regulatory.

Annual detection surveys begin in spring and last through late fall. Each of the fifty-eight counties in California is assigned a 'Tier' based on likelihood of harboring infestations of *C. japonica*. Tier I is "highest risk," Tier II is "moderate risk," and the remaining counties are either infested or determined to be unsuitable for establishment of *C. japonica*. Each of the Tier I counties and a majority of the moderate risk counties were surveyed by CDFA crews in 2007. Over 20,000 net miles comprising 4.8 million primarily urban and some rural residential properties were surveyed for the presence of Japanese dodder in 2007, only one site was found infested. In January 2007, almost the entirety of the state experienced a prolonged period of below freezing temperatures. This event appears to have decimated existing infestations of

Japanese dodder in most areas and, decreased the viability of other infested sites, except in some coastal environments.

Currently 206 infested sites in 14 counties have been detected and treated. The primary method of ‘treating’ infested sites is total host removal or severe pruning to eliminate infested material. Post-treatment monitoring occurs on a regular basis, with eradication declared after two years. CDFA will continue its outreach and education efforts and enlist the public’s assistance in locating previously undetected sites.

Solarization And Steam Heat For Soil Disinfestation In Flower And Strawberry

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Abstract

The objective of this research is to develop an economically feasible combined solarization and steam heat, soil disinfestation system for field-grown flowers and strawberry. Soil solarization performance in cool coastal areas of California is often inconsistent due to fog and cool summer temperatures that do not allow soil to reach high temperatures required to reliably kill soil pests. Coastal California is also the principal strawberry fruit and cut flower production region, and solarization has displaced virtually no methyl bromide (MB) use in these crops. Soil disinfestation with steam has a long and proven track record for control of soil pests including weeds and pathogens in greenhouse and nursery settings. However, use of steam at the field level has been limited due to difficulty in treating large areas with existing steam applicators and high energy costs for steam disinfestation. A steam blanket prefabricated to fit the bed widths and plot lengths was used for the injection of steam into finished planting beds with a mobile steam generator. Each plot required about 1-1.5 hours to apply steam and raise soil temperatures to 70°C at a depth of 6 inches. We do expect large increases in efficiencies by treating larger areas. Results to date indicate that weed control with steam plus solarization was comparable to MB.

Full Season Drip Irrigation in Lettuce – Impact on Weed Control

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INTRODUCTION

The acreage of lettuce under drip irrigation in the Salinas Valley has noticeably increased during the past 10 years; in 2005, 31% of the vegetable acreage was drip irrigated compared with 3% of the acreage in 1993 (Thomasberg et al. 2007). Despite the increased acreage under drip, overhead sprinklers are used on most of the vegetable acreage from planting until thinning. After thinning and side-dressing of fertilizer, drip tape is usually installed on top of the beds and used to irrigate the crop until harvest.

Growers have justified the costs of using surface-placed drip after sprinklers by such advantages as reducing water use, minimizing foliar diseases, and increasing fertilizer-use efficiency. Growers in the Salinas Valley have experimented with irrigating lettuce with drip tape from planting to harvest. Full season use of drip maximizes the benefits of drip irrigation and eliminates some of the disadvantages of sprinklers. For full season use, the tape is buried a few inches below ground so that the crop can be planted and thinned without damaging the tape. Besides eliminating the costs of using overhead sprinklers, using only drip can improve access to the field by keeping the furrows dry, prevent the formation of soil crusts which reduces emergence, and permits growers to irrigate with a high uniformity during windy conditions.

Obtaining uniform germination with shallowly buried drip tape can be a significant limitation to using full-season drip: particularly, obtaining uniform wetting of the bed tops. Where as overhead sprinklers apply water directly to the seed line, water from the buried drip tape must move both upward and horizontally to the seed. In some cases, growers have needed to irrigate for as much as 24 hours during a single set to obtain a satisfactory level of moisture in the seedline, and on some soil types, such as well-aggregated clays, the drip system was unable to move moisture to the seedline if the soil was initially too dry.

Weed control can be another challenge to germinating lettuce with drip tape. Where overhead sprinklers are used they effectively activate the commonly applied preemergent herbicides, Kerb and Prefar. Sprinkler applied water is considered necessary to obtain full efficacy from these herbicides, because the overhead application of water moves the herbicide from the soil surface to the depth where germinating weed seed are located. Questions arise about the efficacy of activating surface applications of Kerb and Prefar with drip irrigation due to differences in the movement of the germination water from the drip tape. Water from the drip tape is moving laterally as well as downward and the question is, can water from the drip system effectively activate the preemergent herbicides and provide good weed control.

METHODS
We conducted two field trials: ***Trial No. 1***: In 2006 we compared sprinkler and drip germinated lettuce. The trial was conducted at the USDA Spence research farm on a sandy loam soil. Three application methods of Kerb: 1) bedtop spray, 2) injection into the drip tape, and 3) no Kerb. Three irrigation methods were tested: 1) one line of drip tape in the bed middle on the bed surface, 2) one line of drip tape in the bed middle buried at 2 inch depth; and 3) sprinkler irrigation. Kerb was applied at 1.2 lbs a.i./A. Each treatment was replicated four times and each plot was one bed wide by 135 feet long. The sprinkler plots were separated from the from the drip plot to prevent contamination between plots. ***Trial No. 2:*** 2007 trial was conducted with a cooperating grower on a site with Salinas Clay Loam Soil. The drip tape buried drip at 2-3" depth. The herbicides were sprayed 14 hours after the initiation of the germination water and the water was run for 4 hours following the application. All materials were applied with a CO_2 backpack sprayer at 30 psi applying 72 gallons of water per acre. Each plot was one 40 inch bed wide by 30 feet long.

RESULTS
Trial No. 1: The primary weed species at the trial site were shepherd's-purse and common groundsel. Plots treated by Kerb Chemigation had less common groundsel than plots treated with Kerb on the bed top. Drip germinated treatments had significantly fewer weeds that sprinkler irrigated treatments (Table 1). Kerb had no effect on the lettuce stand whether applied by spray or chemigation. Lettuce stand in the drip irrigated treatments were higher than in the sprinkler irrigation treatments. Kerb application method did not affect lettuce yield, but lettuce yields in drip irrigated plots were higher than in sprinkler irrigated plots (data not shown).

Trial No. 2: On August 3 the weeds were small and there were fewer purslane plants in the Prefar treatments than in the Kerb treatments (Table 2); however, by August 31 there were no difference in the number of purslane plants per plot between the Kerb and Prefar treatments indicating mortality of purslane seedlings in the Kerb treatment. Prefar provided better control of burning nettle on the August 3 evaluation date; on August 31 the high rates of both Prefar and Kerb provided better control of this weed than the lower rates. Prefar provided better weed control of total weeds than Kerb on the August 3 evaluation date but there were no significant differences among the herbicide treatments on the August 31 evaluation date with both herbicides providing greatly improved weed control than the untreated.

An evaluation of the movement of Kerb in the soil was conducted to better understand the movement of Kerb in a situation where it is activated by water coming from drip tape as opposed to sprinklers which is the common method currently used in the Salinas Valley. The evaluation showed that about 75% of the 2.0 lb a.i. application of Kerb remained in the top 2.0 inches of soil (Table 2); 62.5% of the material was in the top 0.5 inch of soil which is the zone of active weed seed germination. These results help us to better understand the movement of Kerb in soils under this irrigation scheme and will need to be built upon in the future to better understand the movement of Kerb and how best to optimize its use in lettuce production.

CONCLUSIONS

The irrigation system used for germinating lettuce impacted weed pressure; drip germinated lettuce had less initial weed pressure than sprinkler germinated lettuce. The movement of water from drip tape differs from the pattern of movement from sprinkler irrigation; however, Kerb and Prefar were successfully activated and provided good weed control in the two trials conducted in these studies.

LITERATURE CITED

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Table 1. Effect of Kerb application method (spray, chemigation or untreated) and irrigation method (surface tape, buried tape or sprinkler) on weed densities, lettuce stand and visual injury.

Kerb application	Irrigation	Weed densities (no. / species / 10ft^2)			Lettuce stand	Visual Injury
		Shepherd's Purse	Common groundsel	Total Weeds	No./ 10ft[1]	Rating [2] (0-10)
Spray	Surface	1.9 b	12.0 c	21.4 c	60.3 a	0.0
Spray	Buried	4.1 b	13. 1c	24.0 c	60.5 a	0.0
Spray	Sprinkler	86.4 b	52.1 a	145.3 b	42.6 b	0.0
Chemigation	Surface	8.3 b	10.8 c	26.9 c	56.6 a	0.0
Chemigation	Buried	5.8 b	10.1 c	24.4 c	52.1 ab	0.0
Untreated	Surface	16.6 b	11.3c	41.1c	59.1 a	0.0
Untreated	Buried	16.5 b	14.1 c	46.1 bc	51.9 ab	0.0
Untreated	Sprinkler	243.4 a	38.4 b	297.6 a	42.3 b	0.0
LSD (P=0.05)		90.6	10.6	102.6	10.1	---
Treatment Prob (F)		0.0002	0.0001	0.0001	0.0029	---
Main effects of Kerb application						0.0
Spray		30.8 b	25.8	328.9	54.5	0.0
Chemigation		7.0 b	10.4	300.1	54.4	0.0
Untreated		92.2 a	21.3	347.7	51.1	0.0
Anova						---
Kerb application		0.0177	0.2589	0.6925	0.3343	---
Main effects of Irrigation method						
	Surface	8.9 b	11.3b	286.5 b	58.7 a	0.0
	Buried	8.8 b	12.5 b	290.7 b	54.8 a	0.0
	Sprinkler	164.9 a	45.3 a	449.1 a	42.4 b	0.0
Anova						---
Irrigation method		<.0001	<.0001	<.0001	<.0001	---

[1] Number of seedlings in 10 feet of a single plant line

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

Table 2. Number of weeds per 45 ft^2 on two dates

Material	Material/A	a.i./A	Purslane		Shepherd's Purse		Burning Nettle		Total Weeds	
			8/3	8/31	8/3	8/31	8/3	8/31	8/3	8/31
Kerb 50W	2.0 lbs	1.0	12.0	2.5	2.3	1.0	6.3	1.3	23.7	7.3
Kerb 50W	4.0 lbs	2.0	11.0	2.3	1.0	0.8	6.5	0.3	22.2	6.5
Prefar 4E	3.0 quarts	3.0	1.5	5.8	1.8	0.5	2.5	0.8	9.0	8.5
Prefar 4E	6.0 quarts	6.0	0.3	3.8	1.5	0.3	1.0	0.0	6.0	4.5
Kerb 50W Prefar 4E	4.0 lbs 6.0 quarts	2.0 6.0	0.3	1.8	1.8	0.0	1.0	0.3	7.3	3.5
Untreated	---	---	25.5	43.5	1.0	0.3	7.3	1.5	37.8	45.8
LSD (0.05)			7.7	13.4	n.s.	n.s.	3.7	0.9	8.6	13.2

Table 3. Analyses of Kerb in soil on August 1.

Soil Depth	2.0 lbs a.i./A Kerb Treatment ppm Kerb	Percent of 2.0 lbs a.i./A Kerb application at each soil depth[2]	Untreated[1] Treatment ppm Kerb
0.0 – 0.5 inch	7.53 a	62.5	0.0
0.5 – 1.0 inch	0.70 b	5.5	0.0
1.0 – 1.5 inch	0.48 b	4.0	0.8
1.5 – 2.0 inch	0.30 b	2.5	0.0
LSD (0.05)	2.71	---	---

1 – One replication sampled; 2 – a total of 74.5% of the 2.0 lb a.i./A application was recovered in the top 2.0 inches of soil.

Weed Management in Intermountain Alfalfa and Grass Hay

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Forages, primarily alfalfa, grasses and mixed planting of alfalfa and grasses, are important crops in the intermountain area of Northern California occupying the majority of the irrigated acreage in the region. The intermountain alfalfa and grass hay production area is unique compared with other production areas in California. The growing season is shorter and cooler and the winter is much colder than in the Central Valley and desert areas of California. Therefore, alfalfa is typically only harvested three to four times per season and grass hay crops are cut three times. Hay destined for the dairy and horse markets must be nearly weed-free—a difficult accomplishment given the broad spectrum of weeds encountered in many fields.

The intermountain environment creates some unique weed control issues and challenges. The primary issues are the following: timing of herbicide application timing for winter annual weed control in established alfalfa, summer annual weed control, weed control in mixed stands of alfalfa and orchardgrass, and weed control in grass hay fields. Trials were conducted over the past several years in Siskiyou and Lassen Counties to address these issues.

Application Timing for Winter Annual Weed Control in Established Alfalfa

Unlike other areas of California, alfalfa in the intermountain area goes completely dormant over the winter and visible growth ceases for several months. During mid winter, frozen soil and/or snow can preclude herbicide applications. In late winter, inclement weather and windy conditions make herbicide applications difficult often delaying applications into early spring, mid- to late-March. The question arises as to whether it is better then to make applications in late fall, late winter or early spring. To evaluate which of the three timings is superior, a series of trials were established where herbicides were applied in November, January-February, or mid March. The herbicides evaluated in the fall timing included hexazinone (Velpar), diuron (Karmex), and metribuzin (Sencor). Those same herbicides plus a Karmex and Gramoxone tank mix were applied in late winter. The same herbicide applied in late winter were applied in early spring except an imazamox (Raptor) treatment replaced the Karmex alone treatment.

The late winter (late January-February) treatment timing generally provided the best weed control. Figure 1 shows the results for shepherdspurse, but other weeds responded similarly. The fall application may be less effective because at the rates tested the herbicides may not have enough soil residual to control late-emerging weeds, especially with the amount of rainfall received in the years we conducted the study. Weed control with a March application was generally less than the late-winter application timing because by this time the weeds were larger and more difficult to control. Another problem with mid to late March applications is that oftentimes there is insufficient rainfall after application to incorporate the herbicides.

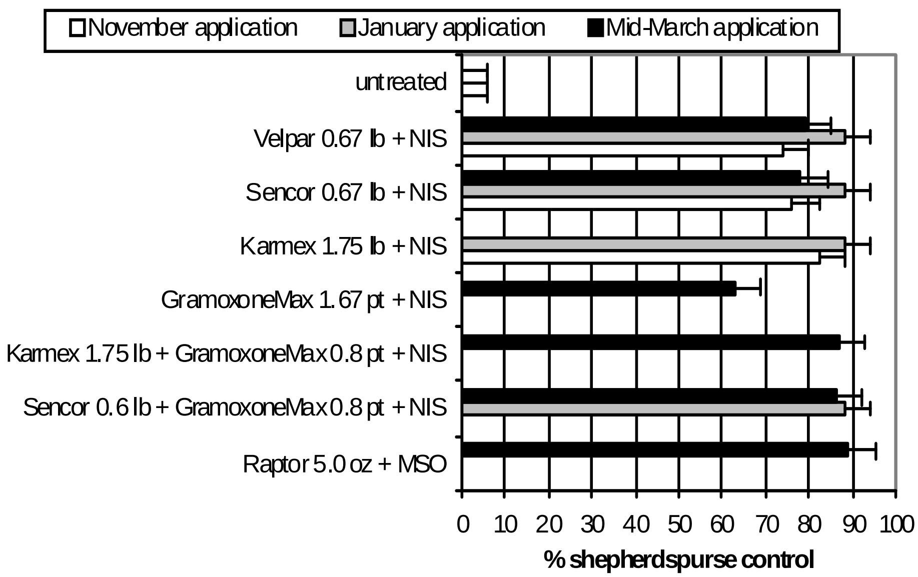

Figure 1. The effect of application timing on shepherdspurse control in established alfalfa.

Another major drawback of spring applications is that they are more injurious to the alfalfa. These studies demonstrated that late winter is the preferred herbicide application timing to maximize weed control while minimizing alfalfa injury.

Summer Annual Weed Control

Summer annual weeds (such as summer foxtails, lovegrass, and pigweed) can be problematic in established alfalfa fields in some areas of the Intermountain Region. This is especially the case in older fields where the alfalfa stand is less competitive with weeds. Alfalfa stand life in the intermountain area is longer than other areas in California—typically 5 to 7 years—due to the environment and lack of profitable rotation crops.

Trifluralin (Treflan) is often used to control summer annual grasses in established alfalfa. However, in the Intermountain area summer annual weeds only infest the second and third cuttings making it more difficult to justify the cost especially since Treflan granules require a separate application. Research was conducted during the 2007 growing season to evaluate the effectiveness of pendimethalin (Prowl H2o) for summer annual weed control. As a liquid, Prowl can be tank mixed with the standard herbicides used for winter annual weed control. A trial was established where Prowl was tank mixed with Velpar, Sencor or Gramoxone at 1.9 or 3.8 pounds active ingredient per acre. Combining Prowl with the dormant herbicides resulted in a slight increase in the control of the winter annual weeds. This was surprising because the weeds were already emerged at the time of application and Prowl is generally not effective on the winter weed spectrum. Prowl provided effective control of the summer annual weeds (both green foxtail and pigweed). The higher rate was needed for near perfect control but this may have been due to the low alfalfa stand density in the trial affording little competition to the weeds. The overall most effective treatment for the control of both winter and summer annual weeds was a tank mix of Velpar and Prowl. These results are promising because they demonstrate that season-long control of both winter and summer annual weeds may be feasible with a single application of herbicides.

Weed Control in Mixed Stands of Alfalfa and Orchardgrass

Alfalfa/grass mixtures have become very popular in the Western U.S. due to a strong horse-hay market that often prefers mixed hay over pure alfalfa. Excellent weed control is needed to produce the quality of hay desired by horse owners. A dense vigorous stand competes well with weeds so in many cases weed problems in alfalfa/grass mixtures are the result of poor stand and/or improper irrigation, fertility, or harvest management. Alfalfa density thins in an aging stand and the grass component, typically orchardgrass, becomes more dominant. While a 50:50 mixture of alfalfa was considered optimum in the past, a higher proportion of grass has become acceptable, or even preferred, by some horse owners allowing growers to keep the stand in production longer. Weeds have become more of a problem in these older stands.

Weed control in mixed alfalfa/grass stands is challenging, as the herbicides must be safe to both species. Several herbicides including Velpar, Sencor, Gramoxone, Pursuit, Raptor and MCPA were evaluated in the Intermountain Region with two treatment timings (late-November to early December and early March). The most effective treatment was Sencor DF at 0.5- 1.0 lb/A plus non-ionic surfactant applied in late fall. This treatment provided excellent weed control and very little injury to either the alfalfa or the orchardgrass. Prior to conducting this research, it was thought that Gramoxone would be an effective treatment thinking that Gramoxone would only cause temporary “burn-back” of the orchardgrass and alfalfa foliage. However, it was found that Gramoxone alone or in combination with other herbicides was much more injurious to the orchardgrass than expected and caused yield reduction and even stand loss. In contrast to the results with pure alfalfa, a fall application to alfalfa/orchardgrass was preferred. The herbicides were more effective for grass control when applied pre-emergence and long soil residual was not as important as with pure alfalfa because the orchardgrass resumes growth earlier in the spring and shades the soil. Pursuit plus methlyated seed oil applied shortly after green-up provided good control of emerged mustards and excellent selectivity to both alfalfa and orchardgrass. Currently, Sencor is the only one of these herbicides with specific label instructions for use in mixed alfalfa/grass stands.

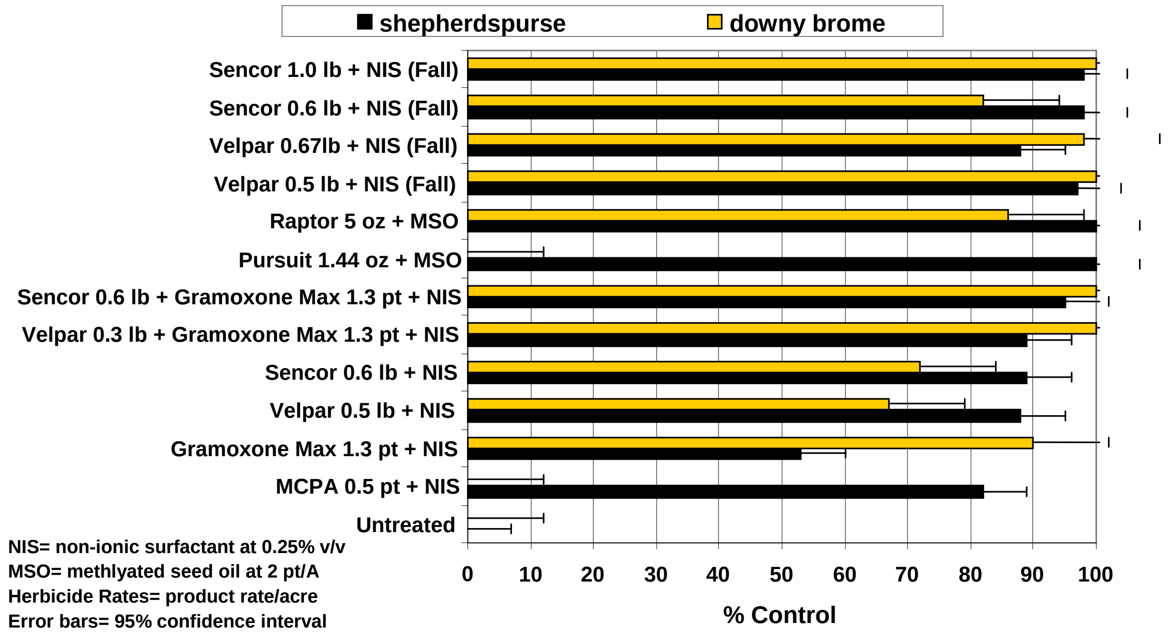

Figure 2. Shepherdspurse and downy brome control in alfalfa/orchardgrass with fall or early March herbicide applications (data combined over years and sites).

Weed Control in Grass Hay Fields

Pure grass hay has become very popular for the horse market. A dense vigorous stand of grass is an outstanding competitor with weeds. Adequate nitrogen fertilizer throughout the growing season improves grass vigor helping to reduce weed problems. Besides dramatically increasing yield and forage quality, nitrogen speeds growth in the spring and after cutting minimizing the chance for weed encroachment. If grass stands become patchy and depleted, reseed to thicken the stand because weeds quickly invade bare areas in the field.

Even with a good stand, herbicides are sometimes needed and they offer an effective and undisruptive weed control option. Several herbicides are labeled for use in grass hay for broadleaf weed control. These herbicides are best applied in spring, fall, or between cuttings when annual weeds are in the seedling stage. For control of most perennial weeds, target herbicide applications in late spring when they are flowering or in fall to new re-growth. Controlling grassy weeds in grass hay is far more problematic and current research is underway to evaluate potential herbicides and to determine their safety to different grass hay species.

Factors Affecting Glyphosate Efficacy of Horseweed (Conyza *canadensis*) and Hairy Fleabane (Conyza *bonariensis*)

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Abstract:

Horseweed (Conyza *canadensis*) and hairy fleabane (Conyza *bonariensis*) are troublesome weeds in many agricultural settings. Herbicides applied postemergence are often ineffective due to its woody-like stalks and lack of leaf surface area. Previous research has indicated that fall applications of postemergence herbicides provide the best control. In this study Roundup WeatherMAX® (glyphosate) was evaluated for controlling hairy fleabane at four growth stages and four rates. Horseweed was evaluated at three different growth stages and three application rates. Trials were conducted in 2006 at the CSU-Fresno Farm and in 2007 at commercial peach and plum orchards located in south Fresno and central Tulare counties. In conjunction with rate and growth factors, a nozzle and spray volume study was conducted for each species to compare efficacy of glyphosate. Glyphosate was applied at a single rate of 1.0 lbai acre^{-1}, targeting a single growth stage (bolting >6 inches) and applied at three spray volumes (10, 20 and 30 gpa). Three nozzle types were evaluated: TwinJets (TJ60-8001 and TJ60-8003) and XR TeeJets (11001, 11002 and 11003) from Spraying Systems, Inc., and Air-Bubble Jets (11001, 11002 and 11003) from Billericay Farm Systems. Hairy fleabane and horseweed control was evaluated visually for all experiments. Glyphosate applied at 0.5. 1.0, 1.5 and 2.0 lbai acre^{-1} provided similar control of hairy fleabane at the early and late rosette stages. Hairy fleabane control decreased significantly after bolting, especially at the lower rates (0.5 and 1.0 lbai acre^{-1}). Control measures are best applied at the early growth stages for horseweed. Horseweed control by glyphosate decreased significantly as growth increased from early rosette to bolting >6 inches. Glyphosate applied in low spray volumes (10 gpa) provided greater control of horseweed and hairy fleabane as compared to higher spray volumes (20 and 30 gpa). Comparison of nozzle types suggested that control of horseweed and hair fleabane was superior using TwinJet nozzles at low spray volumes (10 gpa).

Key Words: AMS, Ammonium Sulfate, carrier, Conyza *bonariensis*, *Conyza canadensis*, glyphosate, hairy fleabane, horseweed, lbs ai acre^{-1} (pounds active ingredient per acre), marestail, replicate, Roundup WeatherMAX, Touchdown.

Spatial Pattern of Glyphosate Resistance in Ryegrass in Yolo County

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Abstract

In 1996, approximately 20 years after the introduction of the herbicide glyphosate, the first glyphosate-resistant weed, rigid ryegrass, was identified in Australia. Today, glyphosate-resistant weed populations have been identified in 12 species and 11 countries. The proliferation of glyphosate-resistant weeds is impacting both agriculture and the environment by increasing the concentration and number of herbicides required to control weeds. Preventing both the evolution of new glyphosate-resistant weed populations and preventing the spread of currently resistant populations is now an important task for weed scientists. Annual ryegrasses (both rigid and Italian) are the most notorious glyphosate-resistant weeds with populations on 5 continents evolving glyphosate resistance. The first ryegrass population with glyphosate resistance in North America was identified in 1998 in an almond orchard near Chico CA. Today, many weedy ryegrass populations throughout the Central Valley are reported to contain glyphosate-resistant plants. Identifying which populations are most resistant relative to land and weed management practices may help farmers and managers design control strategies for resistant weeds and prevent further evolution and spread of glyphosate resistance. We worked on identifying which environments have the highest concentration of herbicide resistant individuals. In the summer of 2006, we surveyed weedy ryegrass populations within Yolo County for glyphosate resistance. We found, unsurprisingly, that ryegrass populations in environments with glyphosate application had higher frequencies of glyphosate-resistant individuals. We also found that in those environments where glyphosate was applied, roadsides had populations with higher frequencies of glyphosate-resistant individuals than agricultural fields. We also found that populations in fields adjacent to roads had higher frequencies of resistant individuals than their more secluded counterparts. Our results suggest that roadsides in Yolo County may often be reservoirs of glyphosate-resistant ryegrass. Thus, controlling glyphosate-resistant ryegrass populations along public roads may limit the spread of glyphosate resistance in agricultural fields.

Vines and Ovines: Using SHEEP with a trained AVERSION to grape leaves for spring VINEYARD floor management.

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Traditional vineyard floor management practices have limitations and potentially undesirable consequences. Herbicide applications can reduce surface and ground water quality, especially when applications are made during the rainy season. Volatilization and drift can damage developing grape buds and shoots if applications are made after bud emergence. Mowing and tillage are commonly utilized in late winter or early spring, but can be delayed if excessive rain prevents tractor access into the vineyard. Such delays can affect vine development by allowing vegetation to compete with the vines for soil nutrients and by increasing the risk of frost damage.

Sheep grazing is a cultural practice to manage the vineyard floor that is growing in use and acceptability. Several vineyards in California's wine growing regions have been experimenting with sheep grazing and have adopted the practice to supplement other floor management practices. Sheep can eliminate the need for herbicides, and they can be used in vineyards rain or shine. Currently, the biggest impediment to their use is the fact that sheep like to browse the spring growth of grapevines. Some vineyards work around this problem by using Babydoll Southdown sheep, which are too short to reach the vines. Vineyard managers are pleased with the results, but the use of these miniature sheep is very limited due to their rarity and consequent high price. Other vineyards are using normal commercial sheep, but only by placing electric fencing around each vine row or by limiting grazing to times of the year when the vines are not susceptible to sheep damage, such as between the time of harvest and the emergence of new spring growth.

Training sheep to have a dietary aversion to grape leaves will extend the time sheep can graze in vineyards through the spring months when weed and cover crop vegetation grow most vigorously. Expanding the time during which sheep can graze in vineyards should make this practice attractive to more growers. Sheep grazing is a reduced risk alternative to herbicide applications and is an attractive option for sustainable, organic and biodynamic grape production programs, which are becoming more popular among wine grape producers and consumers.

Our project team conducted two research trials from June 2006 through June 2007 at the University of California Hopland Research and Extension Center. The first trial tested the persistence of a grape leaf aversion induced by two different methods of orally administering lithium chloride (LiCl) to sheep. In the second trial we grazed vineyard plots with the trained and untrained sheep in the spring of 2007 and compared the browsing impacts on the vines.

<u>Aversion Trial</u>

The aversion training was conducted in barn corrals and followed the procedures and recommendations obtained from Dr. Fred Provenza and his colleagues at Utah State University and their BEHAVE program. In June 2006, sixty ewe lambs were divided into three groups of twenty. Sheep in each group were presented with fresh grape leaves for ten minutes, which was sufficient time to consume an average of 135 bites per sheep. Immediately following the grape leaf consumption, one group of sheep was orally administered LiCl (150 mg/kg body weight) in gelatin capsules (Capsule group), the other group was orally administered the same dose of LiCl in a liquid solution (Drench group), and sheep in the third group were orally administered either an empty gelatin capsule or water (Control group).

We tested the aversion at intervals of one day, one week, one month, two months and nine months after the initial aversion training. The one-day test revealed a very weak aversion in the trained groups. We then allowed the "trained" sheep to consume more grape leaves, followed by a second and larger dose of LiCl (175 mg/kg body weight). All the subsequent aversion tests indicated a very strong aversion in both the capsule and drench groups and normal grape leaf consumption in the control group.

<u>Vineyard Grazing Trial</u>

The vineyard grazing trial occurred between the months of March, April and May of 2007, with one grazing event per month. The trial was structured as a complete randomized block design with four treatments and four replicates per treatment.

Treatment 1: No vine row or middle management.
Treatment 2: Normal vine row and middle management (chemical and mechanical).

Treatment 3: Vine row and middle grazed by untrained sheep.
Treatment 4: Vine row and middle grazed by trained sheep.

Each replicate plot was approximately 0.05 acres and included 16 or 17 grape vines. Sheep from the capsule and drench groups in the aversion trial were comingled and randomly assigned into two equal groups of trained sheep and used for the vineyard grazing treatments along with the control group as the untrained sheep.

A strategy of high density and short duration grazing was used to quickly graze the vineyard floor. Approximately 16 ewes (100 lb. average weight) grazed each plot for a 10 to 12 hour period, equaling a stocking density of 53 animal units (AU) per acre. The stocking period did vary according to the amount of floor vegetation. Sheep were removed once they appeared to have consumed all the palatable forages.

Although the data analysis for the grazing trial is not complete, we do have some preliminary results and anecdotal observations to present in this paper. An important finding we learned with the March grazing event is that the trained sheep were not averted to developed grape buds. Damage to the very small buds was minimal, but increased as the size and maturity of the buds increased. We suspect that the buds have a different flavor than mature grape leaves, to which the sheep were averted, leaving the buds vulnerable to damage by trained and untrained sheep. This can be avoided by grazing the sheep well before bud emergence and not returning the sheep to the vineyard until mature leaves are present on the vines.

The April and May grazing events demonstrated that the trained sheep had almost no impact on the grape vines while the untrained sheep removed much of the foliage within reach. We estimated that an average of 50% of the combined length of all vine shoot material was damaged by the untrained sheep. This trial also showed that the amount of vineyard floor vegetation in the grazed treatments at the end of the May grazing event was comparable to the treatment with normal floor management.

This project demonstrates that sheep with a trained aversion to grape leaves can be used for spring vineyard floor vegetation management without damaging the grape vines. Also revealed are many factors that must be addressed in future research before developing a complete set of recommendations to commercial practitioners. Some of the more salient topics that deserve future investigation include the determination of forage conditions that cause sheep to lose the aversion, regulations on the use of LiCl in livestock consumed by humans, a cost analysis on the use of sheep for vineyard floor vegetation management, the long-term effect of sheep grazing on soil quality and on grape vine health.

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Vineyard Weed Management Practices Influence Soil Nitrogen Retention

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Cultivation has been shown to reduce soil organic matter content and labile carbon pools, which are important factors in soil nitrogen (N) retention. Cultivation also causes changes in soil bulk density, effecting changes in soil porosity which can influence soil water and nutrient movement. Using herbicides for weed control instead of cultivation avoids the soil disturbance caused by cultivation. Therefore, we hypothesized that soil N dynamics would differ between these weed management practices. We also investigated the effects of the two weed management practices (i.e., cultivation and herbicide) on soil N dynamics during a fertigation event.

We tested this hypothesis in a Chardonnay vineyard planted on Teleki 5C rootstock in Greenfield, Monterey Co., CA. In the cultivated treatment ('Clemens'), the Clemens® vineyard cultivator was used to mechanically cultivate the vineyard rows as needed during the season (i.e. 4-6x). In the herbicide treatment ('Standard'), simazine (2.0 lbs a.i./A) + oxyfluorfen (1.5 lbs a.i./A) was applied in the winter. In summer, post emergence applications of 2% glyphosate + 0.25% oxyfluorfen were applied as needed. These treatments had been established and repeated annually four years prior to the current study as part of a separate experiment. Thus, the current study occurred during the fifth year of this original study. In November 2005, emitters on one side of each grapevines (4 total in each treatment) were plugged, leaving one emitter open on the opposite side of the grapevine. At this time, soil characteristics were characterized to a depth of approximately 1-1.5 meters. These included cation exchange capacity, exchangeable cations (X-cation) (i.e., X-Mg, X-Ca, X-K), total carbon (C) and N, bulk density, inorganic N pools [i.e., ammonium (NH_4^+-N) and nitrate (NO_3^--N)], and soil texture. Anionic resin bags were inserted at 1 m depth to determine the amount of inorganic N moving through the soil profile from November 2005 to November 2006. At the conclusion of the experiment in November 2006, soil bulk density, dissolved organic C, potential soil respiration as a measure of labile C pools and inorganic N pools were measured in the soil profile. During the main fertigation event in July 2006, soil inorganic N pools, nitrous oxide (N_2O) efflux, and soil moisture were documented in the upper 20 cm of the soil profile. The vineyard was fertigated at a rate of 28.32 lbs. N per acre (UN32: 32% total N, of which was 44.3% NH_4NO_3 and 35.4% Urea). The soil type was the Elder loam with gravelly substratum (Coarse-loamy, mixed, superactive, thermic Cumulic Haploxeroll).

We found that most soil characteristics varied with soil depth, but few differences occurred between the 'Clemens' and 'Standard' treatments. Cation exchange capacity ranged between 15.1 – 17.2 $cmol_c\ kg^{-1}$. Exchangeable Mg ranged between 3.4 $cmol_c\ kg^{-1}$ and soil pH ranged from 7.6 – 7.7. The only noted difference was in total soil C, which was approximately 0.8% g C g^{-1} in 'Clemens' and only 0.7% in 'Standard' in the upper 20 cm. Exchangeable K was greater in the upper 30 cm (ca. 0.44 $cmol_c\ kg^{-1}$) than the lower depths (ca. 0.21-0.28 $cmol_c\ kg^{-1}$, 30-105 cm). Also, total soil N decreased with depth, ranging from 0.063-0.078% g N g^{-1} in the upper 30 cm, and 0.051-0.056% g N g^{-1} in the lower depths (30-105 cm). Bulk density decreased with increasing depth, but did not differ between treatments. Soil texture among all depths and treatments was approximately 60% sand, 25% silt, and 15% clay.

During the fertigation event, soil gravimetric water content in the upper 20 cm decreased from 30% to 15% over three days, remaining at a similar value for the subsequent two weeks. Soil ammonium concentrations increased to 80-100 μg NH_4^+-N during the first three days after irrigation, decreasing over the next two weeks to pre-fertigation levels, and no difference between treatments was observed. Soil nitrate concentrations were greater in 'Standard' than 'Clemens' three days after irrigation, increasing to approximately 75 μg NO_3^--N g^{-1} in 'Standard' and 40 μg NO_3^--N g^{-1} in 'Clemens'. In both treatments, these values decreased to pre-irrigation concentrations after approximately 10 days, and then showed small increases to approximately 20 μg NO_3^--N g^{-1}, potentially due to upward movement of soil nitrate during soil drying or mineralization of urea. Nitrous oxide efflux was greater in the 'Standard' than 'Clemens'. At its greatest efflux rate after fertigation, which occurred one day after fertigation, N_2O efflux from 'Standard' was approximately 4.3 μg N_2O-N m^{-2} s^{-1} while it was about 2 μg N_2O-N m^{-2} s^{-1} in 'Clemens'. Nitrous oxide efflux decreased thereafter, reaching pre-irrigation values ten days after fertigation in both treatments. There were no noted changes in soil N pools and water content in soils where the emitter had been plugged.

When soil resin bags were removed in November 2006, inorganic N concentrations were greater in the 'Standard' than 'Clemens'. The resin bags in 'Standard' had collected approximately 1300 μg NO_3^--N while in 'Clemens' they had <1 μg NO_3^--N, indicating that less NO_3^--N had reached that soil depth. This suggests that the 'Clemens' treatment had increased soil N retention than the 'Standard'. Preliminary estimates suggest that approximately 4-10% of the total N added to the vineyard soil during the growing season was captured by the resin in 'Standard'.

These preliminary findings suggest that weed management practices had impacts on N_2O efflux as well as soil N retention. Few differences in soil characteristics that are often linked to movement (i.e., bulk density) and retention (i.e., soil C content, DOC, labile C by respiration) of soil N were detected in the two treatments. We suggest that the increased weed biomass (K. Steenwerth, personal observation) and weed frequency (R. Smith, personal communication) underneath the grapevines in 'Clemens' captured some fraction of the fertilizer-derived N. Interestingly, it appears that the grapevines did not show any clear response to these respective weed treatments in the four years prior to this experiment (L. Bettiga and R. Smith, personal communication). In addition, total C was greater in the 'Clemens' than 'Standard', suggesting that the 'Clemens' soil may support greater soil microbial biomass, which could then immobilize relatively greater soil N within their biomass than in 'Standard'. In conclusion, the 'Clemens' treatment provided an unexpected service of increased soil nitrogen retention. Further study is required to quantify the role that weeds play in N retention, the temporal dynamics of decomposition and N release, and potential long-term effects on grapevines in the 'Clemens' system.

Competitive Effects of Glyphosate-Resistant and Susceptible Horseweed with Young Grapevines and Established Vineyards

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Horseweed *(Conyza canadensis)* is an annual weed in the Asteraceae family that has recently became a major pest in San Joaquin Valley vineyards. A glyphosate-resistant (GR) biotype of horseweed was confirmed in California in 2005, from the banks along an irrigation canal in the central San Joaquin Valley. Studies have shown that the GR biotype flowers earlier and accumulates more biomass than the glyphosate-susceptible (GS) biotype of horseweed. This disparity in phenology and growth led us to hypothesize that the GR biotype may be more competitive than the GS biotype. To evaluate the competitive effects of both GR & GS biotypes of horseweed on grapevine, we conducted two experiments in 2006 and 2007. The goal of the first experiment was to compare the respective competitive abilities of GR and GS horseweed biotypes on one-year old grapevine in a greenhouse setting. Among the response variables measured were grapevine shoot length, dry vegetative biomass, chlorophyll levels, leaf number and leaf area. The goal of the second experiment was to examine the effects of increasing density of GS horseweed on grapevine growth, yield, and fruit quality in an established vineyard. Grape yield and time to harvest were measured. Soluble sugars, titratable acidity and the number of clean clusters per vine were also measured as indicators of fruit quality. Results from the greenhouse experiment showed that young grapevines were significantly affected by competition from either horseweed biotype. Both the GS & GR horseweed reduced grape aboveground dry mass significantly, as well as decreased leaf number, canopy leaf area, and chlorophyll levels in grapevines. However, contrary to our hypothesis, the two biotypes did not differ in their ability to suppress grapevine growth. Both biotypes compete equally with grapevine. Results from the density experiment showed that increasing horseweed densities did not affect grape yield, quality, or the time required to harvest the grapes. There was, however, a negative correlation between weed dry mass and pruning weights which suggests that high densities of annual weeds may reduce vegetative growth of established vines.

Biofuels and Invasive Species

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In response to growing energy demands and climate change awareness, alternative energy sources are being sought. Biomass-derived energy from dedicated biofuel crops is under active research by many nations with exotic rhizomatous perennial grasses as the leading candidates. To be economically viable, biofuel crops are being selected/breed/engineered that are highly efficient (e.g., water, nutrients), tolerate poor growing conditions (e.g., drought, saline and infertile soils), possess few resident pests, and produce highly competitive monospecific stands. These desired agronomic traits, however, typify much of our invasive flora, and pose a potential threat of some biofuel crops becoming invasive pests. To test the potential invasiveness of leading biofuel candidate crops, including switchgrass, giant reed, and miscanthus, we used the standard Weed Risk Assessment protocol to qualify their risk potential under various assumptions. In addition, we are conducting ecological studies of fitness responses to various environmental and disturbance scenarios, which will provide data in climate-matching models to predict the potential invasiveness of biofuel species in a variety of ecosystems. Breeding and genetic engineering for enhanced environmental tolerance (e.g., drought tolerance), increased harvestable biomass production (e.g., lower root-to-shoot ratio), and enhanced energy conversion through fermentation (e.g., lower lignin content) may have unexpected ecological consequences outside the agronomic framework. For example, using the WRA protocol, switchgrass was found to have a high invasive potential (‘reject’) in California, unless sterility was introduced (‘accept’). The potential societal benefits of a biologically-based energy supply are great, but the introduction and development of biofuel crops should be conducted to minimize the risk of these proposed feedstock species escaping cultivation and causing economic or environmental damage.

Herbicide Control and Revegetation of Medusahead Sites in Northeastern California

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The invasion of non-native annual grasses is considered by many private and public range managers to be one of the most serious pest problems in the West. These species dominate more than 130 million acres throughout California, Idaho, Oregon, Nevada, Washington, and Utah and continue to rapidly spread. Medusahead dramatically reduces plant diversity and richness, shrinks wildlife habitat, decreases livestock forage by 50-80%, and promotes out-of-control wildfires. Annual grass invasion is also a major obstacle for successful implementation of several Great Basin range projects including sage grouse habitat restoration, juniper removal, wildfire rehabilitation, and improving rangeland carry capacity. This project evaluated herbicide efficacy for medusahead control in big sagebrush rangeland. It also examined when native and introduced perennial grasses common to Northeastern California can be re-seeded following herbicide application.

Herbicide Efficacy for Medusahead Control

Fall applications of Matrix at rates ≥ 4 oz/A, Landmark XP at 1 oz/A, Oust at 1 oz/A, and Plateau at 6 oz/A gave >95% control of medusahead and Japanese brome. Fall (pre-emergence) application of Matrix provided better medusahead control compared to early spring (post-emergence) application. Low rates of glyphosate (Roundup Original 4L) at rates ≤ 16 oz/A applied in early spring (post-emergence) failed to give > 80% control of medusahead, but in other trials where the site was tilled before herbicide application, 1 qt/A of Roundup Original applied in early spring gave 100% control. Matrix at rates ≤ 6 oz/A and Plateau at 6 oz/A were safe on established squirreltail and California brome. Landmark XP, Oust, and Roundup at 16 oz/A caused > 50% injury to these perennial grasses.

Perennial Grass Plant-Black Safety Following Herbicide Application

Matrix, Landmark XP, and Plateau reduced perennial grass cover and yield compared to the untreated control when grasses were spring-seeded 4 months after winter herbicide application. The herbicides' reduction in spring-seeded grass yield differed between grass species and ranged from 34 to 84% for Matrix at 4 oz/A, 65 to 98% for Matrix at 8 oz/A, and 50% to 97% for Plateau at 6 oz/A five months after planting. None of the spring-seeded grass species established in plots treated with Landmark XP at 1.5 oz/A. Delaying perennial grass seeding a full growing season after herbicide treatment increased herbicide safety. When grasses were fall-seeded 8 months after herbicide application, Matrix at 4 and 8 oz/A and Plateau at 6 oz/A did not decrease seedling grass cover compared to the untreated control. Landmark XP at 1.5 oz/A reduced fall-seeded grass cover compared to the untreated control for all grass species, but Landmark's injury to fall-seeded perennial grasses was less compared to the earlier spring seeding. It is important to note that Landmark XP at 1.5 oz/A is a high rate, and Landmark XP rates between 0.75 and 1.0 oz/A gave effective annual grass control in previous trials.

Out-Competing Roadside Weeds with Native Plants

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Rural roadsides in every part of the state are predictable nurseries and reservoirs for a broad array of invasive weeds and seeds. Typical roadside management programs, whether sponsored by county road departments or managed by adjacent landowners commonly involve spraying, scraping and/or discing. If county road departments are tasked with doing this, there is typically a significant investment in equipment such as scrapers, the personnel to operate them, and in keeping those personnel busy cycling through the county from one road to the next and back again. This investment in equipment and the personnel to operate it can be a significant barrier to different approaches.

Current water quality improvement requirements throughout the state are forcing a new look at how to manage roadside weeds with reduced chemical input. The Yolo County RCD has more than a decade of experience with managing rural roadsides using California native grasses for multiple benefits. Detailed methods are explained in the RCD publication "Bring Farm Edges Back to Life," which can be viewed on-line at the above-listed website, publication page 19. Tables below have been excerpted from this publication.

The battle against recurrent roadside weeds is un-winnable, given the current approach. Continuing with current methods promotes replanting of weed seeds and repeating the same measures the following year. It produces herbicide-resistant weeds over time and releases pesticide runoff into regional waterways. Wherever soil is left bare, something will try to grow. A more effective approach involves planting something on those roadsides that is desirable, that will compete effectively with annual weeds, something that will not require extensive annual spraying, discing or scraping and will not be invasive to neighboring areas.

California native perennial grasses are excellent candidates for use in this kind of system and can provide additional benefits beyond weed management. Native perennials are long-lived. Once established individual plants can live ten years or more and can re-seed themselves in the interim. They can provide dense soil coverage, competing with annuals for sunlight and soil nutrients. Their roots are deep – sometimes four to six feet – compared with annual weeds whose roots can be only inches deep, and can assist with greater storm water penetration and reduced runoff. Native grasses can provide habitat for native wildlife and insects that can benefit the neighboring land.

Establishing a native roadside is very similar to planting a new alfalfa field, pasture or lawn and does not require any new tools. Begin in spring by eliminating as many of the existing weeds as possible through a combination of approaches such as repeated discing, burning, spraying and/or mowing, with a focus on preventing new weed seed from being set. If possible, re-grade the slope of the roadside ditch from that shown in Figure 1 to improve safety and to promote ease of maintenance.

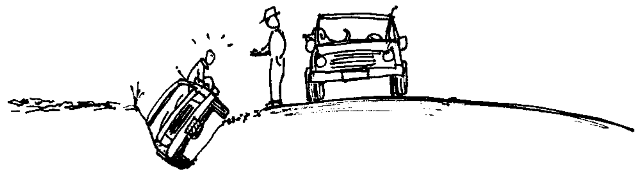

Figure 1

In the fall, after the first good seed-germinating rain, disc under the new weed seedlings. Prepare a fine seedbed and broadcast a native grass seed mix that is designed for your area. Lightly harrow the seed in. Example mixes for different strips are shown in figure 2, below. If there is no roadside ditch, a single seed mix could be used.

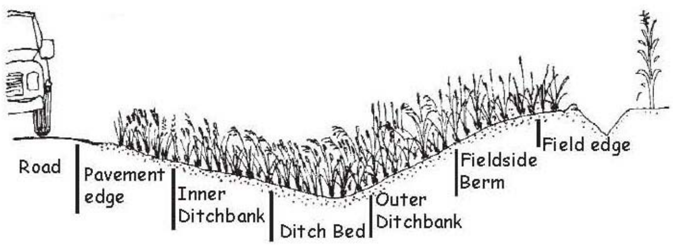

Figure 2

Pavement edge: California barley (Hordeum californicum), Pine bluegrass (Poa secunda), Purple needlegrass (Nassella pulchra), Nodding needlegrass (Nassella cernua), California oniongrass (Melica californica).
Roadside berm and inner ditchbank: California barley, California oniongrass, Meadow barley (Hordeum brachyantherum), Nodding needlegrass, Pine bluegrass, Purple Needlegrass, and Squirreltail (Elymus elymoides).
Ditch bed: Meadow barley, Purple needlegrass, and sedges and rushes.
Outer ditchbank and fieldside berm:
Deep, Good Soils: Blue wildrye (Elymus glaucus), Purple needlegrass, Slender wheatgrass (Elymus trachycaulus ssp. trachycaulus), California barley, and Deergrass (Muhlenbergia rigens).
Poor Soils: Purple needlegrass, Nodding needlegrass, California barley, and Pine bluegrass.
Field edge: Creeping wildrye (Leymus triticoides).

Native roadsides need attention to maintenance during the first two to three years, just as if you were managing a crop. Thereafter, maintenance should be minimal. The most important maintenance measure is reduction of weed competition while the perennials are getting established. During the first year or two perennials develop a deep root system rather than top-growth, so reducing early competition for sunlight is critical to their survival.

The following three tables provide guidelines and costs for successfully establishing native grasses along a rural roadside. Once the grasses are well established and broadleaf weeds have been reduced to a minimum, native wildflower seed can be scattered among the grasses to enhance the roadside's appearance and diversity. It is advised to consult someone who has had experience with native grass establishment to ensure success. Although initial costs may be high, the pro-rated costs over ten years or more, coupled with the associated improvements in water quality, reduction of pesticide applications, appearance improvement, and wildlife habitat make the benefits clear. Cost-share options are available through the USDA Natural Resources Conservation Service, conservation organizations and local RCD's.

Native Grass Establishment Schedule

Month	Project	Description
Year 1		
March-September	Prepare Seed Bed	• disking in spring and/or burning in fall removes weeds and prepares the soil for planting
September-March	Seeding & First Weed Control	• drill or broadcast and harrow seed • spray glyphosphate on 1st flush of weeds before native grasses emerge
February-March	Broadleaf Weed Control	• spray phenoxy herbicides to eliminate broadleaf weeds in planted area
March-June	Late Grass Weed Control	• mow, hay, or lightly graze planted area to remove annual grasses before they go to seed
Year 2		
October-December	Fall Weed Control	• pre-emergent herbicides (consult Ag Extension) or a broadleaf herbicide after weed emergence
April-June	Spring Weed Control	• broad-leaf herbicides, mowing, burning, or grazing can be used, depending on the weeds that are present
Year 3 and Beyond		
October-November	Fall Weed Control	• pre-emergent herbicide or burning
April-July	Spring or Summer Management of Grasses	• mowing, burning, or grazing (grass lands are healthiest when these management practices are alternated from year to year)

Native Grass Establishment Program Checklist
(reproduce for project reference)

Project/Location______________________________ Date________________

___ Choose a site that will not be awkward to protect and that can be accessed with equipment for maintenance
___ Minimize weed generation and seed production on proposed site for at least one year
___ Order seed (see vendor list)

Year 1 (Summer/1st Fall-2nd Fall)
___ Prepare seed bed by disking in spring and/or burning in fall
___ Kill first flush of fall weeds after early rains
___ Drill or broadcast seed (preferably before December, but sometimes OK as late as March)
___ Spray out weed seedlings that germinate within two weeks of seeding
___ In mid-to-late winter, spray phenoxy herbicides to eliminate broadleaf weeds in planted area (use only herbicides such as MCPA that won't burn perennial grass seedlings)
___ In spring, mow, hay, or lightly graze planted area to remove annual grasses before they produce viable seed (in a wet spring, this may need to be repeated)
___ Late-spring/summer weed control by hoeing, mowing, or with chemicals (as needed)

Year 2 (2nd Fall-3rd Fall)
___ (Optional) Apply pre-emergent herbicides (consult Ag Extension) or a broadleaf herbicide after weed emergence in fall
___ In late winter, spot spray phenoxy herbicides or hoe to eliminate broadleaf weeds in planted area
___ Mow, hay, or lightly graze planted area to remove annual grasses before they produce viable seed (in a wet spring, this may need to be repeated)
___ Late-spring/summer weed control by hoeing or with chemicals (as needed)
___ (Optional) Late spring/summer/fall burn to reduce weed seed production and thatch; timing depends on the available fuel (dry matter to carry a fire) and type of weeds present

Year 3 and Beyond
___ Fall weed control with pre-emergent herbicide or fire
___ Selective hoeing and spot spraying for winter broadleaf and grass weeds
___ Spring mowing, burning, or grazing (grasslands are healthiest when these management practices are alternated from year-to-year)
___ Selective hoeing and spot spraying for summer broadleaf and grass weeds

Grassed Roadside Installation and Maintenance Cost Estimate (1999)

For one mile of roadside, 15 feet wide (approx. 1.8 acres)

	Cost/hr.		Time		Total Cost	
	Low Range	**High Range**	**Low Range**	**High Range**	**Low Range**	**High Range**
Installation						
Earthwork*	$70.00	$70.00	2	8 hrs.	$140.00	$560.00
Bed preparation	50.00	50.00	2	4 hrs.	100.00	200.00
Pre-plant Herbicide		60.00	0	0.5 gal.	30.00	
Labor		10.00	0	2 hrs.		20.00
Spray rig		25.00	0	2 hrs.		50.00
Seeding:						
20-40 lbs./acre for 1.8 ac.	10.00	35.00	36	72 lbs.	360.00	2,520.00
Broadcast/Harrowing Seed	35.00	35.00	2	8 hrs.	70.00	280.00
Total Installation Cost					**$670.00**	**$3,660.00**
Maintenance Costs (first three years):						
Mowing	40.00	40.00	2	2 hrs.	80.00	80.00
Spot spray broadleaf weeds	10.00	10.00	1	3 hrs.	10.00	30.00
Herbicide	22.00	60.00	0.125	0.25 gal.	2.75	15.00
Second mowing		40.00	0	2 hrs.		80.00
Controlled Burn (once in 3 yrs)		10.00	0	7 hrs.		70.00
Annual Cost					**$92.75**	**$275.00**
Perpetual Costs:**						
Mowing	40.00	40.00	2	4 hrs.	80.00	160.00
Spot spraying		10.00	0	4 hrs.		40.00
Herbicide		60.00	0	0.25 gal.		15.00
Controlled burn (ea. 2nd yr. max.)		10.00	0	10 hrs.		100.00
Annual Cost				**$80.00**		**$315.00**
Average annual maintenance cost over 10 years				**$83.83**		**$303.00**

For comparison, standard roadside management in Yolo County (a combination of "blading," spraying, and/or mowing) costs between $140 and $490 per year depending on the roadside and management system. This does not include the secondary weed control costs to landowners or downstream water quality problems.

* Depending on your roadside's existing configuration, there may be minimal or extensive re-grading required. This grading estimate assumes work done by a county roadside blade operator (in which case, the cost is theirs).

** The degree of long-term maintenance can depend on the individual landowner's tolerance for *some* weeds or no weeds

Biological Control of Russian Thistle (Tumbleweed)

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Abstract

Russian thistle (*Salsola tragus*) is an important alien weed that first appeared in the 1870s and has invaded about 100 million acres in the western U.S. Tumbleweeds invade fallow fields, clog irrigation systems, are hazardous to automobile traffic, spread wildfires and harbor insect pests that transmit viruses to many vegetable crops. Two moth biological control agents that were introduced in the 1970s have became widely established, but they are not providing sufficient control. We have evaluated several prospective new agents of this weed and have rejected two of them because they are not sufficiently host specific. A petition was submitted to the USDA-APHIS Technical Advisory Group (TAG) in Dec. 2004 requesting permission to release the blister mite (*Aceria salsolae*) to control Russian thistle. A seed-feeding and stem-boring caterpillar, *Gymnancyla canella*, is undergoing a third year of host-specificity evaluation in Albany. Two interesting weevils (*Anthypurinus biimpressus* and *Baris przewalskyi*) have been discovered during foreign exploration in Tunisia and Kazakhstan. These new biological control agents should help reduce the populations of this weed to innocuous levels over extensive regions. Successful biological control would provide self-perpetuating long-term management of this weed, reduce the need to apply pesticides, and increase the productivity and utility of millions of acres in the western U.S.

Russian thistle (tumbleweed, *Salsola tragus*, Chenopodiaceae) is an alien weed that first appeared in North America in Bonhomme county, South Dakota in 1874, and has invaded about 100 million acres in the western U.S. Because it is alien and is not closely related to any native North American species, it has been targeted for classical biological control (Goeden and Pemberton 1995, Pitcairn 2004). The plant is native to central Asia and historically has been called *S. australis*, *S. iberica*, *S. kali*, and *S. pestifer* (Mosyakin 1996, 2003). Similar weedy species in North America include *S. paulsenii* (barbwire thistle), which occurs primarily in desert habitat, and *S. collina* (slender Russian thistle), which occurs east of the Rocky Mountains. Recent botanical studies using morphological characters and molecular genetics have revealed the existence of two newly described species. *Salsola australis* (sometimes called "type B") apparently originates from Australia and occurs in the San Joaquin Valley and southern coastal zone of California. *Salsola* x *ryanii* is a hybrid between *S. tragus* and *S. australis* (F. Hrusa unpubl. data). *Salsola tragus*, *paulsenii* and *collina* all originate from Eurasia.

Two species of moths (*Coleophora klimeschiella* and *C. parthenica*) were evaluated and introduced in the 1970s for biological control of *S. tragus* (Goeden 1973). *Coleophora klimeschiella* is a case-forming caterpillar that feeds on leaves, and *C. parthenica* larvae mine the stems. Both moths became widespread, but predators and parasites prevent them from being abundant enough to control the weed (Goeden et al. 1987, Müller et al. 1990). Further foreign exploration in the Mediterranean Region by R. Sobhian led to the discovery of several prospective new biological control agents (Table 1). Evaluations conducted by R. Sobhian (USDA-ARS, European Biological Control Laboratory) demonstrated that two of these are specific enough to warrant further evaluation, and that two should be eliminated from further consideration.

The blister mite (*Aceria salsolae*) is an eriophyid mite that destroys the young growing tips of the plant, stunting its growth and preventing development of flowers. The blister mite has been evaluated for host plant specificity, and its ability to damage the plant in quarantine experiments at the USDA-ARS quarantine laboratory in Albany, CA. These studies demonstrated that the mite attacks only a few closely related species of *Salsola*, all of which are invasive alien weeds. A petition was submitted to the USDA-APHIS Technical Advisory Group (TAG) in Dec. 2004 (Smith 2005), and TAG recommended approval of release in Aug. 2005. An application for a release permit was submitted to USDA-APHIS-PPQ in Nov. 2005. APHIS has not yet completed review of the permit application. Both AHIS and the California Department of Food and Agriculture must approve the permit before the mite can be released.

Caterpillars of the moth, *Gymnancyla canella*, commonly attack Russian thistle on beaches of southern France. Larvae feed on developing seeds and stems, causing extensive damage. Host specificity tests have been conducted for several years at Montpellier France and in the Albany quarantine laboratory and are expected to be finished in another year.

Foreign cooperators are exploring new regions in Central Asia (Turkey, Kazakhstan and Uzbekistan) and have discovered many species of beetles attacking Russian thistle. Several of these are thought likely to be host-specific (Table 1). Initial experiments to evaluate host plant specificity are being conducted by cooperators in Italy. Access to Central Asia greatly improves our chances of finding safe, effective biological control agents because this appears to be the region of highest biodiversity of this plant.

These new biological control agents should help reduce the populations of this weed to innocuous levels over extensive regions. Successful biological control would provide self-perpetuating long-term management of this weed, reduce the need to apply pesticides, and increase the productivity and utility of millions of acres in the western U.S.

In anticipation of obtaining permission to release the blister mite. We have begun to select sites in a variety of climatic zones in California and collect baseline data on *Salsola* abundance.

Table 1. Status of prospective biological control agents of Russian thistle.

Taxonomic name	Common name	Current information
Evaluated species		
Aceria salsolae (Acari: Eriophyidae)	blister mite	The mite attacks developing tips. Petition "approved" by TAG, release permit submitted to APHIS (Smith 2005).
Gymnancyla canella (Lepidoptera: Pyralidae)	seed and stem moth	Caterpillar feeds on seeds and young branch tips. Host specificity testing almost completed.
Colletotrichum gloeosporioides	rust	More damaging to Russian thistle type A than to type B (Bruckart et al. 2004). Being evaluated by W. Bruckart USDA-ARS, Maryland.
Uromyces salsolae	rust	Damages Russian thistle type A (Hasan et al. 2001). Being evaluated by W. Bruckart USDA-ARS, Maryland.
Kochiomyia [=*Desertovelum*] *stackelbergi* (Diptera: Cecidomyiidae)	gall midge	Uzbekistan strain attacks *Salsola* type A more than type B. Apparently requires a yet unidentified fungal symbiont to reproduce (Sobhian et al. 2003b). Research suspended.
Lixus incanescens [=*salsolae*] (Coleoptera: Curculionidae)	stem weevil	Adults feed on many plants in choice test at Montpellier, France (Sobhian et al. 2003a). Rejected.
Piesma salsolae (Hemiptera: Piesmatidae)	plant bug	Develops on beets in no choice lab test at Montpellier, France (R. Sobhian pers. com.). Rejected.
New species		
Anthypurinus biimpressus (Coleoptera: Curculionidae)	jumping weevil	Found in Tunisia in 2004. Larvae and adults feed on leaves. Biology is unknown.
Baris przewalskyi (Coleoptera: Curculionidae)	weevil	Abundant on *Salsola* in Kazakhstan in 2004. Biology is unknown.
Salsolia morgei (Coleoptera: Curculionidae)	weevil	Found in Kazakhstan in 2004. Reported to be monophagous.

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Controlling giant reed (*Arundo donax*) within the Tijuana River Valley.

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EcoSystems Restoration Associates (ERA), in cooperation with Southwest Wetlands Interpretive Association (SWIA), has been conducting chemical and physical control of giant reed (arundo donax) as well as habitat restoration throughout the Tijuana River Valley Regional Complex for the last three years. In the Tijuana River Valley, giant reed occurs in a patchy distribution in comparison to the large, dense stands that are more typical in San Diego County. Since the habitat surrounding infestation areas was primarily composed of riparian woodland, riparian scrub, and open water, project specifications required that ERA avoid substantial impacts to sensitive biological resources such as the federally listed least Bell's vireo, while cost-effectively controlling this highly invasive species. The control techniques utilized included foliar treatment on intact and trampled stands of giant reed, as well as cut-stump treatment. The foliar herbicide treatments included the application of 4%, 6%, and 7.5% glyphosate over a three-year period. The most effective means of control was achieved thorough foliar application of 7.5% glyphosate, which resulted in complete eradication within four weeks. The 4% and 6% glyphosate application rates resulted in approximately 60-80% suppression of the stands. The cut-stump treatment was overall unsuccessful with nearly 100% re-growth, although these results varied by year. From a cost perspective, using a 7.5% treatment was equivalent to using the cut-stump method. The results ran contrary to original beliefs, but confirmation from the third year of experimentation showed that the cost benefit and effective means were maintained by the using 7.5% application rates.

Hydrilla Eradication Efforts in the Chowchilla River and Eastman Lake in Central California; a Success Story

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Hydrilla is an invasive, non-native aquatic plant that is a serious threat to the water resources of the State. It reduces the storage capacity of lakes and ponds, impedes movement in streams and canals; clogs pumps and hydroelectric generators; degrades fish and wildlife habitat; and can even endanger public health by creating mosquito breeding habitat. Hydrilla can reproduce by stem fragments that root and form mature plants; turions that form in the leaf axils; and most troubling, tubers that form on the end of underground rhizomes in the spring and again in late summer through fall. These tubers can survive in the hydrosoil for several years or more. Following the first introduction of hydrilla into California, in 1977 the California Legislature mandated that the CDFA Secretary initiate a detection program for hydrilla and to eradicate it wherever "feasible". This mandate is stated in the California Code of Regulations.

The discovery of hydrilla in Eastman Lake and the Chowchilla River presented new challenges to the CDFA. Previous infestations had occurred primarily in locations that were easily accessible and where the water could be controlled. This infestation was the first to be seen in a free flowing seasonal river. The Chowchilla River originates in the Sierra Nevada foothills in Mariposa County. The three forks of the Chowchilla fill Eastman Lake, an 1800-acre reservoir owned by the U.S. Army Corps of Engineers. Eastman is used primarily for flood control, irrigation, recreation and wildlife preservation.

Hydrilla was first detected in Eastman Lake on June 20, 1989, during a routine survey by CDFA and Madera County Department of Agriculture personnel. Plant samples were collected, sent to the CDFA Diagnostics Lab and confirmed as dioecious hydrilla. Initially the infestation appeared to cover approximately 100 gross acres in the northern section of the lake. CDFA acted immediately to prevent hydrilla spreading to other local lakes or into the irrigation canals by requesting that the U.S. Army Corps of Engineers close off the northern portion of the lake to recreational activities on June 23. Just 5 days later the entire lake was placed under quarantine as many more plant sites were found along the eastern shore line.

While Eastman was being inspected, additional teams of Biologists were starting a delimitation survey to discover the full extent of the problem. When they discovered hydrilla in the Chowchilla River in a few easily accessible places upstream of Eastman Lake it was clear that personnel needed to follow the river upstream to find the source of the infestation. This was not as simple as it sounds. Since the Chowchilla flows completely through private land, property owners had to be contacted in order to gain access to the river. Most owners granted permission immediately but others had to be persuaded to allow people on their property. Government types aren't exactly welcomed in many of the foothill and mountain areas of California, especially when questions are being raised about precious water resources. When the most upstream site of the infestation was located in the West Fork of the Chowchilla River, 26 miles upstream from Eastman Lake, the entire West Fork of the river was closed, restricting all water related activities.

Right at the beginning of this project there were many who questioned the "feasibility" of eradicating hydrilla from the Chowchilla River. It flows through some extremely rugged terrain, with steep hills and deep canyons. Just getting to the water in many places involves driving on a rugged 4-wheel drive road, then hiking for a half mile or more on cattle trails through oak grassland or chaparral, sometimes through stands of poison oak. Biting and stinging insects, rattlesnakes, the occasional mountain lion or bear, the not so occasional wild pig, and even people with guns, add to the adventure of just getting to the water! Once in the river personnel are faced with the daunting task of staying upright on slippery rocks, or hacking through thick stands of cattails or willows. In the early years of the project, all of this was done while carrying a backpack sprayer with 40 pounds of liquid herbicide sloshing around! Weather is another big challenge. Summer temperatures in these foothill canyons can easily reach 105 degrees Fahrenheit and beyond, with hot afternoon winds that feel like they are right out of a blast furnace; winter days can be just as miserable with thick fog and wind chill down into the 20's. In spite of these logistical environmental roadblocks, a Scientific Advisory Panel, convened in July 1989, concluded, "anything less than an eradication effort is unacceptable". It was therefore deemed "feasible" to eradicate hydrilla from the Chowchilla River and Eastman Lake.

Work began immediately. Within a month after the initial detection, seasonal staff was hired to work with CDFA Biologists. The first step was mapping the river and lake. This was before we had GPS so the primary tools were a topo map, a compass and a good sense of direction. The river system was divided into 38 management units for ease of record keeping. While the river was mapped, several crews of three to four people surveyed foot by foot, looking at every pool and puddle. Hydrilla was found in every management unit, ranging from single plants to large masses filling entire ponded areas.

Chemical control was an essential tool early in the project, so any plants found were treated with Komeen, a copper based contact herbicide used to control the top growth of hydrilla plants. Crewmembers had to learn the terrain and river access points, and also how to use the herbicide, and how much to carry each day. By the second season crews were surveying the entire river every two weeks, treating as necessary. A number of heavily infested ponded sites were measured and treated a number of times with predetermined amounts of Komeen. During 1989, 1990 and 1991 an average of 450 gallons of Komeen per year were applied to ponded and slow moving water in the river.

In the meantime, work at Eastman Lake was progressing. In 1989 mats and individual plants of hydrilla were detected, marked with bamboo stakes, and removed by hand. Plant site areas were netted to catch any fragments that might break off. Project officials also started a chemical treatment program. Komeen was applied to pre-measured sections of the lake using a custom boom sprayer system with weighted down dragger hoses to get the material down into deep water, and a spray gun for the more shallow areas along the shoreline. In the years 1990 through 1992, 1000 to 2000 gallons of

Komeen were applied to the lake per year, during regularly scheduled treatments. In addition to the Komeen treatments, in 1990 the upper lake delta area was fumigated with Vapam. This area was heavily infested with hydrilla and held a massive reserve of tubers. Vapam is a soil fumigant that kills tubers, roots and stems of plants in the soil. The lake water level was drawn down to dry the sandy soil of the delta. Private contractors brought in sprinkler irrigation pipes to apply the Vapam to the area. This treatment was highly successful, as very few plants were later found in the treated area.

Along with the herbicide treatments, personnel were hand-removing plants. The herbicides eliminated the huge mats, so by 1990 individual plants could be counted. Crewmembers literally waded, swam and even snorkeled in the water of the river and lake to look for plants. And not only did we have to find hydrilla plants, but find and identify them among many other aquatic plants, often in deplorable water conditions. When plants were found they were gently pulled out of the soil, often still attached to the tuber from which they grew. When tubers broke off they were removed by sifting the soil material through hardware cloth welded inside a metal ring. This became known as the "shovel and sift" method. When large numbers of plants were found in one area, we would shovel and sift, then use suction dredges to remove more tubers from the soil. Dredging requires a lot of manpower, not only to get the equipment to the site, but also to simply look through the material to find the tubers. Use of our four-inch intake dredge was highly successful at the site of the source of the infestation, where in the span of five weeks in 1991, approximately 35,000 tubers were removed.

Up through 1996, this routine continued: survey, pull plants, shovel and sift, treat and dredge, and survey again. Plant numbers declined dramatically. In 1993 over 6,000 plants were removed; by 1997 we saw a major drop to 562. In 1997 we were given a new weapon – Sonar. Sonar is a selective systemic aquatic herbicide that causes the breakdown of chlorophyll. At the end of 1998 we saw another major drop in plant numbers – down to 49! We frankly did not expect that dramatic a reduction in one season. We ascribe this to several factors: effective use of Sonar, hand removing plants, which prevented the production of new tubers, and the fact that the existing tuber bank was being exhausted. Hand removal became our primary tool and only two plants were found in 2002!

While all this work was conducted in the lake and river, additional detection work was done in a corridor two miles wide on both sides of the river. All stock ponds, fire ponds, and creeks within that corridor were thoroughly checked. The Middle and East Forks of the Chowchilla River, and the outflow from Eastman Lake were also surveyed. No hydrilla was ever found in any other body of water in the area.

A bio-control agent, a weevil called *Bagous affinis*, was released in the river, but unpredictable water flows made the attempt impractical. Besides, as a tool for this project the very nature of bio-control is inconsistent with the mandate to eradicate all hydrilla plants.

Mother Nature did help us, however. Several periods of drought during the project years left many sections of the river dry for much of the season. Even if hydrilla plants sprouted they did not have the opportunity to grow and produce new tubers before the water evaporated or disappeared underground.

The dry years also helped to reopen Eastman Lake by leaving dormant tubers high and dry above the water level. Even after a small number of plants appeared in July 1992, CDFA officials were so confident that the hydrilla was well under control they worked with officials from the U.S. Army Corps of Engineers and the State Department of Fish and Game to open the west shoreline for fishing in August 1992. Hundreds of happy anglers lined up elbow to elbow along the shoreline to catch those bass that had been growing undisturbed for three years. In 1995 almost the entire lake was opened to all forms of water activities. A small portion of the lake remains closed today to protect nesting bald eagles that moved in when the lake was closed.

We are excited that zero hydrilla plants have been found in the Chowchilla River and Eastman Lake system since 2002. Native aquatic vegetation is thriving in the river, enticing wildlife in the region. However, because the plants found in 2002 were located approximately 20 miles upstream from Eastman Lake, the entire system must still be considered infested, and the river remains under quarantine. In 2004 and 2005 each management unit of the river was surveyed at least two times and Eastman Lake was thoroughly checked four times. Sonar herbicide treatments were completed in 2005. In 2006 and again last summer the river system was surveyed once and we are cautiously optimistic that our hard work will be rewarded by one more year of negative hydrilla finds, the minimum required before eradication can be declared.

The first key element to successfully eradicating hydrilla is early detection and rapid response. The Chowchilla River/Eastman Lake infestation was estimated to be about four years old, and while portions of the river were thickly infested, the amount found in the lake was not yet completely out of control. Irrigation and recreational activities would have been severely impacted if CDFA had not acted immediately. Another key element in eradication is a complete commitment to the project by all parties involved. And in this respect the Chowchilla project really stands out. CDFA made a full time commitment to attacking this problem, supplying not only financial resources, but a dedicated staff as well. The U. S. Army Corps of Engineers, Madera and Mariposa County Departments of Agriculture and other agencies continue to supply financial and logistical support. But it is not only the financial resources that made this project a success; it is the legion of dedicated people who have made the difference. People who were willing to immerse themselves in algae covered water that was pretty disgusting; willing to encounter dead animals, fish, and smelly rotting vegetation and endure being literally covered in hydrilla plants! People who used every tool - swimming, snorkeling, using herbicides, hand pulling, dredging, and surveying again and again - to eliminate hydrilla. And that is the final key point – hydrilla cannot be ignored, it requires constant attention. To be successful, we cannot afford to turn our backs on current projects and we must be vigilant, always looking for new infestations, finding them early, and acting on them quickly. Only by doing so can we keep the vital water resources of the State of California free of this noxious pest.

Roadside Vegetation and Disaster Mitigation

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This discussion focuses on roadside vegetation and how disasters affect our work. Roadside vegetation managers can assist others (such as engineers) during major disasters in many ways which can lessen future noxious and invasive weed invasions and help to reestablish native plants.

This presentation shows how the 2005 winter storms devastated southern California. Many areas in California received over 300% of their normal annual rainfall from January through March of 2005. Governor Schwarzenegger declared an emergency in eight counties (Los Angeles, Ventura, Santa Barbara, Riverside, San Bernardino, Orange, San Diego and Kern) on January 15, 2005.

There are many types of failures that affect roadways and roadsides. These photographs illustrate the variety of types of failures which occur during disasters. It is important to correctly identify the specific type of failure, since money and resources are tied to such repairs. Some of the most common roadside disaster failures include:

Bridge failures - when excessive water scours out bridge supports, causing failure or collapse.

Roadbed failures occur due to excess saturation.

Culvert failures occur when water volumes greater than the culvert can handle either blowout, topple or separate. Failures normally occur at culvert entrances and detention basins when they fill up with mud and debris.

Mudslides - when water and dirt combine to overtop roadways.

Rockslides and landslides occur when saturated hillsides can no longer support their own weight, falling down onto the roadways below.

Slipouts occur when saturated hills fail below the roadways, taking the roadway with it.

Washouts - a violent form of flooding that takes the entire roadway with it.

Flooding - when runoff overtops roadways.

Roadside vegetation managers should suggest appropriate repair strategies. By acknowledging drainage patterns and nearby site features, roadside vegetation managers can suggest: appropriate seed mixes (including pioneer species, forbs, wildflowers and native grasses); planting options (such as broadcast seeding, no-till drilling, imprinting, hydroseeding, and plug planting); drainage options (such as rock-lined swales, geocells, different size and tonnage of boulders); erosion control options (including bonded fiber matrixes, erosion control blankets and stabilizing mats); and grading options (such as slope steepness, berms next to roadsides to channelize water, and slope rounding/contour grading). By helping others during a disaster, we can help to make our roadsides better in the future!

Weed Control in Caneberries

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Weed control in caneberries is done for many of the same reasons as other crops; weeds compete with the crop for light and water, and contaminate the crop and soil with seeds and debris. There are several additional matters with weed and vegetation management in caneberries however.

One particular problem is that caneberries are usually grown over multiple years and canes for next year are produced vegetatively in the cropping year. First year, non-bearing canes are called primocanes, while flowering and fruiting canes are called floricanes. However, while the primocane is next year's crop, it also competes with the current crop for nutrients, so it is vital that this vegetative cane be managed properly to minimize the potential for yield loss brought about by competition for nutrients.

There are several options available to growers to manage the vegetative cane. Growers generally remove the first flush of vegetative cane, or all cane when in the last year of production. Cane can be removed by hand, but this is very expensive and time consuming.

... In California, herbicides are playing a larger and larger role in the management of primocane. The use of herbicides is of twofold utility, one to control weeds and the other to control primocane. Paraquat (Gramoxone), while very effective in burning down primocane and weeds, has very little residual effect. Oxyfluorfen (Goal), which is not registered in California, appears to have a longer residual effect in suppressing primocane and weeds. Some growers in the Pacific Northwest, where this material is registered, do caution that this material can be deleterious to a weakened caneberry stand. Finally, carfentrazone (Shark) is effective in suppressing primocane and has a small residual effect, as well as being registered in California.

Tillage is effective for weed control in caneberries, outside of the hedgerows which are generally too thick to work with tractor drawn implements. Caneberry roots do not generally grow into furrows and row middles, since there is very little water there in the summer, so tillage does very little harm there.

... Cover cropping is also an important tool in suppressing weeds, especially during the winter months when it can be difficult to get into the field with a tractor because the soil is so wet. Still, cover crops should be low growing and not interfere with air circulation through the caneberry hedgerow. Cover crops should be seeded after completion of harvest in the fall, and tilled back into the ground in the spring.

The loss of methyl bromide, controlling methyl bromide and glyphosate resistant weed species, primocane control, hardships of hand weeding and organic production methods are all challenges facing strawberry and caneberry growers in California.

The impending loss of methyl bromide as a pre-plant soil fumigant has brought about the use of several alternative fumigants, such as 1,3-D, chloropicrin and metam sodium.
Since many of these alternative fumigants are applied through the drip system with the bed mulch already in place, strawberry growers are working with fuller and longer duration bed coverage, better water management, and planting through the mulch. Additionally methyl bromide tolerant weed species, such as little mallow, *Malva parviflora*, and glyphosate resistant weeds such as burning nettle, *Utrica urens*, will be less of a problem with the application of alternative fumigants. The use of the herbicides flumioxazin (Chateau) in the furrows and oxyfluorfen (Goaltender) over the top of the bed has gone hand in hand with the bed applications of the alternative fumigants.

Management of vegetative primocanes in is an important part of caneberry cultivation. Growers can burn these canes with a propane burner, cut them out by hand or use herbicides. Herbicide use and flaming is most advantageous in raspberries, where the floricane is woody and resistant to burning. Most of the cane of blackberries is green, and more susceptible to herbicide and flaming damage. One trail done on our farm tested the efficacy and length of control of applications of paraquat (Gramoxone), oxfluorfen (Goal- not registered in California) and carfentrazone (Shark) in suppressing primocanes. Oxyfluorfen appeared to have a little longer effect than carfentrazone, and significantly longer than paraquat.

Organic production of caneberries presents more challenges in terms of weed control. A promising herbicide for organic use, pelargonic acid, is yet to be registered, so organic caneberry growers continue to use hand weeding as their main weed management strategy in organic caneberries.

Integrated Weed Management in Strawberry

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Summary. Field studies were conducted to further develop the use pattern of oxyfluorfen herbicide (GoalTender) which is used to control weeds such as little mallow and filaree in strawberry. Oxyfluorfen herbicide is labeled for application on strawberry beds at least 30 days before transplanting. Oxyfluorfen treated soil must be tarped prior to strawberry transplanting to avoid injury to strawberry. Studies were conducted to determine if oxyfluorfen must be activated with sprinkler irrigation prior to tarp installation or if fallow beds can be tarped as soon as the oxyfluorfen has been applied. We found that when oxyfluorfen was applied and tarped right away without sprinkler irrigation activation that weed control was as good as when oxyfluorfen was irrigated before tarp installation.

Introduction. Oxyfluorfen is applied at least 30 days before transplanting, and is often watered in with sprinkler irrigation to activate the herbicide prior to tarp installation on the planting beds. Eliminating the irrigation activation step would allow installation of the tarp directly after the herbicide application and would both reduce costs and simplify the process. The primary objective was to verify whether or not the irrigation activation step is necessary for effective weed control with oxyfluorfen. A second objective was to evaluate oxyfluorfen in combination with napropamide (Devrinol), pendimethalin (Prowl H_20) and dazomet (Basamid).

Materials and methods. Two field studies were conducted to evaluate the effect of irrigation activation of several herbicide treatments on weed control and crop tolerance. The treatments were arranged in a randomized complete block with four replicates. Each plot was 20-ft long by 52-in wide with a 26-in bed top. The first herbicide trial was conducted at Monterey Bay Academy at Watsonville, CA on soil previously fumigated with methyl bromide/chlorpicrin (MBPic) at 350 lbs/A. Black medic and little mallow were seeded throughout the trial on Oct. 6, 2005. On Oct. 7 herbicide treatments were applied to the bed top using a single nozzle backpack type CO_2 sprayer at a volume of 40 GPA. Treatments included oxyfluorfen at 0.125, 0.25, 0.375 and 0.5 lb ai/A plus an untreated control. One-half of the plots were then directly tarped without sprinkler irrigation, while the other half of the plots received 0.5-in irrigation and were not tarped until just before transplanting. Strawberry 'Albion' was transplanted on Nov. 7, 2005.

The second trial was initiated at the USDA-ARS/UCCE Spence research farm near Salinas, CA on soil previously fumigated with MBPic at 350 lbs/A. As in the previous trial, black medic and little mallow were planted on the bed tops prior to herbicide application. At Salinas, oxyfluorfen at 0.125 lb ai/A, 0.25 lb ai/A, 0.375 lb ai/A, and 0.5 lb ai/A and flumioxazin (Chateau) at 0.063 lb ai/A were applied on Oct. 28, 2005 (30 days pre transplant). Other treatments included: pendimethalin at 1.0 lb/A, napropamide at 2.0 lb/A, pendimethalin plus oxyfluorfen at 1.0 plus

0.125 lb ai/A, and napropamide plus oxyfluorfen at 2.0 plus 0.125 lb ai/A. A sequential application of dazomet at 150 lb followed by 0.125 lb ai/A oxyfluorfen was also evaluated. Untreated control treatments were also included. One-half of the plots were then immediately tarped without sprinkler irrigation, while the other half of the plots received 0.55 in sprinkler irrigation on Nov. 2 and were not tarped until just before transplanting. On Nov. 29, 2005 strawberry 'Diamante' was transplanted.

At Watsonville, crop injury ratings, 0 = safe, 10= dead, were taken on Dec. 15, 2005, Jan. 16, and Feb. 9, 2006. Weed densities were measured on: Nov. 16, and Dec. 15, 2005 and Feb. 23, 2006. Planted weeds were counted separately from native weed species. Fruit was harvested twice weekly from April 6, to Sept. 14, 2006. At Salinas, crop injury ratings were taken on: Jan. 9, Feb. 7, and Mar. 8, 2006. Weed densities were measured Nov. 28, 2005, Jan. 12, and Mar. 1, 2006. Fruit was harvested May 9, to Sept. 22, 2006. Analysis of variance was performed on the data and mean separation was performed using LSD's. Analysis was also conducted to determine the main effect of irrigation activation of the herbicides on weed control.

Results. Oxyfluorfen caused little crop injury at Watsonville, but at Salinas the 0.375 and 0.50 lb ai/A rates caused moderate crop injury (Tables 1 and 2). The data also shows that irrigation activation had no effect on fruit production at either Watsonville or Salinas. Weed control in the no irrigation activation treatments was essentially the same as the treatments that received irrigation activation and delayed tarping. At Watsonville and Salinas, oxyfluorfen at 0.375 ai/A and above controlled little mallow and black medic (Tables 3 and 4). Control of little mallow and black medic was excellent with the combination of pendimethalin plus oxyfluorfen at 1.0 plus 0.125 ai/A. The napropamide plus oxyfluorfen 2 plus 0.125 lb ai/A combination gave good control of little mallow and black medic, much better than napropamide alone. The sequential application of dazomet (150 lb ai/A) followed by oxyfluorfen (0.125 lb ai/A) gave excellent control of planted black medic and little mallow. Overall weed control results at Watsonville and Spence suggests that sprinkler irrigation activation of oxyfluorfen on fallow beds is not required for effective weed control.

Table 1. Strawberry injury ratings and fruit yields at Watsonville, CA.

Treatment	Rate lb ai/A	Irrigation Activation	Crop injury 0 = safe, 10 = dead		Mkt.yield
			12.15.05	1.12.06	gr./plant
1 Untreated	0	Yes	0.0 d	0.0 d	651
2 Untreated	0	No	0.0 d	0.0 d	668
3 Oxyfluorfen	0.125	Yes	0.4 cd	0.1 cd	640
4 Oxyfluorfen	0.125	No	0.0 d	0.7 abc	652
5Oxyfluorfen	0.25	Yes	0.5 bc	0.8 abc	710
6 Oxyfluorfen	0.25	No	0.3 cd	0.5 bcd	643
7 Oxyfluorfen	0.375	Yes	0.9 ab	1.3 a	667
8 Oxyfluorfen	0.375	No	0.6 bc	1.0 ab	621
9 Oxyfluorfen	0.5	Yes	1.1 a	1.3 a	674
10 Oxyfluorfen	0.5	No	0.6 bc	1.3 a	656
Main effects					
GoalTender			0.0001	0.0001	0.7340
Activation			0.0157	0.9449	0.3212

Table 2. Strawberry injury ratings, and fruit yields at Salinas, CA.

Treatment	Rate lb ai/A	Irrigation Activation	Crop injury 0 = safe, 10 = dead		Mkt.yield
			1-9-06	2-7-06	gr./plant
1 Untreated	0	Yes	0.0 g	0.0 h	633
2 Untreated	0	No	0.0 g	0.0 h	679
3 Oxyfluorfen	0.125	Yes	0.3 g	0.5 e-h	712
4 Oxyfluorfen	0.125	No	0.4 fg	0.1 gh	696
5 Oxyfluorfen	0.25	Yes	0.5 efg	0.6 d-g	706
6 Oxyfluorfen	0.25	No	1.3 cd	1.1 cd	761
7 Oxyfluorfen	0.375	Yes	1.1 cde	1.5 bc	789
8 Oxyfluorfen	0.375	No	1.5 bc	2.0 ab	677
9 Oxyfluorfen	0.5	Yes	2.3 a	2.4 a	696
10 Oxyfluorfen	0.5	No	2.0 ab	2.1 a	661
11 flumioxazin	0.063	Yes	0.1 g	0.1 gh	659
12 flumioxazin	0.063	No	0.4 fg	0.8 def	685
13Oxyfluorfen/pendimethalin	0.125/1.0	Yes	0.6 d-g	0.8 def	658
14Oxyfluorfen/pendimethalin	0.125/1.0	No	1.0 c-f	1.5 bc	742
15 pendimethalin	1.0	Yes	0.3 g	0.5 e-h	624
16 pendimethalin	1.0	No	0.6 d-g	0.4 fgh	710
17 Oxyfluorfen/napropamide	0.125/2.0	Yes	0.4 fg	0.4 fgh	673
18 Oxyfluorfen/napropamide	0.125/2.0	No	1.0 c-f	1.0 cde	669
19 napropamide	2.0	Yes	0.1 g	0.3 fgh	644
20 napropamide	2.0	No	0.3 g	0.4 fgh	685
21 dazomet	150	Yes	0.4 fg	0.4 fgh	696
22 dazomet /Oxyfluorfen	150/0.125	Yes	1.1 cde	1.1 cd	784
LSD			0.56	0.72	164
Treatment probability			0.0001	0.0001	0.584

Table 3. Season total weed densities at Watsonville, CA.

Treatment	Rate lb ai/A	Irrigation Activation	Blk.Medic Planted	L.Mallow Planted	Total resident weeds
			------------- No./20 ft. --------		No. 41.7 ft^2
1 Untreated	0	Yes	139.0 ab	25.8 b	28.0 a
2 Untreated	0	No	150.3 a	71.0 a	19.3 ab
3 Oxyfluorfen	0.125	Yes	78.8 bc	5.0 c	11.5 bc
4 Oxyfluorfen	0.125	No	34.0 cd	9.0 bc	11.0 bc
5Oxyfluorfen	0.25	Yes	30.3 cd	1.0 c	1.8 c
6 Oxyfluorfen	0.25	No	11.0 d	3.5 c	4.0 c
7 Oxyfluorfen	0.375	Yes	15.8 d	0.3 c	2.0 c
8 Oxyfluorfen	0.375	No	3.5 d	0.0 c	0.8 c
9 Oxyfluorfen	0.5	Yes	16.3 d	0.3 c	1.3 c
10 Oxyfluorfen	0.5	No	2.0 d	0.0 c	1.0 c
LSD			61.15	19.72	11.31
Main effects					
GoalTender			0.0001	0.0001	0.0002
Activation			0.25	0.0244	0.5

Table 4. Season total weed densities at Salinas, CA.

Treatment	Rate lb ai/A	Irrigation Activation	Blk.Medic Planted	Mallow Planted	Total Weeds
			--------No. /20 linear feet------		No./ 41.6 ft2
1 Untreated	0	Yes	310.5 a	99.8 a	10.3 a
2 Untreated	0	No	174.5 b	86.8 a	6.5 b
3 Oxyfluorfen	0.125	Yes	21.5 de	24.0 bc	1.4de
4 Oxyfluorfen	0.125	No	29.3 de	13.3 cd	1.4 de
5 Oxyfluorfen	0.25	Yes	10.0 de	5.0 cd	0.5 de
6 Oxyfluorfen	0.25	No	9.0 de	3.8 cd	0.4 de
7 Oxyfluorfen	0.375	Yes	4.3 e	0.0 d	0.2 e
8 Oxyfluorfen	0.375	No	9.8 de	0.8 cd	0.4 e
9 Oxyfluorfen	0.5	Yes	3.3 e	0.8 cd	0.1 e
10 Oxyfluorfen	0.5	No	8.3 e	0.3 d	0.4 e
11 flumioxazin	0.063	Yes	4.0 e	1.0 cd	0.2 e
12 flumioxazin	0.063	No	16.5 de	4.0 cd	0.6 de
13Oxyfluorfen/pendimethalin	0.125/1.0	Yes	5.8 e	1.0 cd	0.3 e
14Oxyfluorfen/pendimethalin	0.125/1.0	No	3.3 e	0.3 d	0.1 e
15 pendimethalin	1.0	Yes	110.3 c	47.3 b	4.2 c
16 pendimethalin	1.0	No	62.8 cd	16.5 cd	2.0 d
17 Oxyfluorfen/ napropamide	0.125/2.0	Yes	11.5 de	2.8 cd	0.4 de
18 Oxyfluorfen/ napropamide	0.125/2.0	No	17.0 de	0.8 d	0.5 de
19 napropamide	2.0	Yes	185.5 b	101.8 a	7.3 b
20 napropamide	2.0	No	200.0 b	105.5 a	7.7 b
21 dazomet	150	Yes	12.3 de	16.8 cd	1.0 de
22 dazomet/Oxyfluorfen	150/0.125	Yes	2.0 e	1.5 cd	0.2 e
LSD			54.399	23.620	1.623
Treatment probability			0.0001	0.0001	0.0001

Control of Difficult Weeds in California Strawberry Production.

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INTRODUCTION

Strawberries for fresh market and processing were grown on 21,200 ha in the United States in 2005, a crop valued at $1.4 billion (USDA ERS 2007). Nearly 90% of U.S. strawberries were grown in the California coastal areas around Watsonville (36% of California production area), Oxnard (33%), and Santa Maria (18%) (USDA ERS 2007); fruit is harvested from January to June in the southern region of the state and from March to October in the northern region.

Strawberry transplants are particularly sensitive to competition with weeds early in the season (Fennimore et al. 2005). Soil fumigation and opaque plastic mulch are standard practices costing $1,750-5,000 per ha that provide some initial weed control (Daugovish et al. 2004), however weeds with hard seed coats such as little mallow and clovers escape fumigation and germinate during production season. Oxyfluorfen and flumioxazin herbicides were effective against broadleaf weeds when tested in vegetable production (Daugovish et al. 2006, Hatterman-Valenti and Auwarter 2007, Shrefler and Webber 2004) and are registered for strawberry in California but their use has been limited. Flumioxazin is new to strawberry industry in California, while oxyfluorfen applications raised concerns due to potential crop injury. Oxyfluorfen moves with water vapor from the soil surface to strawberry foliage, a process known as "lift off" or codistillation (Fennimore et al. 2005) and can injure the plants. Alternative fumigants are less effective than methyl bromide in controlling yellow nutsedge. Shoots of nutsedge penetrate opaque mulch and rapidly establish in strawberry beds. When applied via drip fumigants do strawberry beds, the furrows remain non-fumigated, allowing weed growth. Yet another increasing problem is with weeds with wind dispersed seed which establish in strawberry planting holes and furrows throughout the season. One of the common wind dispersed species – horseweed has been recently reported to be resistant to glyphosate.

Our studies focused in four areas: pre-plant application of oxyfluorfen to beds, control of yellow nutsedge in non-fumigated strawberry, furrow weed control, and control of wind-dispersed weeds.

MATERIALS AND METHODS

Pre-plant application of oxyfluorfen to beds

Eight randomized complete block (RCB) experiments (2002-2006) with four replications each evaluated weed control and crop injury with 0.6 or 0.3 kg· a. i. ha^{-1} of oxyfluorfen applied 30 days before strawberry transplanting. Individual plots were 1.5 m wide and 30 m long at Oxnard, California and 1.3 m wide and 6.1 m long at Salinas, California. Following application, beds were either immediately covered with PVC mulch or remained bare until 4-5 weeks after planting.

Yellow nutsedge control.

An RCB experiment with five replications was conducted at Oxnard, California (2006-2007) to compare emergence of yellow nutsedge and crop performance in beds covered with black PVC mulch alone and beds were Novovita paper (recycled newspapers, gypsum) was laid under mulch. In 2007-2008 this experiment was repeated but Novovita paper was installed between the two layers of plastic mulch, and, as additional treatments, weed barrier matt and water resistant Tyvek (DuPont) home wrap paper were tested under black PVC mulch. All plots were 1.5 by 8 m.

Furrow weed control.

An RCB experiment with three replication at Camarillo, CA compared weed control with flumioxazin at 0.1 kg a. i.$\cdot$ha^{-1} and oxyfluorfen 0.3 kg a. i. $\cdot$ha^{-1} applied to furrows 30 days pre-transplant. Individual plots were 12 by 35 m. In an additional RCB experiment with four replications at Santa Paula, CA we evaluated weed control and crop safety of flumioxazin applied at 0.1 kg$\cdot$a. i. ha^{-1} to furrows or over the bed top during strawberry fruiting in March 2007.

Herbicide evaluation for control of fleabane and sowthistle.

This RCB experiment at Santa Paula, California with four replications evaluated flumioxazin at 0.1 kg$\cdot$a. i. ha^{-1} and oxyfluorfen at 0.3 kg a. i.$\cdot$ha^{-1} for fleabane and sowthistle control at Santa Paula, CA. Weed seed were collected locally, mixed with sand and dispersed manually on moist bed tops to simulate natural deposition. Herbicides were applied the next day, the beds were immediately covered by clear mulch and strawberry was transplanted 30 days later.

In all studies weeds were counted by species, injury evaluated in percent and weeding time recorded for two persons per plot at Oxnard, Camarillo and Santa Paula. Analyses of variance for weed numbers, percent injury and weeding times were performed with the GLM Procedure in SAS (SAS Systems, Cary, NC) with the overall error rate controlled by Tukey-Kramer adjustment.

RESULTS AND DISCUSSION

Pre-plant application of oxyfluorfen to beds.

Averaged over the eight studies, oxyfluorfen at 0.3 kg a. i.$\cdot$ha^{-1} provided 89-100% control of little mallow and most other broadleaf weeds, but only 0.6 kg a. i.$\cdot$ha^{-1} rate controlled of yellow sweetclover 45-95%. Weeding times in oxyfluorfen treated plots were, on average, 37-

63% less that in untreated controls. Oxyfluorfen did not control yellow nutsedge and injured strawberry when plastic mulch was not present before transplanting. However, when mulch was laid prior to crop transplanting the co-distillation of herbicide was greatly reduced and no injury occurred. This indicated that with proper application, oxyfluorfen is an effective, economical and safe herbicide that especially valuable in controlling hard-seed weeds that survive fumigation.

Yellow nutsedge control.

In fall and winter the combination of paper under plastic completely eliminated yellow nutsedge germination that otherwise germinated through plastic at a density of 5 plants m^{2-1} per week. However, in spring when the paper disintegrated due to contact with wet soil and when soil temperature increased above 16ºC the nutsedge resumed germination at a rate of 3 to16 plants m^{2-1} per week in all treatments. This indicated that paper with greater water resistance or/and protected from contact with wet soil may be needed for a season- long control. In 2007-2008 the weed barrier matt, paper layered between two plastic mulch layers and water resistant Tyvek (Du Pont) paper all provided 100% control of nutsedge shoots that otherwise germinated through plastic at a density of 0.6 plants m^{2-1} per week. This study suggests that persistent mechanical barriers prevent nutsedge germination and are especially valuable in non-fumigated and organic production in the absence of other nutsedge control tools.

Furrow weed control

At Camarillo, both oxyfluorfen and flumioxazin treatments reduced weed densities (primarily wind-dispersed weeds) 84-95% at 4 weeks after application, about 68% at 8 weeks, and reduced weeding time 50% or more compared to untreated control. This study showed that pre-plant furrow application of oxyfluorfen and flumioxazin to furrows were safe and effective, however, additional in-season weed control in furrows is needed. At Santa Paula, flumioxazin provided complete (100%) control of burning nettle (*Urtica urens*), little mallow and nettleleaf goosefoot (*Chenopodium murale*) in furrows and did not injure strawberry. However, when applied over the bed top, flumioxazin damaged strawberry fruit and foliage resulting in significant fruit losses for 3 weeks after application. This indicates that flumioxazin may be useful for in-season weed control but caution should be exercised to prevent herbicide drift to strawberry plants during furrow application.

Herbicide evaluation for control of fleabane and sowthistle

Both, oxyfluorfen and flumioxazin controlled sowthistle near 100% and did not injure strawberry. Fleabane failed to germinate until 12 weeks after strawberry transplanting and was not controlled by either herbicide at that time. In this and in previous studies we have observed that wind-blown weeds continuously reinfest the strawberry planting holes and furrows as they blow in from the surrounding areas. Thus, destruction of seed sources in and outside the production field is essential in minimizing weeding expenses associated with this wind-dispersed weeds.

Overall, this weed management program identified cost-effective management tools for difficult to control weeds in California strawberries. We continue investigation of mechanical barriers and herbicides to control difficult weeds.

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Pesticide Enforcement in the Urban Environment

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Los Angeles County is approximately 4,000 square miles and has a population of over 10 million people. Agriculture is still prevalent in the outlying areas of Los Angeles County. In the L.A. basin, wholesale nurseries grow plants under power lines and Edison right of ways. Nursery stock is one of Los Angeles County's top grossing commodities. However, urbanization has dramatically increased over the last several years, and the use of pesticides has been under understandable scrutiny.

No matter where pesticides are used, it is vital that the application be done safely, with consideration for the applicator, the neighbors, and the environment. The perception of pesticide usage is generally not a favorable one with the public. A well planned pest control program makes use of the cultural, physical, chemical methods. Using the pesticide permitting program, inspectors can verify that a safe material handling program is in place. By performing pesticide use inspections we can ensure that potentially dangerous materials are being used in a safe and effective manner.

California Department of Food and Agriculture's Regulated Noxious Weed Programs

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The Mission of the California Department of Food and Agriculture is to promote and protect California agriculture. This includes the prevention, introduction and spread of injurious insects or animal pests, plant diseases, and noxious weeds. The Noxious Weeds Program is authorized by the California Food and Agricultural Code, Section 403 where it states, "The Department shall prevent the introduction and spread of … noxious weeds." The term "noxious weed" is defined in the code, Section 5004 as "any species of plant which is, or is liable to be, detrimental or destructive and difficult to control or eradicate." USDA/APHIS, CDFA Exterior (border stations), and CDFA Interior (CDFA biologists) and County Agricultural Commissioners share responsibility in regulating noxious weeds at California's borders, as well as within the state.

An Action-Oriented Pest Rating System provides guidance from the California Department of Food and Agriculture to county and state agricultural inspectors on regulatory actions to take when a plant pest is detected or intercepted in trade or in the environment. Under the system, plant pests are assigned a rating (A, B, C, D, or Q). The rating designates the recommended regulatory action, ranging from eradication and containment to release at the discretion of the county agricultural commissioner. Although not codified as a law, the Plant Pest Rating System is a policy that enables the Department to carry out laws intended to protect California's agriculture against pests.

A procedure is in place to change a pest rating and includes the following steps and guidelines: (1) "Q" pests to be reviewed every year, (2) a request can come from any interested person to change an existing "A", "B", "C" or "D", (3) a Pest Study Team is convened to review new requests, (4) supporting documentation is review by the team, (5) other affected agencies are consulted, (6) A new rating is proposed to County Agricultural Commissioner's and a 30-day comment period follows, and lastly (7) a final rating is published.

The Department has a proven track record with A-rated statewide noxious weed eradications. Thirteen A-rated weeds have been eradicated from the state entirely: whitestem distaff thistle (*Carthamus leucocaulos*), dudaim melon (*Cucumis melo* L. var. *dudaim*), giant dodder (*Cuscuta reflexa*), serrate spurge (*Euphorbia serrata*), Russian salt tree (*Halimodendron halodendron*), blueweed (*Helianthus ciliaris*), tanglehead (*Heteropogon contortus*), creeping mesquite (*Prosopis strombulifera*), southern meadow sage (*Salvia virgata*), heartleaf nightshade (*Solanum cardiophyllum*), Austrian peaweed (*Sphaerophysa salsula*), wild marigold (*Tagetes minuta*), and Syrian beancaper (*Zygophyllum fabago*). In addition, several A-rated noxious weeds are approaching statewide eradication: golden thistle, *Scolymus hispanicus* (zer o-few plants in Alameda County), perennial sowthistle, *Sonchus arvensis* (small sites in Modoc and Santa Barbara Counties), long-leaf groundcherry, *Physalis longifolia* (small sites in Siskiyou County), Taurian thistle, *Onopordum tauricum* (small sites in Siskiyou and Monterey Counties), Illyrian thistle, *Onopordum illyricum* (zero-few plants in Santa Clara County), and camelthorn, *Alhagi maurorum* (only 1 site in Inyo County). Examples of County/Regional Eradications of A-rated noxious weeds include: hydrilla, *hydrilla verticillata* from eleven Counties and Scotch thistle, *Onopordum acanthium* from twelve Counties.

California has a unique and coordinated noxious weed program/system with a long history. District Biologist and County Agricultural Commissioner's Offices are out there working A-rated Noxious Weed populations to eradication. Eradication of incipient populations of A-rated Noxious Weeds is possible. Continued successes are tallied each year.

Registration for Sales of Pesticides with Department of Pesticide Regulations

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Before a company can sell a pesticide in California, the product must first be registered by the Department of Pesticide Regulation (DPR). As part of the registration process, the company must submit certain supporting data to DPR. Scientists in a variety of disciplines review these data to determine the accuracy of the data, the results of the studies, the potential impacts to humans and the environment, and whether the pesticide (herbicide) works according to the label claims. A significant portion of these required data represent the pesticide's potential impact on fish, wildlife and the natural environment.

The submitted data include acute, subacute, and chronic studies on the impacts of the active ingredient on various species of freshwater and estuarine fish and invertebrates, birds, mammals, sediment dwelling aquatic invertebrates and honeybees. The species tested are intended to represent other similar species. For example, the results of the bluegill sunfish toxicity study are extrapolated to represent the effects of the pesticide on all warm water fish species. In addition, scientists review environmental fate data to determine what the pesticide does in the environment. These data tell us how long a pesticide lasts in the environment under a variety of conditions, what the metabolites are, how long the metabolites last in the environment, the solubility of the pesticide in water, and whether the pesticide will move in soil.

The results of all the data reviews are then used to build a picture of what the pesticide will do in the environment when used according to label directions. This picture is the basis for the recommendation of whether the pesticide should be registered as submitted by the registrant.

Volatile Organic Compounds Regulation Update

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The State Implementation Plan (SIP) for ozone requires the Department of Pesticide Regulation (DPR) to track and reduce volatile organic compound (VOC) emissions from pesticides in five non-attainment areas. DPR estimates and tracks VOC emissions based on pesticide use report data, lab data on the VOC content of pesticide products, and field emission data for fumigants. Three of the five non-attainment areas currently do not meet the reduction obligations in the SIP. DPR has developed regulations to obtain the needed reductions by controlling fumigant emissions.

The regulations contain five major elements. First, pest control businesses must have at least one person certified in the new licensing sub-category for fumigation. Second, only "low-emission" fumigation methods can be used during May - October in the three non-attainment areas that need additional reductions. Third, pesticide use reports for fumigations in the five non-attainment areas must include the specific method of fumigation. Fourth, DPR must implement a fumigant limit for a non-attainment area if emissions exceed a trigger level. DPR will implement a fumigant limit for the Ventura non-attainment area in 2008, and likely in the San Joaquin Valley and Southeast Desert non-attainment areas in 2009. The fumigant limits are enforced through "emission allowances" included as a condition on restricted materials permits for each grower. Fifth, DPR must publish an annual report containing the latest emission estimates and any needed fumigant limits.

Research Authorization Program in California

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The Research Authorization (RA) program governs the experimental application of pesticides in California. The permits are requested by, and granted to researcher personnel working for registrants, contract researchers, commodity groups, and individuals seeking to test pesticides to study efficacy, residues, environmental fate and other aspects of pesticide use. The purpose of these tests is to gather information to eventually support the registration and use of a product in California and with the USEPA. The oversight of the RA program resides in the Department of Pesticide Regulation (DPR), Pesticide Registration Branch, in the Plant Physiology station.

Authorization for Research (CCR Section 6260)

Authorization for research shall be obtained from DPR prior to any experimental, unregistered use of pesticide. The authorization may specify conditions under which the research shall be conducted. The condition may include handling of the treated commodity, safety equipment, reentry intervals, medical monitoring, and field posting. Research requiring an approved human exposure protocol pursuant to Section 6710, shall be conducted in accordance with that protocol.

DPR may terminate, amend, or refuse to issue a RA whenever it is determined that 1) the research may involve a hazard to handlers and/or field workers, the public health or the environment; 2) the research is used for purposes unrelated to pesticide data development; or 3) violation of the authorization, a previous authorization, or Division 6 or 7 of the Food and Agriculture Code, or regulations adopted pursuant to them, have occurred in connection with such research.

Application for Research Authorization (CCR Section 6262)

Application for a RA may be obtained from DPR at www.DPR.CA.gov/docs/regforms/ra/ramenu.htm. The application requires applicants to provide the following information: 1) Name, mailing address and telephone number of applicant; 2) pesticide to be applied; 3) type of site or commodity and stage of growth at which pesticide will be applied; 4) size, number, and total area of trials; 5) date of first and last applications; 6) type of data sought; 7) planned disposition of treated commodity; 8) signature and title of persons responsible for the trials. Additional data may be required if necessary to assess the potential adverse effects to workers, the public, and/or the environment.

Notification and Use of Research Authorization (CCR Section 6264)

At least 24 hours prior to beginning application of a pesticide, the researcher shall submit to the agricultural commissioner of the county where the proposed trial site is located a copy of the RA. In addition a notice of intent as provided in Section 6434(b) specifying the location of each trial. If not submitted with the notice of intent, the research shall submit a plot map of the exact location of each trial within seven days after initial application of the pesticide. If no application of pesticide is made following the notice of intent, the researcher shall notify the agricultural commissioner within two weeks by submitting an Experimental Trial Report as required in Section 6266 (a).

Reports of Research Authorization Use (CCR Section 6266)

The researcher shall submit an Experimental Trial Report to California agricultural commissioner following the final application of a pesticide requiring an RA, and at least 24 hours prior to either harvest or crop destruction the following information: 1) firm name; 2) RA number;3) commodity or site treated; 4) date of report; 5) trial location; 6) date and method of planned disposition of treated commodity; and 7) name and telephone number of researcher or representative responsible for crop disposition.

The researcher shall submit to the DPR an Experimental Pesticide Use Report within two weeks following the expiration date of the RA. The report shall include the following information: 1) RA number; 2) pesticide product applied; 3) commodity or site treated; 4) rate of active ingredient per acre or unit; 5) Total amount of active ingredient used 6) total acres or units treated; 7) counties where trials were conducted; 8) name, address, and phone number of researcher; 9) certification that the commodity was harvested/disposed of as required by RA.

Exemption from Authorization for Research (CCR Section 6268)

A pesticide registrant is exempt from these requirements when the registrant is the operator of the property upon which the research is to be conducted and continues to be the operator until the treated commodity is destroyed or harvested. Also, personnel employed by colleges and universities and engaged in pesticide research are exempt if they are operating according to the current established policy of the college or university, which covers pesticide use and experimentation.

Position of Authorization (CCR Section 6272)

Each person making an application of a pesticide under a RA shall have a copy of the RA available at the use site at the time of application.

Herbicide Efficacy and Phytotoxicity Requirement

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Efficacy data is required for herbicide registration to support label claims and uses. Data must demonstrate consistent product efficacy whether the product is used according to label directions. The user of the product must be assured that there is significant benefit from the use of product.

Efficacy data development generally follows USEPA Guidelines Subdivision G, Product Performance, series 94. Herbicide registrants develop data, which they submit, or data from the public literature.

Field trials shall be designed to allow for appropriate statistical analysis such as randomized complete block design. P retreatment and post treatment of trials shall be documented. Treatments shall include untreated controls, standard products, and several rates to demonstrate that selected label rates are appropriate. Statistical analysis of data is required to demonstrate significance at 95 percent confidence.

Efficacy trials shall be conducted in California or under California like conditions. Trials shall be conducted over two growing seasons and at several locations based on where crops are grown in California.

Phytotoxicity data are required to demonstrate safety of formulated products to crops/plants being treated and crops located off-site or adjacent. Usually use injury ratings or other parameters such as yield, vigor, necrosis, chlorosis is documented. At a minimum, documentation or lack of phytotoxicity as part of efficacy trials and residue studies are acceptable. Margins of safety may be established by using twice label rate or higher rates.

Data presentation is very important part of reports for efficacy and phytotoxicity studies. Reports should include product overview, summary of results of field trials with the use of tables, charts, and graphs. Individual trial results should include trial summary, raw data, statistical analysis, terms definitions, and any abbreviations.

Precision Guided Cultivation in Lettuce and Celery

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Abstract

In 2007, three trials were conducted to evaluate the efficiency of the Robocrop vision-guided system with various cultivation tools in conjunction with post-emergent and pre-emergent herbicides. The lettuce trials were arranged as a split plot with pronamide as the main plot and cultivator tool or directed herbicide as the subplot. Half of the main plots were treated with a pre-emergent application of pronamide at 1.2 ai/Ac in 40 GPA, the other half of the plots received no pronamide. The cultivator tools included in the comparison were: sweep knives, bezzerides, and coulters with sweep knives. The post-emergent directed herbicides included Scythe 4.2EC and Shark 2E. Scythe was applied at 3 and 6% v/v in the first trial and second trials respectively, while Shark was applied at 0.032 lb/ai/Ac in both trials. Data gathered were the number of marketable heads, weed densities and hand-weeding times. In the celery trial, the Robocrop was used to guide an application of Scythe herbicide at 3% v/v in a volume of 100 GPA directed between the plant lines and to guide a close cultivation with sweep knives. Data gathered in the celery study were crop injury, and yield, weed densities and hand weeding times. The first lettuce trial showed that the pronamide application significantly reduced hand weeding times, produced larger marketable heads, and increased yield. The bezzerides gave the highest yield when the pronamide was applied. The best weed control in both trials was found in the plots that used knives, coulters with knives, and Shark. However Shark caused crop injury and lowered yields. In the second trial, the bezzerides and the Scythe treatments produced the largest heads; Shark again injured the crop. In the celery trial, the knives and directed Scythe spray significantly reduced weeds, and no crop injury was observed. The Scythe treatment produced the greatest number, weight, and size of marketable celery stalks.

Simazine, Diuron, and Atrazine Detections in California Surface Waters

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Introduction

A wide variety of herbicides are applied annually in high amounts throughout California. In 2006, 65 herbicide active ingredients were each applied in amounts over 1,000 kg active ingredient; this amounted to about 8.8 million kg herbicides applied. For many of these herbicides, recent surface water monitoring data from areas of high use are lacking; such data are needed in order to assess their potential impacts on aquatic systems.

Simazine and atrazine, both triazine herbicides used to control broadleaf weeds and annual grasses, are toxic to non-target aquatic plants. Simazine is used in several agricultural regions of California and is applied to wine grapes in the Sonoma/Napa area during California's wet season. Almost half of California's atrazine use occurs in the Imperial Valley. No recent triazine surface water monitoring data are available for these regions of high use. In 2006, DPR initiated a monitoring study designed to begin assessing pesticide contamination of surface waters in high-use regions of the state. As part of that study, surface water samples were collected from Napa, Sonoma, Monterey, and Imperial Counties in early 2007 and analyzed for a suite of seven herbicide active ingredients.

Materials And Methods

Twenty-eight monitoring sites were chosen in three regions of California: Napa/Sonoma, Imperial, and Monterey Counties. From the 28 sites, a total of 35 samples were collected in January, February, or March 2007. In two regions of California, sampling was timed to coincide with historic periods of high triazine herbicide use; simazine in Napa/Sonoma Counties, and atrazine in Imperial County. For one sampling interval in Napa/Sonoma, storm run-off samples were collected during a winter storm. All other sampling occurred during dry weather.

Surface water samples were collected as close as possible to the center channel by using an extendable pole, collecting the water sample directly into a 1 L amber bottle. After collecting the samples, bottles were sealed with Teflon®-lined lids and transported on wet ice or refrigerated at 4°C until extracted for chemical analysis. At each site, dissolved oxygen, pH, specific conductance and water temperature were measured *in situ*.

The California Department of Food and Agriculture's Center for Analytical Chemistry (CDFA) analyzed the surface water samples for the following herbicides: atrazine, simazine, diuron, prometon, bromacil, hexazinone, and norflurazon. Reporting limits (RL) for all herbicides are 0.05 $\mu g\ L^{-1}$. Detections above the RL were reported in $\mu g\ L^{-1}$; detections below the RL but above the method detection limit were reported as trace detections but were not quantified.

Results And Discussion

Several herbicides were detected in the water samples from the three regions (Table 1). Simazine was detected only in the Napa/Sonoma region; all storm samples had detections above the RL. Samples collected during dry weather in Napa/Sonoma had two trace detections of simazine. Atrazine was detected only in Imperial County; two samples were detectioned above the RL and two additional samples were trace detections. An additional sample from Imperial County had a trace detection of deethyl-atrazine (DEA), a degradate of atrazine. Diuron was detected above the RL in all three regions. The overall detection frequency of diuron, including trace detections, was over 30%; this is especially significant considering that diuron use is relatively low in these regions at the times sampled.

The detected concentrations of simazine, atrazine and diuron did not exceed the US EPA Aquatic Life Benchmarks. However, triazine herbicides, as well as diuron, have been shown to potentiate the effects of organophosphate (OP) insecticides. As such, concentrations of these herbicides that are not themselves toxic to aquatic organisms can increase the toxicity of OP insecticides that are present in the aquatic system. OP insecticides were co-detected with diuron in two samples from Monterey County and one sample from Imperial County. Additionally, both atrazine and simazine are suspected endocrine disruptors and the US EPA has recommended additional monitoring for these compounds. For diuron, monitoring results available elsewhere indicate that, in over 1200 samples collected throughout California between 2000 and 2005, the diuron benchmark of 2.4 $\mu g\ L^{-1}$ was exceeded in about 5% of samples.

The mass loading of herbicides during storm samples can also be substantial, as shown in Table 2. Mass loading calculations for simazine, diuron, and prometon indicate that large amounts of these herbicides can enter water bodies during storm events. Perhaps the most interesting data are for atrazine in the Salton Sea. The Salton Sea contains ca. 9.25 trillion L of water; it represents a large reservoir for potential dilution of incoming water. While the number of samples were limited, atrazine concentrations in the Salton Sea were greater than those in the primary input waters (Alamo and New Rivers). In addition, atrazine was detected in the Salton Sea ca. 42 km from the primary agricultural drainage inflows. Because the Salton Sea is a sensitive aquatic habitat, further sampling is warranted to better define the temporal and spatial extent of atrazine concentrations, evaluate those concentrations relative to aquatic toxicology benchmarks, and investigate the mass budgets of atrazine and other herbicides in the Salton Sea.

The results from this study indicate that atrazine, simazine, and diuron are contaminants in surface water. Based on these results, additional monitoring for these herbicides is warranted. Monitoring for other herbicides with low aquatic toxicity benchmarks and high use, especially those with high use during California's wet season, is also recommended. Herbicides that fit this profile include oxyfluorfen and several of the dinitroaniline herbicides (trifluralin, pendamethalin, and oryzalin). Where indicated, simultaneous monitoring for OP insecticides should also be considered.

Table 1. Summary of 2007 herbicide monitoring results.

Region	Date	Number of Samples	Detections (trace detections[2])			
			Simazine	Atrazine	Diuron	Other
Napa/Sonoma	Jan 2007	14	0 (2)	0	2 (3)	none
Napa/Sonoma	Feb 2007[1]	7	7	0	2	prometon: 1
Imperial	Mar 2007	10	0	2 (2)	1	DEA: 0 (1)
Monterey	Mar 2007	4	0	0	2 (1)	none

[1] Storm samples

[2] First number is the number of detections (> RL); the number in parentheses, when present, is the number of trace detections (< RL).

Table 2. Mass loading of water bodies from detected herbicides using flow data from USGS gauging stations.

Water Body (flow rate, L sec^{-1})	Herbicide detected ($\mu g\ L^{-1}$)	Mass loading (mg sec^{-1})	Mass loading (g day^{-1})
Napa River (14,385)	diuron (0.095)	1.4	118
Napa River (14,385)	simazine (0.556)	8.0	691
Russian River (291,664)	diuron (0.077)	22.5	1,940
Russian River (291,664)	simazine (0.842)	245.6	21,218
Russian River (235,879)	simazine (0.096)	22.6	1,957
Mark West Creek (42,192)	simazine (1.94)	81.9	7,072
Mark West Creek(42,192)	prometon (0.092)	3.9	335
Sonoma Creek (15,065)	simazine (0.227)	3.4	296

Acknowledgements

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Disclaimer

The mention of commercial products, their source, or use in connection with material reported herein is not be construed as either an actual or implied endorsement of such products.

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MILESTONE™ HERBICIDE (AMINOPYRALID): NEW EFFICACY RESEARCH ON NOXIOUS AND INVASIVE WEEDS

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Introduction

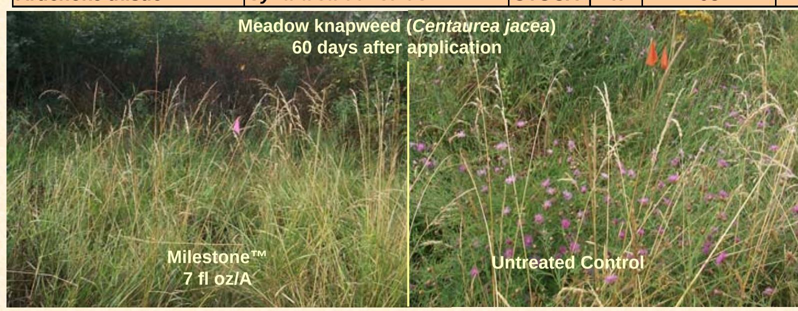
Aminopyralid is a new pyridine carboxylic acid herbicide intended for use in rangelands, pastures, Conservation Reserve Program (CRP), and industrial vegetation management areas, including rights-of-way for roads, railroads and electric utility lines. This Dow AgroSciences herbicide was designed and developed specifically for the control of noxious and invasive weed species on non-cropland sites. Aminopyralid is a new generation active ingredient that is effective at very low rates as compared to currently registered herbicides with the same mode of action, including 2,4-D, clopyralid, triclopyr, picloram and dicamba. Aminopyralid is a broadleaf weed herbicide that provides systemic, postemergence control of noxious and invasive annual, biennial and perennial weed species, agronomically important weeds and certain semi-woody plants. Aminopyralid can provide residual control, thus reducing the need for re-treatment, depending on the rate applied and the target weeds. Currently aminopyralid is registered as Milestone™, Milestone VM, and ForeFront™ R&P (premix with 2,4-D).

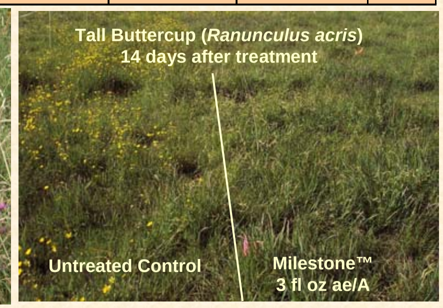
Materials and Methods

Multiple research trials were initiated in 2005 and 2006 on non-cropland sites in California, Idaho, Montana, Nebraska, Oregon, South Dakota, and Washington. Studies were conducted as small, replicated trials with Milestone at 3, 5, and 7 fl oz product/A, 3 to 4 replications in a randomized complete block design, applied with CO_2 backpack sprayers, and using spray volumes of 15 to 44 GPA. Treatments were applied with the addition of a non-ionic surfactant at 0.25% v/v . Plots were evaluated at 47 to 379 days after application for percent visual control. Trials were established to assess mullein (*Verbascum thapsus*), Scotch thistle (*Onopordum acanthium*), purple starthistle (*Centaurea calcitrapa*), rush skeletonweed (*Chondrilla juncea*), St. Johnswort (*Hypericum perforatum*), meadow knapweed (*Centaurea jacea*), tall buttercup (*Ranunculus acris*), and Italian (*Carduus pycnocephalus*), woolly distaff (*Carthamus lanatus*), artichoke (*Cynara cardunculus*) and Scotch (*Onopordum acanthium*) thistles responses to aminopyralid.

TABLE 1. Percent Control with Various Rates of Milestone™ (aminopyralid) on Target Weed Species

				% Control				
Common name	Scientific name	Bayer Code	DAA	Milestone 0.75 oz ae/A (3 fl oz/A)	Milestone 1.25 oz ae/A (5 fl oz/A)	Milestone 1.75 oz ae/A (7 fl oz/A)	Application timing	State
Meadow knapweed	*Centaurea jacea*	CENJA	379	NA	80	99	05-May-05	OR
Woolly distaff thistle	*Carthamus lanatus*	CAULA	378	92	100	100	06-Apr-05	CA
Italian thistle	*Carduus pycnocephalus*	CRUPY	378	47	48	80	06-Apr-05	CA
Tall buttercup	*Ranunculus acris*	RANAC	363	88	100	100	08-Jun-05	MT
St Johnswort	*Hypericum perforatum*	HYPPE	352	65	87	99	05-Jul-05	WA
Rush skeletonweed	*Chondrilla juncea*	CHOJU	283	75	92	95	08-Nov-05	WA
Artichoke thistle	*Cynara cardunculus*	CYUCA	117	82	77	92	13-Jan-06	CA
Purple starthistle	*Centaurea calcitrapa*	CENCA	113	98	99	100	27-Mar-06	CA
Scotch thistle	*Onopordum acanthium*	ONRAC	112	98	99 (2 reps)	99	05-May-05	NE
Mullein	*Verbascum thapsus*	VESTH	100	NA	85 (4 fl oz/A)	96	05-Jun-06	SD
Artichoke thistle	*Cynara cardunculus*	CYUCA	47	93	88	99	24-Mar-06	CA





Results

Milestone at 5 and 7 fl oz/A provided excellent control of woolly distaff thistle (100/100%), rush skeletonweed (92/95%), St Johnswort (87/99%), and tall buttercup (100/100%) 1 year after application (Table 1). Milestone at 7 fl oz/A controlled meadow knapweed (99%), artichoke thistle (92%), and Italian thistle (80%) at 1 year after application. Within the growing season of application Milestone provided excellent control of purple starthistle (≥95%) and Scotch thistle at 3 fl oz/A or more and common mullein (85/96%) at 4 and 7 fl oz/A, respectively.

Summary

Milestone was registered by the US EPA in October 2005. Forty-eight weed species, including Canada thistle (*Cirsium arvense*), spotted knapweed (*Centaurea maculosa*), Russian knapweed (*Acroptilon repens*), yellow starthistle (*Centaurea solstitialis*), musk (*Carduus nutans*) and bull (*Cirsium vulgare*) thistles, and orange and yellow hawkweeds (*Hieracium aurantiacum* and *H. caespitosum*) were listed on the label. Field trials have been conducted since the registration of Milestone to determine efficacy on other weeds. The new weeds controlled by Milestone include meadow knapweed, woolly distaff and Italian thistle, tall buttercup, St. Johnswort, rush skeletonweed, Scotch and artichoke thistles, purple starthistle, and mullein. A total of 24 new weed species were added to the latest revision of the Milestone label that was accepted by EPA in January 2007.

Weed Management in Almonds for 2007

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Weed management in both young and established almonds (*Prunus dulcis*) 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 and new formulations of established materials have been evaluated in 2007 research trials.

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.

4 Year Almond Trial 2007: A four year old almond orchard planted to a 14 x 22 ft spacing was divided into 2 reps of Nonpariel and 2 reps of Fritz for a total of 4 replications of 14 treatments in RCBD. Evaluations in Jan and Feb showed no effects due to the lack of weeds believed to be from the severe cold weather during much of that time. Evaluations were conducted on April 13 (127 Days after the initial treatment - DAT), May 29 (173 DAT), September 11 (278 DAT), 2007. Harvest samples were collected on August 10 & Sept 19, 2007

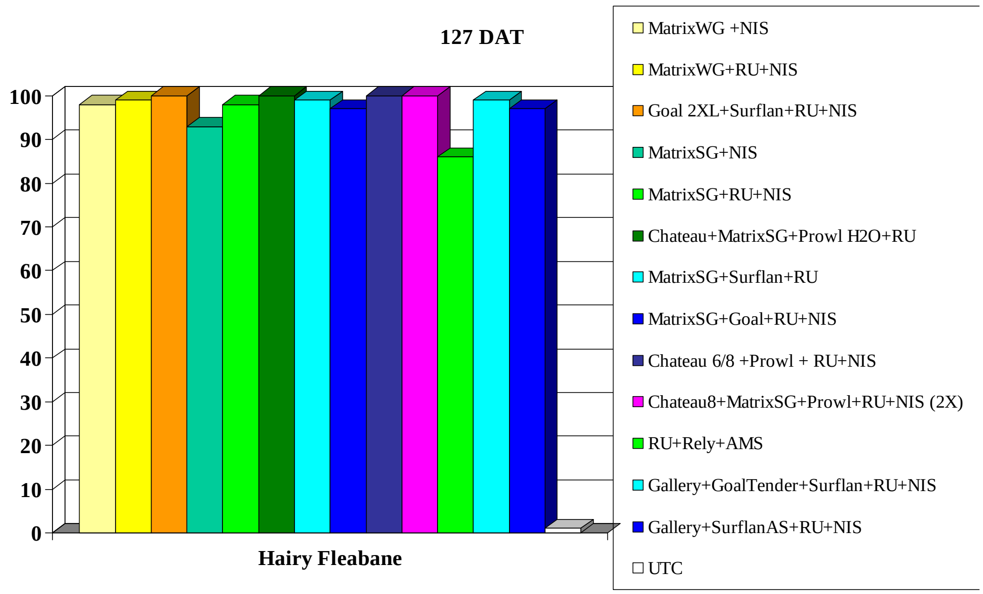
1 Year Almond Trial 2007: An almond orchard planted March 1, 2006 on a 17 by 20 ft spacing was divided into two tree plots of 22 treatments with four replications in a randomized complete block design. Treatments were applied on Jan 3, 2007. Certain treatment were not applied at this time. The second application which included treatments not previously applied and sequentially timed treatments was April 16, 2007. Trunk diameters were taken on January 16, March 19, and June 5, 2007. Due to extremely cold weather, there were no weeds present to evaluate at 30 and 60 days after the initial treatment. Weed and crop injury evaluations were conducted on April 13 (127 DAT) and August 10 (219 DAT), 2007.

Four year old trial site

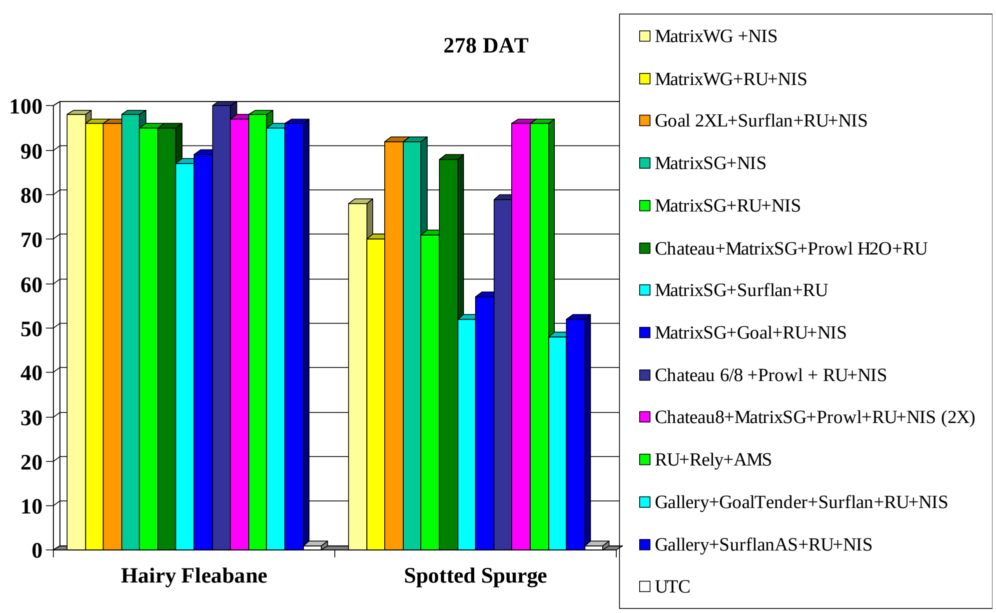
At 127 DAT only Matrix @ 4 oz tank mixed with Glyphosate (RU) at 1 qt and Induce (NIS) at 6.4 oz indicated significantly lower control that the best treatments. However this treatment still exhibited excellent control at 92% for hairy fleabane, foxtail barley, rattail fescue, mayweed, pineapple weed, whitestem filaree, panicle willowweed, shepherd's purse, and white clover. There were no significant differences for brass buttons by any treatment. **At 173 DAT**, all treatments still provided excellent control of hairy fleabane, foxtail barley, and rattail fescue with only Matrix SC at 4 oz tank mixed with NIS or RU tank mixed with Rely and AMS exhibiting significantly less control than the other treatments. Mayweed, pineappleweed and whitestem filaree were completely controlled by all treatments. **At 278 DAT**, excellent control was exhibited for the following weeds by all treatments: barnyardgrass, junglerice - 100%, and cheeseweed - 95 to 100%. Fleabane exhibited 87 to 100% control, white clover exhibited 86 to 100 % control, and sowthistle exhibited 91 to 100% control with no significant differences between treatments. Acceptable control of spotted spurge was only exhibited by the following: Goal 2XL 2 pt mixed with Surflan 1 gal, RU 1 qt and NIS 6.4 fl oz; Matrix SG 4 oz mixed with

NIS 6.4 oz, Chateau 8 oz mixed with Matrix SG 4 oz, Prowl H2O 4 qt and RU 1 qt; Chateau 8 oz mixed with Matrix SG 4 oz, Prowl H2O 3 qt, RU 1 qt and NIS 6.4 oz (2X); or RU 2 qt mixed with Rely 4 qt and AMS 10 lb. There was no indication of crop injury at any evaluation throughout the year.

4 Year Almond Weed Study 2007



4 Year Almond Weed Study 2007



One year old trial site

At 85 DAT, the greatest control of ryegrass was exhibited by Matrix SG tank mixed with Goal, Roundup WeatherMax (RU) and Induce (NIS) and was not significantly different from any treatment but the following: Chateau at 6 oz mixed with Prowl H2O, RU and NIS followed by Chateau at 8 oz mixed with Prowl H2O, RU and NIS (which still provided acceptable control); Gallery T&V at 0.67 lb mixed with Prowl H2O, RU and NIS or the UTC. There were no significant differences in chickweed control for any treatment with all treatments providing excellent control and significantly greater control than the UTC. There was no indication of crop injury by any treatment at this evaluation. **At 219 DAT**, paraquat had been uniformly sprayed over the entire trial site. There were no significant differences in sowthistle or spiny clotbur control. The greatest control of junglerice was exhibited by Gallery T&V at 1 lb mixed with Prowl H2O, RU and NIS at 94 percent. Although other treatments provided significantly similar control, control levels below 80 percent are considered adequate rather than good or excellent and anything less than 70 percent is considered unacceptable. There was no indication of crop injury at this evaluation.

Young Almond Weed Management 2007

85 DAT

Treatment	Rate	Ryegrass	Chickweed
Matrix WG + NIS[a]	4 oz + 6.4 fl oz	99 a	100 a
Matrix WG + RU + NIS[a]	4 oz + 1 qt + 6.4 fl oz	95 ab	98 a
Goal 2XL + Surflan + RU + NIS[a]	2 qt + 1 Gal + 1 qt + 6.4 fl oz	96 ab	100 a
Matrix SG + NIS[a]	4 oz + 6.4 fl oz	98 ab	100 a
Matrix SG + RU + NIS[a]	4 oz + 1 qt + 6.4 fl oz	96 ab	100 a
Chateau + Matrix SG + Prowl H2O + RU[a]	8 oz + 4 oz + 1 gal + 1 qt	92 abc	100 a
Matrix SG + Surflan + RU[a]	4 oz + 1 gal + 1qt	99 a	100 a
Matrix SG + Goal + RU + NIS[a]	4 oz + 1 pt + 1 qt + 6.4 oz	100 a	98 a
Chateau + Prowl H2O + RU/Chateau + Prowl H2O + RU[ab]	6 oz + 3 qt + 1 qt/8 oz + 3 qt + 1 qt + 6.4 fl oz	85 c	100 a
Chateau + Matrix SG + Prowl H2O + RU[ab]	8 oz + 4 oz +3 qt + 1 qt + 6.4 fl oz	96 ab	100 a
RU + Rely + AMS[b]	2 qt + 1 gal + 10 lb		
GoalTender + Prowl H2O+RU+NIS[a]	2 qt + 1 gal + 25.6 fl oz + 6.4 fl oz	94 abc	100 a
Gallery T&V + Prowl H2O+RU+NIS[a]	1 lb + 1 gal + 25.6 fl oz + 6.4 fl oz	89 bc	100 a
Gallery T&V + Prowl H2O+RU+NIS[a]	1.33 lb + 1 gal + 25.6 fl oz + 6.4 fl oz	94 abc	100 a
Gallery T&V + Prowl H2O+RU+NIS[a]	0.67 lb + 1 gal + 25.6 fl oz + 6.4 fl oz	53 d	100 a
Gallery T&V + Prowl H2O+RU+NIS[b]	1 lb + 1 gal + 25.6 fl oz + 6.4 fl oz		
GoalTender + Surflan + RU + NIS[b]	3 pt + 3 qt + 25.6 fl oz + 6.4 fl oz		
Rely + GoalTender + Surflan[b]	4 qt + 1 qt + 3 qt		
Rely + GoalTender + Surflan[b]	6 qt + 1 qt + 3 qt		
Rely + Chateau[b]	4 qt + 6 oz		
Rely + Chateau[b]	6 qt + 6 oz		
UTC		0 e	7 b

Young Almond Weed Management 2007

85 DAT

Treatment	Rate	Ryegrass	Chickweed
Matrix WG + NIS[a]	4 oz + 6.4 fl oz	99 a	100 a
Matrix WG + RU + NIS[a]	4 oz + 1 qt + 6.4 fl oz	95 ab	98 a
Goal 2XL + Surflan + RU + NIS[a]	2 qt + 1 Gal + 1 qt + 6.4 fl oz	96 ab	100 a
Matrix SG + NIS[a]	4 oz + 6.4 fl oz	98 ab	100 a
Matrix SG + RU + NIS[a]	4 oz + 1 qt + 6.4 fl oz	96 ab	100 a
Chateau + Matrix SG + Prowl H2O + RU[a]	8 oz + 4 oz + 1 gal + 1 qt	92 abc	100 a
Matrix SG + Surflan + RU[a]	4 oz + 1 gal + 1qt	99 a	100 a
Matrix SG + Goal + RU + NIS[a]	4 oz + 1 pt + 1 qt + 6.4 oz	100 a	98 a
Chateau + Prowl H2O + RU/Chateau + Prowl H2O + RU[ab]	6 oz + 3 qt + 1 qt/8 oz + 3 qt + 1 qt + 6.4 fl oz	85 c	100 a
Chateau + Matrix SG + Prowl H2O + RU[ab]	8 oz + 4 oz +3 qt + 1 qt + 6.4 fl oz	96 ab	100 a
RU + Rely + AMS[b]	2 qt + 1 gal + 10 lb		
GoalTender + Prowl H2O+RU+NIS[a]	2 qt + 1 gal + 25.6 fl oz + 6.4 fl oz	94 abc	100 a
Gallery T&V + Prowl H2O+RU+NIS[a]	1 lb + 1 gal + 25.6 fl oz + 6.4 fl oz	89 bc	100 a
Gallery T&V + Prowl H2O+RU+NIS[a]	1.33 lb + 1 gal + 25.6 fl oz + 6.4 fl oz	94 abc	100 a
Gallery T&V + Prowl H2O+RU+NIS[a]	0.67 lb + 1 gal + 25.6 fl oz + 6.4 fl oz	53 d	100 a
Gallery T&V + Prowl H2O+RU+NIS[b]	1 lb + 1 gal + 25.6 fl oz + 6.4 fl oz		
GoalTender + Surflan + RU + NIS[b]	3 pt + 3 qt + 25.6 fl oz + 6.4 fl oz		
Rely + GoalTender + Surflan[b]	4 qt + 1 qt + 3 qt		
Rely + GoalTender + Surflan[b]	6 qt + 1 qt + 3 qt		
Rely + Chateau[b]	4 qt + 6 oz		
Rely + Chateau[b]	6 qt + 6 oz		
UTC		0 e	7 b

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Treatment	Rate	Junglerice	Sowthistle	Spiny Clotbur
Matrix WG + NIS[a]	4 oz + 6.4 fl oz	25 i	98	100
Matrix WG + RU + NIS[a]	4 oz + 1 qt + 6.4 fl oz	36 ghi	91	98
Goal 2XL + Surflan + RU + NIS[a]	2 qt + 1 Gal + 1 qt + 6.4 fl oz	75 ab	100	100
Matrix SG + NIS[a]	4 oz + 6.4 fl oz	26 hi	89	100
Matrix SG + RU + NIS[a]	4 oz + 1 qt + 6.4 fl oz	51 def	94	88
Chateau + Matrix SG + Prowl H2O + RU[a]	8 oz + 4 oz + 1 gal + 1 qt	79 ab	98	98
Matrix SG + Surflan + RU[a]	4 oz + 1 gal + 1qt	45 fgh	92	95
Matrix SG + Goal + RU + NIS[a]	4 oz + 1 pt + 1 qt + 6.4 oz	68 bcde	95	100
Chateau + Prowl H2O + RU/Chateau	6 oz/ 8oz + 3 qt + 1 qt	82 ab	99	92
Chateau + Matrix SG + Prowl H2O + RU[ab]	8 oz + 4 oz +3 qt + 1 qt + 6.4 fl oz	79 ab	100	100
RU + Rely + AMS[b]	2 qt + 1 gal + 10 lb	50 efg	99	100
GoalTender + Prowl H2O+RU+NIS[a]	2 qt + 1 gal + 25.6 fl oz + 6.4 fl oz	76 ab	100	98
Gallery T&V + Prowl H2O+RU+NIS[a]	1 lb + 1 gal + 25.6 fl oz + 6.4 fl oz	64 bcdef	100	94
Gallery T&V + Prowl H2O+RU+NIS[a]	1.33 lb + 1 gal + 25.6 fl oz + 6.4 fl oz	75 ab	100	99
Gallery T&V + Prowl H2O+RU+NIS[a]	0.67 lb + 1 gal + 25.6 fl oz + 6.4 fl oz	74 bc	92	100
Gallery T&V + Prowl H2O+RU+NIS[b]	1 lb + 1 gal + 25.6 fl oz + 6.4 fl oz	94 a	100	98
GoalTender + Surflan + RU + NIS[b]	3 pt + 3 qt + 25.6 fl oz + 6.4 fl oz	70 bcd	99	100
Rely + GoalTender + Surflan[b]	4 qt + 1 qt + 3 qt	55 cdefg	99	100
Rely + GoalTender + Surflan[b]	6 qt + 1 qt + 3 qt	80 ab	99	100
Rely + Chateau[b]	4 qt + 6 oz	55 cdefg	96	98
Rely + Chateau[b]	6 qt + 6 oz	66 bcde	98	96
UTC		80 ab	100	100

Performance of a new organic herbicide based on *d*-limonene

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Marrone Organic Innovations

Introduction

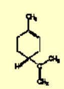
Natural product herbicides have the potential to play an important role in controlling weeds on organic farms by reducing reliance on tillage and cultivation and replacing expensive hand hoeing practices. In addition, cost effective natural products with high efficacy could replace more toxic pesticides currently in use on conventional farms.

Natural herbicides containing either vinegar (acetic acid) or clove oil (eugenol) are commercially available to organic growers, but only limited information is available on their effective use. Greenhouse and field trials have shown that vinegar applied in concentrations between 10 and 30% can effectively suppress multiple broadleaf weed species, but cannot consistently control grasses (Ferguson and Chase 2005). Clove oil at concentrations of 1 to 10 % has also been demonstrated to provide good control of several broadleaf weed species in some studies (Bainard et al. 2006; Tworkoski, 2002) but inconsistent control in others (e.g. Ferguson and Chase 2005).

A new OMRI-listed organic herbicide based on *d*-limonene (GreenMatch™ O, EPA Reg. No. 82052-1) has recently been introduced to the market by Marrone Organic Innovations, and a series of laboratory bioassays and field studies have been conducted to demonstrate its efficacy on some of the most common weeds in organic farming systems.

d-limonene

•***d*-limonene** ((4*R*)-1-methyl-4-(1-methylethenyl)cyclohexene or (*R*)-4-isopropenyl-1-methylcyclohexene) is a relatively stable monoterpene from orange peels and widely used as a cleaning agent.



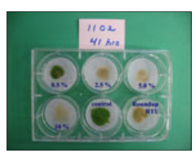
• the fast, non-selective herbicidal effect of *d*-limonene is based on the disruption of the leaf cuticle which leads to fast wilting of plants due to reduced chlorophyll fluorescence and stomatal functioning (Imrahim et al. 2004)

Bioassay set-up

• the phytotoxic effect of GreenMatch was tested in a laboratory bioassay on a 6-well plate using intact leaves of chickweed (*Stellaria media*) as a test subject
• the commercial product containing 70 % of *d*-limonene was diluted with DI water to the following concentrations: 0.5, 2.5, 5.0, 10.0 %. DI water and Roundup® RTU were used as control treatments
• a 0.5-mL aliquot of each solution was pipetted on a filter paper, and one leaf of chickweed was placed on the top of the filter paper
• the leaves were incubated for 2 days in a greenhouse with a 12-hr light/dark cycle, after which the leaves were evaluated for color change

Bioassay results

The results (on the right) show that:
• within 2-days, a direct contact with *d*-limonene at a concentration 2.5 % results in fast destruction of the chlorophyll which can be seen as a total bleaching of leaves.
• the effect of *d*-limonene, as a burndown, non-selective, non-systemic herbicide, is faster than that of systemic Roundup®.



Abstract

In organic farming, biological control of weeds using herbicides based on natural products or phytotoxic microbial metabolites is a potential alternative for hand hoeing and flaming. The herbicidal effects of plant extracts and essential oils have been acknowledged for decades but only recently have these products become commercially available for growers. One of the most promising organic herbicides is d-limonene, a monoterpene extracted from orange peels. It has previously been used as an insecticide in organic farming but recent field studies have shown that a *d*-limonene-product, GreenMatch™ O (70 % *d*-limonene), at 1:3 dilution controls most of the common broadleaved and grass weeds. The non-systemic burn-down effect is based on fast disruption of the leaf cuticle, which leads to wilting. The effect is dependent on temperature as well as the plant age and leaf structure but in most cases, one application of *d*-limonene controls more than 80 % of weeds for 3-4 weeks.

Field studies

A series of field studies have been conducted to test the efficacy of GreenMatch™ O on both broadleaf and grass weeds (see pictures below). Selected field study results are presented in Tables 1 and 2.

Table 1

Treatment	Application rate (% A.I.)	Weed control (%) Common lambsquarters (*Chenopodium album*)			Weed control (%) Annual bluegrass (*Poa annua*)		
		1 DAT	8 DAT	15 DAT	1 DAT	8 DAT	15 DAT
Untreated	0.0	0.0 d	0.0 c	0.0 d	0.0 c	0.0 d	0.0 b
GreenMatch™ O	10.0	50.0 b	87.5 a	98.3 a	30.0 a	47.5 bc	45.0 a
GreenMatch™ O	17.5	63.8 a	98.0 a	97.8 a	28.8 a	68.8 a	56.3 a
Roundup®	4 qt/A	30.0 c	41.7 b	50.0 b	21.3 b	32.5 c	40.0 a
LSD (p≤ 0.05)		8.5	18.5	10.5	6.6	18.7	19.7

Study conducted by BioResearch, Fresno, CA; December 2006, spray volume 40 gpa; Roundup® is a registered trademark of Monsanto Company

Table 2

Treatment	Application rate (% A.I.)	Spray volume (gpa)	Weed control (%) Mustard at 4-5 leaf stage (*Brassica juncea*)		
			1 DAT	13 DAT	34 DAT
Untreated	0.0	0	0.0 d	0.0 d	0.0 c
GreenMatch™O	10.0	140	16.2 b	85.0 a	57.5 a
GreenMatch™O	10.0	70	17.5 b	38.8 c	37.5 ab
GreenMatch™O	17.5	70	28.8 a	52.5 b	25.0 bc
Acetic acid	10 % dilution	70	8.8 c	13.8 d	7.5 c
Matran® EC	10 % dilution	35	17.5 b	36.2 c	25.0 bc
LSD (p≤ 0.05)			6.6	15.5	28.3

University of California, Davis, Jan 2007; Matran® and acetic acid were applied according to manufacturer's recommendations. Matran® is a registered trademark of EcoSmart Technologies, Inc.

Conclusions

• an organic herbicide based on *d*-limonene (GreenMatch™ O) provides fast and effective control of both broadleaved and grass weeds
• the herbicidal effect of *d*-limonene decreases with decreasing temperature and increasing leaf cuticle thickness
• for optimal performance, GreenMatch™ O should be diluted 4–7x (17.5 – 10% A.I.) depending on temperature and the size of weeds
• good coverage (spraying volume of 60 gpa or higher) is required for best weed control especially at low temperatures and for large weeds

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Natural Product Innovation for Pest Management

FIELD EVALUATION OF GreenMatch EX: A NEW BROAD SPECTRUM ORGANIC HERBICIDE

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ABSTRACT

GreenMatch EX is a new contact, non-selective, broad spectrum, foliar herbicide. It is exempt from EPA registration and is approved for use in organic farming. This biological product controls both annual and perennial broadleaf and grassy weeds. GreenMatch EX has been tested in California against various broadleaf and grassy weed species to obtain efficacy and weed spectrum data. Studies with three dilution rates (7.5, 10, and 15%) and three spraying volumes (35, 60, and 100 gallons per acre) showed a significant correlation between concentration/water volume and percent weed control. The best efficacy was achieved at 10 to 15% dilution rate (v/v) employing 100 gallons of water per acre, which indicates that complete tissue coverage is required to achieve full efficacy. GreenMatch EX performance was dependent upon the age of the weeds, and the best weed control was obtained when plants were young and actively growing. GreenMatch EX at 15% was more effective than GreenMatch (d-limonene) and Matran EC (clove leaf oil) at the recommended commercial application rates of 18% and 5%, respectively.

INTRODUCTION

Interest in incorporating natural-based pesticides in "green" integrated pest management programs has increased dramatically during the past few years [2, 3]. Currently, biopesticides represent 2.4% of the global pesticide market, and is projected to increase to 4.2% by 2010[3]. Weeds constitute the main problem in agricultural systems by reducing crop yields up to 12%[4], and various kinds of herbicides are employed worldwide to control weed pests. During 2005, the estimated global pesticide market was 33.6 billion dollars with herbicide use accounting for 45.8% of this market[3]. At present, the number of biological herbicides with potential to control weeds is limited. Corn gluten meal, a by-product in the manufacture of cornstarch, is available as Bioweed™ and has efficacy as a pre-emergence herbicide. Other commercially available post-emergence herbicides include fatty acid (pelargonic acid) sold under the trade name Scythe™, essential oil (clove) sold as Matran™, and monoterpene (d-limonene) from citrus oil sold as Nature's Avenger™ and GreenMatch™ O[1, 2]. The present study discusses the effectiveness of GreenMatch EX as a new non-selective biopesticide with potential to control a broad spectrum of grassy and broadleaf weeds.

MATERIALS AND METHODS

Efficacy of GreenMatch EX was evaluated in three locations in California. The first trial was established in two locations in Davis, CA: inside a peach orchard and in an open field. The second trial was located in Wasco, CA inside an almond orchard. A third trial was performed in Fresno, CA in a golf course. The treatments in all field experiments were arranged under a randomized complete block experimental design with 3 or 4 repetitions. In the trials performed in Wasco and Fresno, Matran® EC and GreenMatch were used as the commercial controls at the rate specified in the label. Treatments in the Wasco and Fresno trials were applied using a hand-held CO_2 sprayer, while all treatments in Davis were applied with a hand-held sprayer. Water was used as a carrier during the treatment application. When indicated, Nu Film P at 0.05% was used as a surfactant.

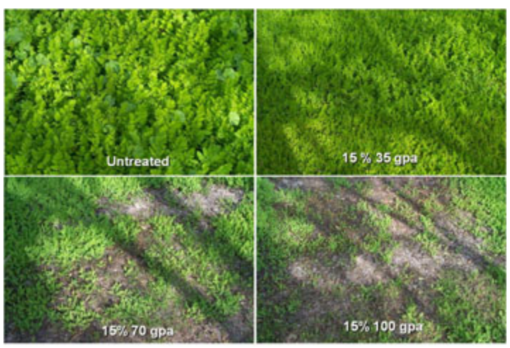

FIG. 1. GreenMatch EX EFFICACY 20 DAYS AFTER TREATMENT (WASCO, CA)

FIG. 2. GreenMatch EX EFFICACY AT 100 GPA 20 DAYS AFTER TREATMENT (WASCO, CA)

RESULTS

GreenMatch EX showed non-selectivity in controlling weeds. Both broadleaf and grassy weeds were burned in the presence of herbicide. In the trial performed inside the peach orchard in Davis, eight weed species were commonly found during the evaluation. Excellent control was observed against spurge and thistle; good control against bindweed, clover, and crabgrass; and satisfactory control against bermuda grass. Poor efficacy was detected in controlling henbit and dandelion. Table 1 shows the overall control estimated during this trial. Herbicidal effect was increased in the presence of surfactant. Control was greater than 86% at 10% dilution of GreenMatch EX at 100 gpa in the presence of 0.05% NuFilm P.

Redstem filaree, little mallow, shepherd's purse, london rocket, hairy fleabane, and annual bluegrass were the most common weeds found in the almond orchard in Wasco (Table 2). Data in table 2 shows that weed control depended upon GreenMatch EX concentration and volume of water employed (Figs 1, 2). All six weeds were controlled at the 15% concentration at 100 gpa. It was interesting to note that efficacy on shepherd's purse, london rocket, and hairy fleabane was higher than 92% at 10% concentration in 70 gpa. At these concentrations, GreenMatch EX performance was better than Matran EC applied at the recommended label rate.

Seven weed species were selected for the trial performed in the golf course in Fresno (Table 3). Smooth crabgrass was highly sensitive to GreenMatch EX followed by prickly lettuce and postrate spurge. Lower efficacy was detected against annual sowthistle, horse weed and flax fleabane. Interestingly, purple cudweed was not affected by GreenMatch EX, GreenMatch, and Matran EC.

TABLE 1. HERBICIDAL EFFECT (%) OF GreenMatch EX AND GreenMatch IN A PEACH ORCHARD (DAVIS, CA)

TREATMENT	5 DAT	14 DAT	31 DAT
EX 5%, 100 gpa	26.7	35.0	40.0
EX 5%, 100 gpa+	7.7	19.7	25.7
EX 5%, 60 gpa	5.3	8.0	2.7
EX 5%, 60 gpa+	1.0	2.7	24.3
EX 7.5%, 100 gpa	23.0	41.0	18.3
EX 7.5%, 100 gpa+	46.7	44.0	51.7
EX 7.5%, 60 gpa	11.0	20.7	12.0
EX 7.5%, 60 gpa+	3.3	6.0	5.7
EX 10%, 100 gpa	58.3	48.3	36.7
EX 10%, 100 gpa+	91.7	92.3	86.7
EX 10%, 60 gpa	18.3	35.0	14.3
EX 10%, 60 gpa+	38.3	49.0	25.0
GM 18%, 100 gpa	84.7	84.3	78.3
GM 18%, 100 gpa+	75.7	83.3	65.0
GM 18%, 60 gpa	29.0	44.0	35.0
GM 18%, 60 gpa+	52.3	71.7	68.3

+In the presence of Nu-Film P (0.05%); gpa= gallons per acre; DAT = days after treatment; EX = GreenMatch EX; GM = GreenMatch.

TABLE 2. EFFICACY (%) OF GreenMatch EX CONTROLLING WEEDS 20 DAT (WASCO, CA)

Treatment	Weed common name					
	Redstem filaree	Little mallow	Shepherd's purse	London rocket	Hairy fleabane	Annual bluegrass
Untreated	0	0	0	0	0	0
EX 7.5%, 35 gpa	6.3	7.5	12.5	11.3	8.8	6.5
EX 10.0%, 35 gpa	10.0	11.3	35.0	33.8	33.8	7.5
EX 15.0%, 35 gpa	42.2	37.5	50.0	52.5	52.5	17.5
EX 7.5%, 70 gpa	30.0	30.0	63.8	58.8	61.3	13.8
EX 10.0%, 70 gpa	68.8	77.3	92.0	92.5	93.8	52.5
EX 15.0%, 70 gpa	76.3	72.5	94.8	94.8	98.0	63.8
EX 7.5%, 100 gpa	68.8	75.0	94.8	94.8	94.8	80.0
EX 10.0%, 100 gpa	77.5	92.0	99.5	99.5	99.0	80.0
EX 15.0%, 100 gpa	94.5	87.5	100.0	100.0	100.0	92.5
GM 18%, 60 gpa	66.3	71.3	92.3	94.3	96.0	62.5
Matran 5%, 60 gpa	40.0	42.5	48.8	46.3	40.0	21.3

Application date: November 8, 2007; gpa= gallons per acre; DAT = days after treatment; EX = GreenMatch EX; GM = GreenMatch.

TABLE 3. EFFICACY (%) OF GreenMatch EX CONTROLLING WEEDS 21 DAT (FRESNO, CA)

Treatment	Weed common name					
	Smooth crabgrass	Prickly lettuce	Annual sowthistle	Postrate spurge	Horse weed	Flax fleabane
Untreated	0	0	0	0	0	1.4
EX 7.5%, 35 gpa	100.0	73.5	62.7	59.4	20.0	8.9
EX 10.0%, 35 gpa	70.0	78.5	61.6	63.1	39.4	22.4
EX 15.0%, 35 gpa	ND	90.3	57.9	68.8	36.5	31.8
EX 7.5%, 70 gpa	100.0	90.0	44.7	65.6	64.3	19.1
EX 10.0%, 70 gpa	ND	78.0	52.9	81.3	ND	26.1
EX 15.0%, 70 gpa	90.0	83.8	48.8	93.8	42.4	38.6
EX 7.5%, 100 gpa	100.0	68.3	55.0	82.5	30.6	13.3
EX 10.0%, 100 gpa	100.0	77.5	50.9	86.7	47.5	29.6
EX 15.0%, 100 gpa	100.0	68.1	55.6	86.3	ND	56.3
GM 18%, 60 gpa	50.0	77.9	65.6	79.4	75.6	28.6
Matran 8%, 60 gpa	100.0	85.6	69.8	86.3	22.5	61.3

Application date: October 18, 2007; gpa= gallons per acre; DAT = days after treatment; EX = GreenMatch EX; GM = GreenMatch.

CONCLUSIONS

- **GreenMatch EX shows good control of a wide variety of broadleaf and grassy weed.**
- **For best efficacy, GreenMatch EX should be used at 10-15% dilution and 100 gal/acre.**
- **Good coverage (high gpa) is important for best performance.**
- **Surfactant improves efficacy at high application volumes.**
- **Excellent control can be obtained for the following weed species: spurge, sowthistle, shepherd's purse, clover, mustard, London rocket, hairy fleabane, annual bluegrass, smooth crabgrass.**

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