The Weeds Are Streetwise

by
David Haskell

Born in the Valley's sugar beet slums,
Enduring the Eptam* water-runs.
Dodging hand-hoes and bed knives.
The weeds grow up streetwise.

Their parents survived the herbicide skid rows,
They learned to make it, anyway the wind blows.
And their children knew when their leaves uncurled,
They would be unwelcome guests in a monoculture world.

With Lillistons** chasing them down the beds,
Survival is the only thought that's left in their heads.
So they learn to hide out in the plant row,
And hang out in the ditches where the tail water goes.

Now those shady Solanaceaes, Hairy and Black,
Lead an army of seedlings on bivouac.
Soon army fatigue covers every bed top.
Another farmer just lost his tomato crop.

Now the weeds know all the survival rules.
They graduated from the UC herbicide schools.
Decorated veterans of many weed wars,
They terrorize their cultivated ancestors.

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*The Brand name of a herbicide formulated by Stauffer Chemical.
**Cultivation equipment that features a rotary hoe.

Soil Disinfestation Using Steam in Field-Grown Cut Flowers

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Methyl bromide is a key component of pest management programs in California cut flower production due to the broad spectrum of pests controlled including weeds, nematodes, and soil borne pathogens. Its short residual activity allows growers to replant an area soon after treatment, limiting the time an area is out of production. However, methyl bromide has been classified as an ozone depleting substance and is being phased out. A critical use exemption has been granted to cut flower growers in California for continued use due to a lack of effective and economical alternatives. Fewer critical use exemptions are granted each year and finding a methyl bromide alternative is imperative. Steam has been used to disinfest potting media for over a century and is a potential alternative to methyl bromide. In a greenhouse trial in 2009, weed population and Oriental lily height and yield were compared among two steam application methods, hot-gas methyl bromide, and an untreated control. Steam treatments were applied using four rows of drain tile buried 12 inches apart and 12 inches deep or using lay-flat hose with 10 inches spikes spaced 10 inches apart pressed into the surface of the bed. Soil in the steam plots was heated to 70^{o}C to a depth of 12 inches for at least 30 min. Weeds were counted one and two months after treatment, and for each date, there were significantly more weeds per half meter^2 in the untreated control compared to both steam treatments and the methyl bromide treatments. Similarly, plants were significantly taller in the steam and methyl bromide plots compared to the control. However, yield was not different among treatments. Additional research is ongoing to determine if steam disinfestation can be an effective and economical alternative to methyl bromide for the California cut flower industry.

Golf Course Weed I.D. and Control

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When you work in the golf industry, you realize that there are literally hundreds of different weed control issues to deal with depending on the course's site, and the level of weed control the course operators want. In order to look at the golf industry as a whole, rather than hundreds of different maintenance scenarios, I try to look at several key issues that allow me to address the bulk of the weed problems faced by each golf course.

I have identified my top 10 weed problems faced by almost all the golf courses in the region I call on based five key factors; Is the weed found throughout the region, does it offer a negative appearance to the course, does it impact play, is it an issue to the high priority areas of the course such as greens or fairways, and do we have good management tools to utilize against the weed.

Based on these key issues, my top10 golf course weeds are Crabgrass, Goosegrass, Kikuyugrass, Nut Sedge, Perennial Ryegrass, Clover, English Lawn Daisy, Knotweed, Spurweed, and my number one weed issue in golf course turf, Annual Bluegrass. These weeds are primarily found in either the greens, or fairways of most of the golf courses throughout the Southern San Joaquin Valley and Central Coast. Many chemical manufacturers do not register their chemistry on golf course greens, due to the high cost to construct or repair greens should there be some sort of damage, therefore we have limited but unique products for use on the greens for weed control. The fairways, tees, and roughs have a much more widely available chemical product line to choose from, thus we have many different product choices.

The pre-emergent products registered for use on golf greens are Bensumec, Dimension, (Anderson Fertilizer) and Tupersan. These products offer us our only registered choices for the prevention of crabgrass, goosegrass, and spurweed. The level of control can vary based on many factors, and in some cases we see virtually nothing but suppression but these are our only choices. The post emergent options for use on greens is even slimmer then the pre-emergent options. We have only one registered product for use on greens and that's a bentgrass formula of a 3-Way product called Trimec. This product does a good job on some of the broadleaf weed problems found on golf course, but as you look at my top 10 list, you see virtually no broadleaf weeds that impact golf greens.

For all areas of the golf course, fairways, tees, and roughs, we have a wider array of products to choose from. The pre-emergent's of choice are the "Yellow Herbicides" such as Surflan, Barricade, and Pendulum, while the non-staining product Dimension also rates high on the preferred list. Additionally, products such as Ronstar, and perhaps the yet unregistered product Tower may offer unique fits for specific weed control issues. The post emergent chemicals available for these areas is also more diversified and allow many more control options. The use of 3-Way and 4-Way chemical blends are available and come in a wide variety of blends and concentrations. We also see newer chemistry coming to the market such as quinclorac, sulfonated urea chemistry, peneoxsulam and carfentrazone. With all these options we can usually find a fix for almost any grassy or broadleaf weed problem.

Use of Mulches to Control Weeds in Landscapes

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Mulches are materials placed on the soil surface. When used in landscapes, they serve both aesthetic and practical functions. Mulches can be organic, synthetic or mineral—mulches can even be composed of rubber or any material that does not easily degrade or harm the plants that grow under them. Mulches prevent evaporation from soil surfaces and thus will cut evaporative loss of moisture from soils. Organic mulches made from recycled greenwastes have the advantage of breaking down into mineral nutrients that plants can use and will also add carbon to soils thus improving their porosity, structure and microbiology (Downer, 2008). Organic mulches are also aesthetic if they are prepared in a uniform size by screening or fine chipping. Recycling organic wastes back into landscapes is also beneficial to the environment as it reduces waste volume disposed in landfills while also reducing the need for petrochemiocal-based fertilizers.

Organic mulches must have several characteristics in order to perform adequately in landscapes for weed suppression. Mulch particles must be of large enough so that the mulch layer does not hold more water than underlying soil layers. This provides a vapor barrier necessary to slow evaporation. Mulches should not hold enough water to allow seed germination, so particles must be large, at least 3-6 cm chips or larger. Mulches must have some longevity as it is expensive to reapply them frequently. Lignified organic materials such as wood and bark make the best mulching materials. Chopped tree branches or trimmings are excellent feedstock for mulch. Manures, composts or other fine materials should be avoided. They may allow germination of weed seeds (Downer and Faber, 2005), and may contain weed contaminants (Daugovish et al., 2006). In a biosolids compost weed suppression effects were lost (Figure 1.). Another disadvantage of using composted materials is that they have already been degraded in the composting process thus shortening their useful mulch life. Mulches made from freshly chipped woody plants are best

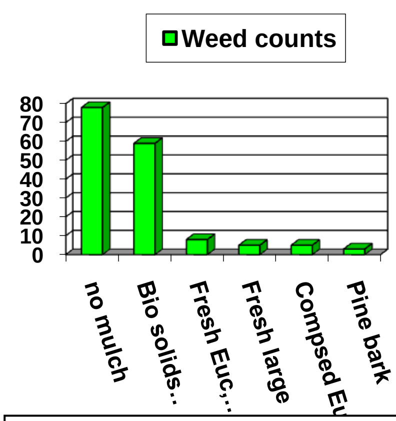

Figure 1. Downer and Faber, 2005

because decomposition has not begun and thus they have the maximum time available for breakdown. There is no published evidence of chipped tree branches drawing the nitrogen from underlying soils. In time, mulch will break down and eventually add nitrogen to the soil (Valenzuela-Solano et al.,2004). The thicker the mulch layer the greater the nutrient contribution.

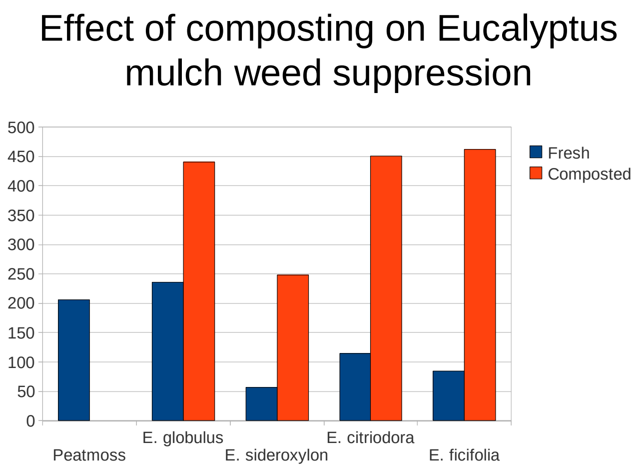

Figure 2. Downer, 1993

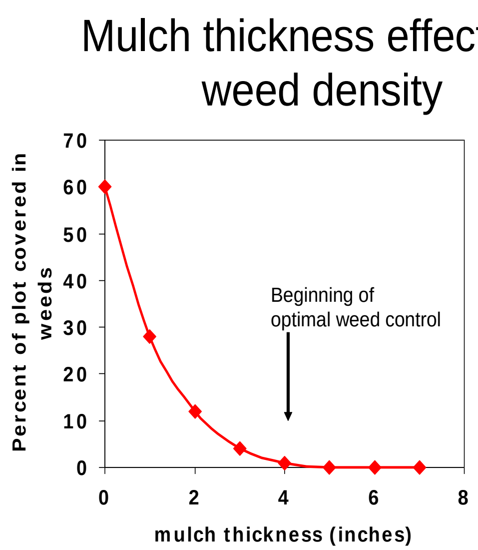

Figure 3. Optimal weed control with mulch

Yardwaste mulches made from Eucalyptus are common in municipal settings. Despite the popular fear of using Eucalyptus as a mulch, Eucalyptus mulches are safe for most horticultural uses and will promote growth of most plants under them. In a study of several different eucalyptus sources we found that different species of eucalyptus when made into mulch have different abilities to inhibit weed seed germination in flats (Figure 2.) *E. globulus* was the least suppressive to weeds while *E. sideroxylon* was very inhibitory to weed germination. When composted, the Eucalyptus mulches were stimulatory to weed seeds under them. Eucalyptus trees are known to contain allelochemicals that inhibit seedling germination; however the compost made from Eucalyptus leaves and small branches stimulated the germination and growth of weed seeds.

When these two eucalyptus species were tested in a field setting for their phytochemical potential there were no significant difference between *E. globulus* and *E. sideroxylon* in their ability to inhibit a variety of weeds such as red root pigweed, malva, fillaree, smooth crabgrass and lambsquarters. In the same study there was a very significant effect based on mulch thickness. As mulches of either source approach 4 inches in depth almost 100% weed suppression can be attained of common annual weed species (Figure 3). The four inch depth has been shown in a number of studies to inhibit most weed seed germination, probably from prevention of light breaking dormancy of the seeds. Mulches should be applied at greater depth than 4 inches because settling will result in shallower depths a few weeks after application.

Some caution should be taken when applying organic mulches. Mulches can be the sources of noxious weeds such as yellow and purple nutsedge. We have shown that nutsedge can survive composting temperatures in yardwaste stockpiles of up to 70C for as many as 56 days. Empirical data suggest that nutsedge is commonly spread in yardwastes and is frequently found invading landscapes from yardwaste mulched shrub and flower beds.

Mulches breakdown: losing over sixty percent of their carbon each year (Figure 4). The decay curve for mulch loss in a landscape approximates the chart to the left. This is for an ideal wood chip mulch of large particle size. By the end of year two, the mulch has lost most of its thickness and ability to suppress weed seed germination. As mulch degrades it also builds up fine materials that store water and allow for germination. Mulch should be applied at least once per year in a 4 inch thick layer to account for decay and mineralization. If mulches are not replenished weeds will "escape" through the mulch and the weed control effects of the mulch will be lost as weeds grow through it, set seed and thus more weeds are produced. It is not uncommon for abandoned mulched areas to become 100% covered by weeds as the decayed mulch materials are nutritive and will now hold more water than unmulched surface soil layers (Figure 5).

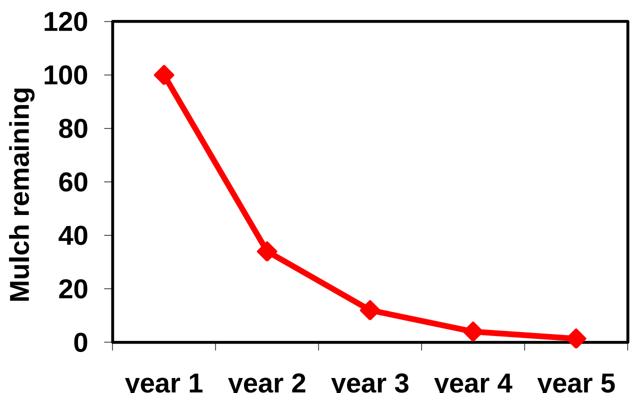

Figure 4. disappearance of mulch over time

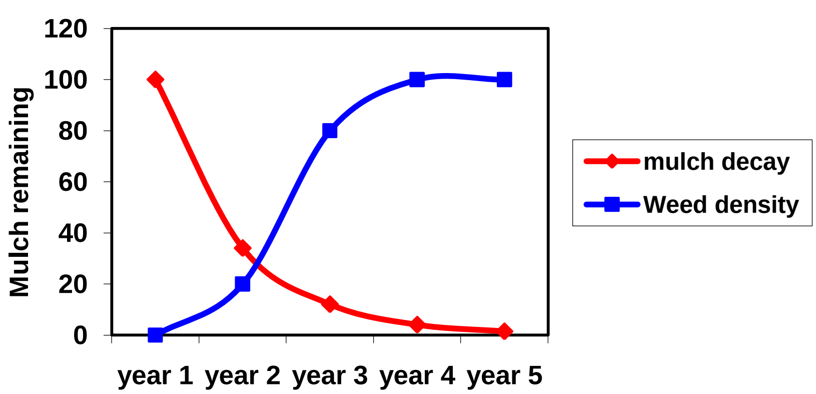

Figure 5. Weed emergence as a function of mulch disappearance

Mulches can be used in landscapes to prevent establishment of annual weeds or perennial weeds that have not yet germinated. Mulches should consist of coarsely chopped tree wastes with a high content of wood. Application should be four inches or greater and mulches should be reapplied on an annual basis. Eucalyptus chips make excellent mulches but they have little or no phytochemical effect in field settings.

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Overview of Integrated Weed Management in Organic Systems

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Summary. Weed management in organic specialty crops is fairly similar to conventional crop production, with one big exception – there is no herbicide rescue treatment for organic crops. Because weeds give no second chances in organic crops you must manage weeds well every day. The principles of weed management in organic crops are universal – field selection, prevention, sanitation and control. Here we will describe each of these points separately.

Field selection. This means carefully choosing a field and avoidance of areas with difficult weed problems. For example it would be extremely difficult and costly to grow organic crops in a field severely infested with perennial weeds such as field bindweed or yellow nutsedge. Fields severely infested with perennial weeds should be cleaned up in the fallow before attempting to grow any crop.

Prevention. This means managing the weed population in the field by avoiding the introduction of weed seed into the soil seedbank. Management of weed seedbanks requires a long-term approach to weed management that focuses on more than just the current crop. For example, by preventing weeds from setting seed even though the crop in the field is past the stage when weed competition can hurt the crop, we practice preventative weed management. A grower who consistently prevents weeds from going to seed will increase the odds of having a clean field. Weed management will be far easier in a clean field with a small weed seedbank than in a severely infested seedbank. Another example of prevention is the use of clean composted manure or organic amendments. A thorough composting process will kill most of the weed seed in organic amendments, and prevent the introduction of weed seed into the field.

Sanitation. This is really just a form of prevention. It is important to control weeds in the vicinity of the field because wind-blown seed from common groundsel, common sowthistle, and hairy fleabane can enter the seedbank in the field from surrounding areas such as fence rows and ditch banks. Control of weeds in the areas around the field is necessary to prevent contamination of the seedbank in the organic field. Similarly, it is essential to clean tillage equipment before moving from fields infested with perennial weeds or other difficult to control weeds to uninfested fields. Soil should be removed from the implement by high-pressure washing to prevent transport of seed or other weed propagules.

Control. These are practices that are used to suppress weeds and consist of cultural, physical and chemical controls.

Cultural control. Pre-plant irrigation to stimulate weed growth can improve the level of weed control before planting. This cultural practice is used to deplete weed seeds from the upper soil layer. After bed formation, the field is irrigated to stimulate weed emergence. Approximately 7 to 14 days after pre-plant irrigation (longer in clay soils), emerged weeds should be removed with shallow tillage, compliant herbicides or propane flaming. This process works by establishing a clean soil layer depleted of weed seed close to the soil surface. If tillage is used, it is important to keep the tillage implement on shallow settings so that the clean soil near the surface is not contaminated with viable weed seed from deeper in the soil. Many weed seeds will remain in deeper layers but most of these deep seeds will not germinate. If time permits, the process of pre-plant irrigation can be repeated a second time to remove weeds that escaped the first pre-plant irrigation cycle. Other examples of cultural controls are the use of transplants instead of direct seeded crops. Transplants are larger and less susceptible to weed competition than seeded crops.

Physical control. Examples of physical control are cultivation and hand weeding. Cultivation in the crop row is an old but reliable method of weed control that kills weeds by uprooting them. Hand weeding is very effective, but also very expensive. The objective of the organic weed management program should be to do everything possible to minimize the cost of hand weeding. Other examples of physical weed control are the use of plastic, paper or straw mulches to suppress weeds. Plastic mulches work well, but are expensive and generally only used in valuable crops like strawberry. Use of paper mulches is being evaluated, but they decompose quickly and are subject to tearing. Straw mulches have been used for years, but must be deep enough to shade out weeds. Straw must either be grown in the same field, e.g. wheat, and then planted into, or the straw must be transported into the field. Solarization with clear plastic mulch during the hottest months of the year is also a very effective means of weed control in interior valleys of California.

Chemical control. There are a limited number of organic-compliant herbicides available. To date all are contact herbicides with no soil activity. So far these products are primarily used by home owners, and there is little use in commercial agriculture due to high cost and weak activity. This may well change in the future as this is an active area of research.

Alternative Weed Management Methods in Orchards

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Organically controlling weeds in orchards requires the use of many techniques and strategies in order to achieve economically acceptable weed control and yields. Weeds can always be pulled or cut out, but the question is simply how much can a grower spend in terms of time and money to reduce weed pressure. The more a grower is able to reduce weed pressure (seed and perennial propagules) the more economical it is to produce crops.

Without some form of weed control, yields and plant vigor will be greatly reduced. In organic farming, weed control is only one goal of weed management. A good organic weed management plan should present a minimum erosion risk, provide a "platform" for the movement of farm equipment, not impact adversely on pest management or soil fertility, while minimizing weed competition for water and nutrients. The following is an overview of some organically acceptable weed control practices for orchards.

Mulches

Weed control in tree crops can be a daunting task whether you are an organic or conventional grower. One encouraging control method is through the use of a mulch. The mulch blocks light, preventing weed germination or growth. Many materials can be used as mulches including plastics or organic materials such as municipal yard waste, wood chips, straw, hay, sawdust, and newspaper. To be effective, a mulch needs to block all light to the weeds; therefore different mulch materials vary in the depth necessary to accomplish this. Wood chip, or other loose material type mulches should be maintained in a layer four or more inches thick. Organic mulches breakdown with time and the original thickness typically reduces by 60 percent after one year.

Cover crops can be grown in the middles and in the spring, “Mow-and-Throw” the mulch in around the base of the trees. Numerous cover crop species can potentially be used in orchards. This works well if the mulch layer is thick. Weeds that emerge through the mulch can be controlled using an organic contact herbicide or hand weeding. Cover crops should not be planted in the tree row, as excess competition may occur, possibly reducing yields.

The additional benefits of mulches are significant. The mulch conserves moisture by reducing evaporation. Soil temperature is better maintained and organic material is added to the soil on breakdown. Weed germination is greatly impeded and growth diminished. Some grasses will survive the mulching but are shallow rooted and can be easily pulled out. Partially rotted straw or hay which is not otherwise of use can be utilized but must come from fields which have not used pesticides or chemical fertilizers. Weed control by mulching is not the only organic option but may be worth considering.

Cultivation

Cultivation is probably the most widely used method of weed control in organic systems. Mechanical cultivation uproots or buries weeds. Weed burial works best on small weeds, while larger weeds are better controlled by destroying the root-shoot connection or by slicing, cutting, or turning the soil to separate the root system from contact with the soil. In systems where permanent sod middles are employed, cultivation may be limited to a row-strip under the drip line in an orchard. The reverse might be true in systems where mulches are employed for weed suppression under the crop and cultivation used to control weeds and incorporate cover crops between the rows. In any case, cultivation must be kept shallow to minimize damage to crop roots and to avoid bringing more weed seeds near the surface to germinate.

Perennial weeds, with established root systems, are difficult to kill with a single tillage operation. In a sense, perennial weed are like an iceberg – 80 to 90% below water (in the soil) and only 10 to 20% above water (emerged). With tillage, the top is removed and a new top is generated using the underground reserves (the iceberg floats back to the surface). For perennials, tillage at 3 or 4 inches in depth depletes the maximum amount of reserves and forces the weeds to use up more of the reserves.

Even the best cultivators will not eliminate all weeds, thus hand weeding is often needed. Hand cultivation alone may be effective on a small scale. In large orchards -where in-row tillage is desired-"mechanical hoes" such as the Weed Badger, Kimco, or Green Hoe may be useful. These tractor-mounted cultivators extend from the tractor and can till right up to the tree without damaging the plant. Attachment options include powered rotary tillage tools and scraper blades which can move soil either away from or to the base of the plants. Specialty tillage equipment is expensive and due to economies of scale it may not be cost effective for small operations. In a orchards less than 3 years old, weed control is still necessary, but grow tube protection is recommended for the young trees.

Night tillage may help to reduce weed germination. Many weeds require a flash micro-seconds in duration, of red light in order to germinate. It is thought that weed seeds get this flash when suspended with soil during tillage. After night tilling, only those seeds left on the soil surface will germinate, which still can be quite a few. Because of seeds left on the soil surface, it may take several tillages to see much affect. Regardless of whether it works or not, at worst you just lose a little sleep. Most summer annual weeds like pigweed, lambsquarters, and barnyardgrass respond favorably to night tillage, as do many winter annual species.

Organically Acceptable Herbicides

In recent years, several organic, contact-type herbicide products have appeared on the market. These include Weed Pharm (acetic acid), C-Cide (citric acid), GreenMatch (d-limonene), Matratec (clove oil), WeedZap (clove + cinnamon oil), and GreenMatch EX (lemongrass oil), among others. All these products will damage any green vegetation they contact, though they are safe as directed sprays against woody stems and trunks. These herbicides kill weeds that have emerged, but have no residual activity on those emerging subsequently.

All of these products will work well when the weeds are small and the environmental conditions are optimum. In studies conducted this past year, we found that weeds in the cotyledon or first true leaf stage were much easier to control than weeds in the four to six true leaf stages. Broadleaf weeds were also found to be easier to control than grasses, possibly due to the location of the growing point (at or below the soil surface for grasses), or the orientation of the leaves (horizontal for most broadleaf weeds).

These herbicides only kill contacted tissue; thus, good coverage is essential. In test comparing various spray volumes and product concentrations, we found that high concentrations at low spray volumes (35 gallons per acre) were less effective than lower concentrations (1/2 of the high concentration) at high spray volumes (70 gallons per acre). Applying these materials through a green sprayer (only living plants are treated), can reduce the amount of material and the overall cost. Additionally, adding an organically acceptable surfactant has resulted in improved control. Because these materials lack residual activity, repeat applications will be needed to control new flushes of weeds.

Another organic herbicide that has appeared on the market in the last few years is corn gluten meal, which is sold under many trade names. It is expensive and has failed to provide even minimal weed control in the vast majority of California trials. Organic herbicides are expensive at this time and may not be affordable for commercial orchard production. Finally, approval by one's organic certifier should also be checked in advance as use of such alternative herbicides is not cleared by all agencies. The efficacy of all these materials is much less than synthetic herbicides.

Weeder Geese

Geese have been used for weed management in a large number of crops for many years. All types of geese will graze weeds. Investigators studied the impacts of populations of domestic geese and chickens in a non-chemical orchard system. Geese were observed to feed heavily on weeds–especially grasses. Geese prefer grass species and will eat other weeds and crops only after the grasses are gone and they become hungry. If confined, they will even dig up and eat johnsongrass and bermudagrass rhizomes. They appear to have a particular preference for bermudagrass and johnsongrass–weeds that can be especially troublesome in perennial crops.

Care must be exercised when using geese to avoid placing them near any grass crops, i.e. corn, sorghum, small grains, etc. as this is their preferred food. Geese also require water (drinking not swimming), shade during hot weather and protection from dogs. Portable fencing helps to keep them in the area you want them work and also keeps dogs and other predators out. Young geese work best, as their major interests are eating and sleeping – older geese prefer to fight and make more geese.

Although geese are mentioned in this report, other animals such as sheep or goats can also be used. Sheep will effectively remove all weeds down to ground level. Goats are browsers, and must be carefully managed to avoid damage to trees.

Flame Weeding

Flamers can be used for weed control with propane-fueled models being most common. Fire causes the cell sap of plants to expand, rupturing the cell walls; this process occurs in most plant tissues at about 130º F. Weeds must have less than two true leaves for greatest efficiency of the burner. Grasses are harder to kill by flaming because the growing point is below the ground. After flaming, weeds that have been killed change from a glossy to a matte finish. This occurs very rapidly in most cases. Foliage that retains a thumb print when pressure is applied between your thumb and index finger has been adequately flamed. Typically, flaming can be done at three to five mph through fields, although this depends on the heat output of the unit being used. Repeated flaming can likewise be used to suppress perennial weeds such as field bindweed. Care must be taken to avoid igniting dry vegetation, which could injure the crop, or start a wildfire.

The specific flaming angle, flaming pattern, and flame length vary with the manufacturer's recommendations, but range from 30° to 40°, at 8 to 12 inches above the base of the plants, with flame lengths of approximately 12 to 15 inches. Best results are obtained under windless conditions, as winds can prevent the heat from reaching the target. Early morning or evening is the best time to observe the flame for adjustment. Flame Engineering, Inc. and Thermal Weed Control Systems, Inc. manufacture both hand and tractor mounted flame weeding equipment.

In a study comparing control of weeds by flaming, species and growth stage were the most important variables. One weed which was resistant to flaming was *Malva neglecta*, (cheeseweed), with little or no control. To control annual weeds at later developmental stages (> 6 true leaves), a single pass flame treatment with was not sufficient. For lambsquarters, three subsequent treatments were necessary for 95 % control. For the flame control of dandelion, the developmental stage is also crucial. Small plants were killed by one flaming, while bigger plants, often survived four flamings.

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Weed Management Potentials of Selected Cover Crops for Organic Vegetable Production[1]

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Abstract

The second year of a three year field experiment was conducted at the University of California's South Coast Research and Extension Center in Irvine, California. We measured weed populations and their biomass in organic broccoli planted after two summer cover crops, cowpea (*Vigna unguiculata*, cultivar UCR CC 36) and marigold (*Tagetes patula* cv. Single Gold). The population density of the dominant weed species, *Portulaca oleracea* (common purslane), peaked at 370 plants per m^2 just before the first hand weeding in broccoli planted after summer fallow . The fallow treatment had 5x as many purslane just before the first hand-weeding as when broccoli followed cowpea and 11x more than the marigold treatment. The population density of all weeds per m^2 of the 2007 trial ranged from 433 plants in fallow plots to 110 and 87 plants in broccoli ($p=0.0009$) planted after cowpea and marigold, respectively, just before the first weeding. Weed density wasn't significantly different between the treatments after the first weeding. However, by harvest, the population of all weed spp. was 4x higher in broccoli planted on previously fallow plots relative to those in the cowpea and marigold plots ($p=0.0291$). During the same trial year (2007), common purslane had the highest dry biomass for broccoli planted after summer fallow. Dry biomass of *Portulaca* was 11, 0.3 and 0.1 grams for broccoli planted after summer fallow, cowpea or marigold, respectively. There were no significant differences for weed population samples taken after the first hand weeding.

Weed population density prior to first hand weeding followed a similar trend in 2008. When sampled prior to hand weeding, there were 4x as many purslane plants in broccoli planted after the fallow treatment ($p=0.0251$) than for broccoli following either cowpea or marigold. However, 2008 harvest time samples found significant differences in weed populations, with, with 7x and 11x more common purslane (p=0.0169) when broccoli followed summer fallow then when broccoli was planted after cowpea or marigold, respectively. Biomass of all weeds for the 2008 trial was also greater for those collected from broccoli planted after summer fallow than those that followed summer cowpea or marigold plots ($p=0.0057$).

Broccoli height and canopy spread were greater following either cowpea, a nitrogen fixing legume, or marigold. Broccoli following cowpea or marigold had a higher number of heads and fresh weight when compared to those grown after summer fallow. Marketable broccoli heads were 115, 90 and 81 from cowpea, marigold and fallow plots, respectively. Similar trends were observed with the fresh weight of marketable broccoli heads. Broccoli plants grown after cover crops matured faster than those that were planted following a summer fallow. The lower densities and biomass of weeds in broccoli plants and better vegetable growth and marketable yields following summer cover cropping are good indications that summer cover cropping reduces the intensity of weed populations and their competitive ability with subsequent vegetable crop production. Grassy weeds were not affected by choice of cover crop. Although cover crops may not provide complete weed control, , they may play a valuable role as a tool in any integrated weed management system, particularly for organic vegetables.

Key words: cover crops, weed population, weed biomass, organic farming

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Similarities Between Pharmaceuticals and Herbicides

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For many years, virtually all pharmaceutical companies had an agrochemical division. This was partly to maximize the benefits of expensive chemical synthesis efforts by searching for many types of useful biological activity. Leads for phrarmaceuticals and pesticides often overlap, in some cases leading to both pharmaceuticals and herbicides. This review will focus on herbicides and herbicide classes that have been found to have potential pharmaceutical properties, both as therapeutics that act through human molecular target sites and those that act on infectious agents. An example of the first case are compounds that target acetyl CoA carboxylase in plants to inhibit fatty acid synthesis and in humans as an anti-inflamatory agent. Another such example are triketones that can act as both herbicides and as treatments for the genetic disease tyrosinaemia. Examples of the second case are the relatively large number of herbicides that have anti-*Plasmodium* spp. (the malaria microbe) activity. It turns out that *Plasmodium* spp. have an organelle that is apparently a vestigial chloroplast, the apicoplast. Although, our lab has found that apicoplast-associated target sites are not necessarily likely to be good targets for herbicides with chloroplast-localized targets. Other herbicides, such a dinitroanilines, are active against several protozoan parasites by the same mechanism by which they kill plants, interaction with tubulin to halt cell division. These and other multiple activities of various herbicides and herbicide classes provide perspective on the broad biological activity of herbicides.

Suggested reading:

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Duke, S.O. 2010. Herbicide and pharmaceutical relationships, Weed Sci. 58: In press.

Herbicide Resistance – An Evaluation of Hard-to-Control Weeds and a Discussion of What Might Be Coming Our Way

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The development of weed biotypes that are resistant to commonly used control measures is becoming an increasingly significant problem in California and around the world. As of January 2010, there have been 194 confirmed reports of herbicide resistance affecting 19 different herbicide mode of action families (Heap 2010). Of these cases, about 60% are broadleaf and 40% are grass or sedge weeds. In the U.S., 128 resistant species have been reported (also 60% broadleaf weeds) and 15 herbicide families are affected. California has 21 individual cases of resistant weeds impacting 7 herbicide families; however, in contrast to the rest of the world, two-thirds of California's resistant species are grasses and sedges due primarily to tremendous selection pressure for grass weeds in rice production

When we consider what herbicide resistant weeds might become important in California in the future, we should focus on weeds that already have reports of resistance in other parts of the world. The 10 most important herbicide resistant species in the world (Heap 2010) are all present in California and can be problematic weeds even without herbicide resistance (Table 1). Four of those (three grasses and one broadleaf) are already known to be resistant to at least one herbicide in California. These 10 species have individual reports of resistance to many different modes of action (MOA) and we can expect that new cases may show up in this state over time. Additionally, other important weeds in these genera also are a likely risk for resistance in California (eg. Lolium spp., Amaranth spp., Echinocloa spp., and Conyza spp.).

A relatively recent trend in the development of herbicide resistant weeds has been the discovery of glyphosate-resistant weeds. Although glyphosate (the active ingredient in RoundUp, and others) has been used for nearly 40 years, no resistance was reported until 1996. However, since 1996, sixteen glyphosate-resistant biotypes have been reported around the world (Table 2). Nine of these are already in the U.S. and four are known to be widespread in California. Similar to the earlier discussion, many of these species or close relatives are common throughout the state and are of great concern with regards to losing efficacy of this important broad-spectrum herbicide.

While this discussion is simply one guess as to which herbicide resistant weeds may become problems in California in the future, we can be certain that resistance is likely to remain a significant problem. Rapid and committed adoption of resistance management practices is critical for the preservation of important tools like glyphosate and other herbicides.

Table 1. Worst herbicide resistant weeds worldwide (based on number of infested sites).

	Present in CA	Resistance outside CA	Resistance in CA
Rigid ryegrass (*Lolium rigidum*)	☑	8 MOA	☑ glyphosate
Wild oat (*Avena fatua*)	☑	6 MOA	☑ difenzoquat
Redroot pigweed (*Amaranthus retroflexus*)	☑	3 MOA	
Common lambsquarters (*Chenopodium album*)	☑	4 MOA	
Green foxtail (*Seteria viridis*)	☑	4 MOA	
Barnyardgrass (*Echinochloa crus-galli)*	☑	7 MOA	☑ ACCase, thiocarbamate
Goosegrass (*Eleusine indica*)	☑	4 MOA	
Kochia (*Kochia scoparia*)	☑	3 MOA	
Horseweed (*Conyza canadensis*)	☑	5 MOA	☑ glyphosate, paraquat
Smooth pigweed (*Amaranthus hybridus*)	☑	2 MOA	

Table 2. Worldwide reports of glyphosate-resistant weeds.

	Resistance USA	Resistance CA
Palmer amaranth (*Amaranthus palmeri*)	☑	
Common waterhemp (*Amaranthus rudis*)	☑	
Common ragweed (*Ambrosia artemisifolia*)	☑	
Giant ragweed (*Ambrosia trifada*)	☑	
Hairy fleabane (*Conyza bonariensis*)	☑	☑
Horseweed (*Conyza canadensis*)	☑	☑
Sourgrass (*Digitaria insularis*)		
Junglerice (*Echinochloa colona*)		
Goosegrass (*Eleusine indica*)		
Wild poinsettia (*Euphorbia heterophylla*)		
Italian ryegrass (*Lolium multiflorum*)	☑	☑
Rigid ryegrass (*Lolium rigidum*)	☑	☑
Ragweed parthinium (*Parthinium hysterophorus*)		
Buckhorn plantain (*Plantago lanceolata*)		
Johnsongrass (*Sorghum halapense*)	☑	
Liverseedgrass (*Urochloa panicoides*)		

Heap, I. 2010. The International Survey of Herbicide Resistant Weeds. Accessed online January 11, 2010. Available at www.weedscience.com.

Transgenic Crops: Their Future Role in Weed Management

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Herbicides-resistant (HR) crops represent more than 80% of the 120 million ha of transgenic crops grown annually worldwide. Most of the HR crops are glyphosate-resistant (GR). GR crops have been rapidly adopted in soybean, maize, cotton, canola, and sugarbeet in large part because of the economic advantage of the technology, as well as the simple and superior weed control that glyphosate delivers. Furthermore, the GR crop/glyphosate technology is generally more environmentally benign than the weed management technologies that it replaced, even though gene flow continues to be a potential problem with some crops. In the Americas, except for Canada, adoption has meant continuous and intense selection pressure with glyphosate, resulting in evolution of GR weeds and shifts to weed species that are only partially controlled by glyphosate. This development is jeopardizing the benefits of this valuable technology. New transgenic crops with resistance to other herbicide classes—in some cases coupled with glyphosate resistance—will be introduced soon. If used wisely, these tools can be integrated into resistance management and prevention strategies. Greater diversity in weed management technologies is badly needed to preserve the utility of the GR crop/glyphosate technology. Transgenes that produce more robust crops due to resistance to drought, temperature extreme, and disease should influence weed management by improving crop competition with weeds. In the long term, allelopathy can theoretically be enhanced in crops via transgene technology, perhaps dramatically reducing the use of synthetic herbicides. Work is being done to accomplish this by enhancing sorgoleone production in sorghum. Transgenes will continue to greatly influence weed management in major crops, but without a solution to the gene flow problem, this technology will not reach its full potential.

Suggested reading:

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Control Strategies for Some Difficult to Control Weeds

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Abstract

Common Groundsel *Senecio vulgaris* and Field Dodder, *Cuscata sp* have long been serious weed pest of alfalfa and are becoming more difficult to control. Groundsel is toxic and has caused animal deaths when mixed in hay and fed to horses and other livestock. Dodder is a parasitic plant that imbeds its haustoria (suction caps) onto alfalfa stems to live eventually leading to plant death. Hairy Fleabane *Conyza bonariensis* is a widespread weed pest plaguing orchards and vineyards of the central valley's of California. More recently fleabane is beginning to invade alfalfa hay fields, and proving difficult to control. Research efforts have demonstrated some new information effective in controlling these three weeds.

Key Works: herbicides, axil branching, Velpar, Gramoxone, Chateau, Raptor.

Introduction

Common Groundsel
The fall/winter weed control programs that are used in central valley alfalfa fields failed to effectively control common groundsel in 2008. Groundsel is a problem weed of alfalfa hay and is of particular importance since it contains toxic alkaloids that are poisonous when fed to livestock. Research field trials were initiated in 2008 evaluating several herbicides practices for post and pre emergent control. Figure 1.
Studies were also set up to evaluate different application timings, and control at various growth stages of groundsel.
Results indicated that groundsel control using a post and pre emergent herbicide combination of Gramoxone, Chateau and Velpar were highly effective. Applications made at the first sign of groundsel germination provided the best overall control. As groundsel plants began to mature and form branches (axil budding) they became more tolerant to post herbicide treatments. Figure2.

Dodder
Dodder is an annual parasitic weed that is sustained by penetrating tissues of host plants to obtain water and nutrients. Seedlings must attach to a suitable host within a few days of germination or they die. Threadlike, leafless stems twine around host plants, eventually creating a tangled mat. Each plant produces thousands of hard seeds that can remain dormant in the soil for years. Flowers and seed capsules are borne in clusters.

Currently, there are two management options effective as control measures using preemergent herbicides Prowl *pedimethalin,* and Treflan *trifluralin* if applications are made in advance of germination with adequate rainfall or irrigation to activate the herbicides. However, in cases where pre emergent herbicides are not applied or weed escapes occur later in the season, dodder plants rapidly grow into colonies and invade large areas of the field. There are few effective post emergent methods and at best are limited in their success. These include using high spray volumes of acid based fertilizers, or propane flaming; both are costly and may reduce the alfalfa stand. Glyphosate herbicide in Roundup Ready alfalfa varieties has demonstrated to a very effective post emergent method in controlling dodder when it begins to attach.
In 2009, research trials were established on an alfalfa field that was 80% covered with dodder. Several post herbicides treatments were applied using high volumes of water and different adjuvant loads to improve spray coverage and penetration into the dense canopy of dodder attached to the alfalfa. To enhance maximum spray coverage, the research plots were mowed with a15'flail chopper set at a height of 2-4" above the soil surface. Good control was achieved in the Chateau and Raptor plus surfactant treatments for approximately 50 days burning 90% of the dodder and reducing competition. Beyond 60 days, even the best treatments became re-infested with dodder that was not initially killed. This suggests that early applications when dodder is small would be the most effective strategy. Figure 4

Hariy Fleabane *Conyza bonariensis* also called flax-leaf fleabane, is a summer annual that reproduces by seed. It begins to germinate in November with rains and continues into midsummer. If emergence occurs in late summer, it can act as a biennial into the following year. Each plant can produce over 40,000 seeds, which are disseminated by wind and with harvest equipment. Frequent tillage or soil disturbance can significantly reduce the population but in undisturbed landscapes such as alfalfa, will often germinate and be present year around. Contamination of fleabane plants reduces hay quality, is difficult to cure in the windrow and unpalatable to horses and livestock.
Research trials in 2009 were established to monitor fleabane germination times and effectiveness of pre and post emergent herbicide treatments. A pre emergent application of Chateau and Velpar that were made on 10/29/2008 and post emergent treatments applied on 12/10/2008 showed promising resluts. Figure 3.
Chateau and Velpar were effective on fleabane germination and provided 90% control for three months after application (Jan, Feb, Mar). Beyond three months time treatments began to break. A sequential application of Chateau plus Chateau was applied in February which provided 90% control into May. The combination of Chateau and Velpar appeared to be synergistic providing control better than each one individually. This combination of two different modes of action herbicides appears to be a good strategy for groundsel control as well.

Summary

All three weeds discussed can be controlled adequately if herbicides are properly timed and combined with good alfalfa cultural practices of irrigation, fertility and harvest management. Proper herbicide combinations will achieve desirable results. Early herbicide timing was always more effective than delayed later timings when plants were larger and more tolerant. Also, spray coverage became an issue when treatments were made later. Dodder remains a problem weed to control and is especially important to attach the problem from a pre emergent herbicide standpoint. Some success was achieved with post attached control using Chateau but this should not be considered the first line of defense and used only as an in season management for escapes and spot treatments.

Figure 1 – Winter Weed Control in Established Alfalfa

			% - Weed Control[1] – Evaluation on 1/6 & 3/5/09											
	Rate	Application	Shepherd purse		**Common Groundsel**		Common Chickweed		Annual Swinecress		Annual Bluegrass		Henbit	
Treatment[2]	lb ai/A	Date	1/6	3/5	**1/6**	**3/5**	1/6	3/5	1/6	3/5	1/6	3/5	1/6	3/5
Velpar L	0.5	12/11/08	50	52	**73**	**100**	65	94	88	95	18	13	70	90
Velpar L + Chateau SW	0.25 + 0.0625	12/11/08	90	97	**100**	**100**	98	99	94	100	45	65	100	100
Velpar L + Chateau SW	0.25 + 0.094	12/11/08	97	99	**100**	**100**	99	100	98	100	55	86	100	100
Velpar L + Chateau SW	0.5 + 0.125	12/11/08	95	100	**98**	**100**	98	100	99	100	75	95	100	100
Velpar L + Sandea WG	0.5 + 0.031	12/11/08	45	74	**88**	**100**	63	91	78	99	10	38	65	86
Gramoxone[3]	0.5	12/11/08	91	58	**98**	**94**	99	84	97	40	93	78	80	50
Gramoxone[3] + Chateau SW	0.25 + 0.0625	12/11/08	96	95	**95**	**97**	100	99	98	97	100	95	100	100
Gramoxone[3] + Chateau SW	0.5 + 0.125	12/11/08	100	100	**99**	**97**	100	100	99	98	100	97	100	100
Chateau SW	0.125	12/11/08	82	96	**45**	**37**	94	100	63	30	35	69	100	100
ChateauSW+ Sandea WG	0.125 + 0.031	12/11/08	73	99	**80**	**84**	88	95	80	100	20	73	100	100
Sencor DF	0.5	12/11/08	80	95	**60**	**72**	85	97	75	96	43	68	88	100
Gramoxone[3] + Velpar L	0.5 + 0.5	12/11/08	100	100	**100**	**100**	99	96	100	100	99	100	100	99
Check	-	-	0	0	**0**	**0**	0	0	0	0	0	0	0	0

[1]0 = No weed control; 100 = Complete weed control

[2]Ad-Wet 90CA (NIS) added to all herbicide treatments at 0.25% V/V (1 qt/100 gal)

[3]Gramoxone Inteon formulation 2AS

Figure 2 – Groundsel Control With Paraquat on Three Growth Stages in Established Alfalfa

Treatment	Rate lb ai/A	% Control[1] – Common Groundsel Growth Stage: No Axil Budding 1-4” Height	Axil Budding[4] 1.25-3.5” Height	Axil Budding[4] Flowering, 4.5- 6” Height
Gramoxone[2]	**0.5**	92	59	47

[1]0 = No groundsel control; 100 = Complete groundsel control
[2]Gramoxone Inteon 2AS formulation
[3]No Foam A (NIS) added at 0.25% V/V (1 qt/100 gal)
[4]Axial budding = branching

Figure 3– Treatment List, Alfalfa Injury and Dodder Control in Established Alfalfa

			% - Alfalfa Injury[1]			% - Dodder Control[1]		
	Rate	Application	Necrosis		Stunting			
Treatment	lb ai/A	Date	6 DAT[2]	33DAT	33 DAT	6 DAT	33 DAT	54DAT
Chateau SW + No Foam A	0.125 + 0.25% V/V	6/24/09	68	0	0	65	37	13
Chateau SW + No Foam A + UN32	0.125 + 0.25% V/V + 1.0% V/V	6/24/09	68	0	0	62	7	0
Chateau SW + UN32 + Silwet L-77 + Hasten	0.125 + 1.0% V/V + 0.125 % V/V + 1.0% V/V	6/24/09	87	0	0	88	71	47
Raptor + Hasten + UN32	0.047 + 1.0% V/V + 1.0% V/V	6/24/09	0	0	0	40	30	13
Raptor + Chateau SW + Hasten	0.047 + 0.125 + 1.0% V/V	6/24/09	83	0	0	92	81	63
Roundup SL[3] + Chateau SW	0.5 + 0.125	6/24/09	28	0	0	61	60	43
Scythe EC+ Hasten + UN32	7.0% V/V + 1.0% V/V + 1.0% V/V	6/24/09	48	0	0	48	7	0
Scythe EC + Chateau SW	7.0% V/V + 0.125	6/24/09	85	0	0	93	73	50
Check	-	-	0	0	0	0	0	0

[1]0 = No dodder control or crop injury; 100 = Complete dodder control; crop dead
[2]Data taken days after treatment (DAT)
[3]Roundup Weathermax formulation

Figure **4 – Treatment List and Weed Control in Established Alfalfa**

Treatment[4]	Rate lb ai/A	Application Date	% Hairy Fleabane Control[1] Fleabane New Plants[2] 12/30[5]	2/12	3/5	5/15	% Preemergence Control[1] Yellow Foxtail 3/25	5/15	Common Lambsquarters 3/25	5/15	AVG%[3] Weed Control
Chateau SW[6]	0.125	10/29/08	100	94	89	73	80	75	94	83	86
Chateau SW[7]	0.125	12/10/08	65	62	63	13	97	92	94	81	88
Chateau SW + Gramoxone	0.125 + 0.5	12/10/08	100	98	95	72	88	75	80	63	89
Chateau SW + Gramoxone + Prowl H_2O	0.125 + 0.5 + 2.0	12/10/08	100	99	95	87	100	100	100	94	98
Chateau SW + Velpar L	0.125 + 0.5	12/10/08	100	98	95	88	73	63	90	81	93
Sencor DF	0.5	12/10/08	73	95	57	17	0	0	0	0	64
Chateau SW + Butyrac 200	0.125 + 1.0	12/10/08	96	80	69	37	90	75	89	75	89
Chateau SW + Butyrac 200	0.125 + 1.5	12/10/08	100	92	83	40	83	65	71	67	86
Velpar L	0.5	12/10/08	60	99	98	68	0	0	0	0	73
Gramoxone + Velpar L	0.5 + 0.5	12/10/08	100	100	85	43	0	0	0	0	67
Gramoxone	0.5	12/10/08	100	73	23	0	0	0	0	0	57
Gramoxone + Prowl H_2O	0.5 + 2.0	12/10/08	100	91	50	17	100	100	97	96	91
Gramoxone + Prowl H_2O	0.5 + 3.0	12/10/08	100	95	75	17	100	100	100	100	92
Gramoxone + Treflan TR10[8]	0.5 2.0	12/10/08 12/10/08	100	89	78	13	100	100	96	95	88
Raptor AS + Butyrac 200	0.032 + 1.0	12/17/08	0	32	0	0	0	0	0	0	33
Raptor AS + Butyrac 200	0.047 + 1.0	12/17/08	0	82	35	0	0	0	0	0	35
Chateau SW[6] Chateau SW	0.125 0.125	10/29/08 2/18/09	100	99	100	92	100	96	100	100	95
Check	-	-	0	0	0	0	0	0	0	0	0

[1]0 = No weed Control; 100 = Complete weed control
[2]Plants that germinated after the first rain event which occurred on 10/30/08
[3]Average % control for the 12 weed species evaluated
[4]No Foam A (NIS) added to all herbicide treatments at 0.25% V/V (1 qt/100 gal)
[5]Data taken on 11/12 & 12/30/08 and 2/12, 3/5, 3/25 and 5/15/09
[6]Herbicide applied preemergence to the above weed species
Herbicde applied post emergent to the above weed species

[8]Treflan (TR10) applied with a fertilizer spreader after the Gramoxone application

Weed Control in Cereal Crops

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Cereals are grown for grain, hay silage, or covercrop. Approximately 1,000,000 acres of wheat, barley, oats, and triticale were planted last season. Durum wheat, barley utilized for grain and triticale used for silage, planted approximately 100, 000 acres each. Since grains are grown under a wide range of conditions, a wide spectrum of weak species may be present in any given field that has the potential to affect both yield and quality.

Grass weeds are increasing due to lack of crop rotations and more use of dairy manures The major grass weeds in small grains are canarygrass *(Phalaris* minor) and wild oats *(Avena* fatua). Other weeds include Italian Ryegrass *(Lolium multiflorum)*, annual bluegrass *(Poa annua)*, ripgut brome *(Bromus diandrus)*, foxtail barley *(Hordeum jubatum)*, and rabbitsfoot grass *(Polypogon monspeliensis).* Even light infestations can reduce yields. They can clog up screens in a harvester and can result in a 5 percent loss due to dockage at the elevator. Italian ryegrass, little seed canarygrass, hooded canarygrass *(Phalaris arundinacea)*, and ripgut brome can cause serious yield losses in some fields.

Most competition studies in cereals have been limited to wild oats. Under irrigated conditions studies showed that wild oats reduced yields at 2 oats/square feet. Wild oats populations commonly exceed 10-20 oats per foot. A wild oat competition study conducted in Manitoba in 1988 demonstrated that this weed had the largest impact on yields. If the wild oat emerged behind the wheat emergence, the impact on yield was less.

Deciding whether a weed control application is economical will depend largely on the price of grain and the cost of treatment. Sound economical weed control practices must be followed to maintain California's present high standing in field crop production. Broadleaf weeds in irrigated cereals can be controlled for as little as 2-4 percent of cash costs. When grass weeds are controlled, costs go up to about 10 percent of the total.

Cultural practices primarily for moisture conservation in dryland cereals include fallowing to keep weeds in check. Wild oat populations in dryland grains would be considerably higher if this was not practiced. Weeds should then be controlled by tillage and/or chemically. Fields not under a good crop rotation system have the worst weed problems. Small grains fields planted behind cotton in which good weed control practices were employed are usually clean and often don't require herbicides. Pre-irrigation or waiting for the first rain can be useful some years in germinating weeds that are then removed by tillage prior to planting. However, this is not usually possible following cotton or corn in the San Joaquin Valley. On heavier soils, it may not be possible for fields to dry in time for planting. This practice is most useful in germinating annual grasses. Usually annual broadleaves germinate later, January through March.

For grass control in wheat and barley, Fenoxaprop (Puma) controls wild oat, and canarygrass. It has a wide window of application, providing effective control when applied between the 1-leaf and 6th leaf grass stage. For best control of wild oat, delay application until most wild oat plants have emerged. A tank mixture with bromoxynil allows for a wide range of weed control at an early timing. Fenoxaprop cannot be tank-mixed with phenoxy herbicides because it may reduce grass control when tank mixed. Most growers are applying a carfentrazone application and then coming back 7-10 days with Puma to keep up with early weed competition.

Mesosulfuron (Osprey) is especially effective on Italian ryegrass, ripgut brome, many broadleaf weeds, wild oat, annual bluegrass, little seed and hooded canarygrass. Most California wheat cultivars have good tolerance to the herbicide. However, wheat often turns a lighter green color for a couple weeks following application. It also provides partial control of many other broadleaf weeds. Mesosulfuron can be tank mixed with bromoxynil and may be applied from the 1-leaf to 1-tiller wheat stage and up to the 2-tiller stage of grass weed development. Restrictions on crop rotations are greater than with Fenoxaprop.

Prowl H20 provides suppression of wild oats applied postplant after the 2-leaf stage of wheat**.** It then controls later emerging grasses so long as there is moisture to activate the herbicide. So far our research studies have show about a 50/50 chance of obtaining good weed control since in many cases weeds are rapidly emerging with the small grains.

Corn

Approximately 55 percent of corn in California is Roundup Ready. The advantages include being able to **s**pray OT early then after 24-30” use a directed spray. There are no plantback restrictions. Growers are able to adapt to conservation tillage systems. I do recommend that growers also consider using other herbicides and tillage when appropriate to reduce glyphosate resistance. Other herbicide options include the following.

Pre-Plant : Atrazine, Aatrex, Eradicane, Roundup, Dual Magnum, Outlook, Gramoxone Inteon, Micro-Tech.
At Planting: Micro-Tech, Aatrex, Atrazine, Dual Magnum, Prowl H2O, Prowl, Roundup, Gramoxone Inteon, Eradicane
After Planting: Accent, Prowl, glyphosate, 2,4-D, Banvel, Clarity, Distinct, Buctril, Gramoxone Inteon, Sencor, Aatrex, Atrazine, Sandea, Shark, ET, Yukon, Option, Outlook, and Distinct.

Roundup Ready Alfalfa Update and Alfalfa Production and Weed Management Systems in South America

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Most growers are familiar with Roundup Ready (RR) alfalfa which was developed using biotechnology to confer resistance to glyphosate in alfalfa. A gene from soil bacterium was inserted in alfalfa in 1997 at Montana State University and the first commercial varieties were released in the fall of 2005. However, a federal court found that USDA (APHIS) erred in approving genetically engineered alfalfa without completing a full environmental review (EIS). The primary issues were the possibility of contamination of organic and conventional fields with RR alfalfa and the possibility of increased glyphosate resistance. Further plantings of RR alfalfa were March 2007 were suspended pending the development of a full EIS. The draft EIS was completed in December, which started a 60-day public comment period. The public comment period was extended to March 3rd after a February snowstorm in Washington D.C. caused the postponement of a public comment meeting. After the public comment period, APHIS will evaluate the comments and respond to the issues raised and issue a final EIS. If and when RR alfalfa will again be deregulated is not known at this time.

The author had the opportunity to work with alfalfa in Chile and Argentina over the past couple of years. The work in Chile was with Fundacion Chile, an economic development corporation funded by governmental and private funds. The visit to Argentina was for the national alfalfa meetings (Jornadas de Alfalfa). Presentations and field visits were made in both countries providing the opportunity to contrast South American alfalfa production systems with those used in California.

It is important to understand the geography of Chile and Argentina in order to get a better feel for alfalfa production systems in both countries. Chile is a long narrow country along the western coast of the continent (2,653 miles long and 221 miles wide at its widest point and 40 miles wide at its narrowest point). It is very similar to California in terms of its geography and the Mediterranean climate. All the alfalfa fields we visited were irrigated. The primary irrigation method was surface irrigation with ditches that ran parallel throughout the interior of the field. The irrigator would place a temporary plastic dam in the ditch so that the water would spread out of the ditch onto the field. In contrast, Argentina is a much larger country (slightly less than three-tenths the size of the United States) and its climate is more like the Midwestern US. Nearly all of the rain comes during the spring and summer months and the quantity is sufficient so that irrigation is not needed in most parts of the county.

In California the majority of the alfalfa is produced as a cash crop by farmers and sold to livestock producers—primarily dairies. In contrast, most of the alfalfa in Chile and Argentina is produced on dairies for their own use. In Chile, most of the alfalfa is either used as green chop or baled hay. In Argentina, the overwhelming majority of the alfalfa is grazed. The alfalfa market in both countries is not nearly as developed as it is in California. Producers recognize the importance of high quality alfalfa for optimum milk production, but alfalfa is not analyzed by laboratories to determine its forage quality.

Because the alfalfa market is not well developed and high quality alfalfa does not receive a premium, growers in these South American countries do not aggressively control weeds to the degree California growers do. However, weed control in seedling alfalfa is relatively common. Growers typically use trifluralin preplant or post emergence herbicides like imazethapyr (sold as Pivot) or flumetsulam. Established alfalfa is rarely treated for weed control. Most producers do not recognize the potential feeding value of the first cutting and consider it to be of poor forage quality due to uncontrolled weeds. Most growers use a “corte de limpieza” or cleaning cut to remove the weeds on first cutting.

Alfalfa growers in both countries are very interested in RR alfalfa. It is not available in either country at this time and its fate depends on what happens in the United States.

Dry Bean and Safflower Weed Management in California

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Dry beans and safflower contribute significantly to the health and welfare of people worldwide. Dry beans are an excellent source of protein and fiber and low in fat and sodium, while safflower seed is important for the cooking oil industry. From 2006 to 2008 dry bean acreage in California has remained mostly stable, while safflower production has about doubled (table 1). A recent decline in milk, alfalfa, and cotton prices has contributed to the increase in safflower production as growers look for alternative agronomic crops to plant. Dry beans are legumes, so they add nitrogen to the soil and are a good rotational crop. Safflower is deep-rooted, more drought tolerant than cereals, tolerates saline conditions, and economic yields can be achieved with as few as 20 acre-inches of water.

Table 1. Harvested acres of dry beans and safflower in California

Bean Type	2006	2007	2008
Baby lima	13,000	15,600	11,700
Blackeye	12,500	12,500	7,100
Garbanzo	15,300	6,000	6,300
Kidney	2,300	2,000	2,600
Large lima	13,000	15,600	11,700
Other	8,900	6,300	12,500
Total	65,000	58,000	51,900
Safflower	55,000	48,500	104,000

Source: USDA NASS

While dry bean and safflower production can be profitable, pest management (particularly weed control) can be very challenging. Dry beans, depending on type, are planted from winter thru spring, so can be exposed to a wide-array of winter and summer weeds, including prickly lettuce, burning nettle, volunteer cereals, black nightshade, annual morningglory, and nutsedge. Since safflower is planted in spring, fields are usually infested with summer weeds like wild sunflower, annual sowthistle, pigweed, and barnyardgrass. Weeds left uncontrolled will reduce stand development and delay crop maturity. In dry beans, the juice from black nightshade berries can result in the staining of mature beans, reducing seed quality and price. In safflower, harvest efficiency is reduced as green weeds become entangled in combine equipment.

Although several herbicides are registered for use in dry beans and safflower in California (table 2), most of the products used at the time of planting have similar modes of action, so control similar weeds. Also, herbicides available after planting dry beans are limited to garbanzo beans only. Furthermore, products registered for use following crop establishment only provide postemergent control of grassy weeds. No products are labeled for use at lay-by, before row closure, for late-season preemergent weed control. Consequently, one to two early-season cultivations and mid- to late-season hand weeding is often required for complete weed control, increasing the cost of production. Late-season hand removal of weeds in dry beans is not encouraged because bean pods can be shattered, while in safflower is not possible because the spiny flower bracts of the plants inhibit physical entrance into the field.

Due to herbicide limitations, selecting a field with an historically low weed population should be an important consideration when deciding if and where to plant dry beans or safflower. Equally important is to consider the specific weeds that are known to be present and whether or not the labeled herbicide products are effective on those particular weeds. Efforts should be made to control weeds during the fallow period and before planting to help reduce the impact of weed competition on early crop stand development. Until new and effective herbicides become available, particularly for mid- to late-season applications, weed control in dry bean and safflower production will continue to be a challenge.

Table 2. Herbicides registered for use in dry beans and safflower in California

	Dry beans – registered use notes	Safflower – registered use notes
Herbicide	Applied to fallow ground or preformed beds	
carfentrazone	up to 1 day after planting	up to 30 days before planting
glyphosate	up to before crop emergence	up to 30 days before planting
oxyfluorfen	up to 60 days before planting	up to 60 days before planting
paraquat	anytime before planting	anytime before planting
pyraflufen	up to 30 days before planting	up to 30 days before planting
	Applied before planting and mechanically incorporated	
EPTC	not for blackeye, garbanzo, or limas	registered
ethafluralin	crop injury if deep seed, overlaps, and stress	registered
metribuzin	registered for garbanzos only	not registered
pendimethalin	registered for garbanzos only	not registered
s-metolachlor	registered for all bean types	registered
trifluralin	registered for all bean types	registered
	Applied after planting and before crop and weed emergence	
flumioxazin	registered for garbanzos only	not registered
imazethapyr	up to 3 days after planting garbanzos only	not registered
metribuzin	registered for garbanzos only	not registered
oxyfluorfen	registered for garbanzos only	not registered
pendimethalin	registered for garbanzos only	not registered
s-metolachlor	not registered	registered
	Applied after crop and weed emergence	
carfentrazone	hooded sprayer only for row middles	not registered
clethodim	registered, controls grasses only, 30-day PHI	registered, controls grasses only, 70-day PHI
sethoxydim	registered, controls grasses only, 30-day PHI	not registered
	Applied as a pre-harvest aid	
carfentrazone	registered, 0-day PHI	not registered

Sources: UC IPM Guidelines and CDMS.net

Biofuel Crops: Invasive Weed Issues and Challenges for the U.S.

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To provide alternatives to petroleum-based energy, the United States (US) government has mandated a greater proportion of plant-based biofuels be integrated into its energy portfolio (e.g., 2007 Energy Independence and Security Act; EISA). However, many of these species that are either proposed or under consideration are invasive or have a high likelihood of becoming invasive.

Economic losses from invasive plants and the cost of control in the US are estimated to be $34 billion annually, and this number primarily considers managed row crop agricultural systems (Pimentel et al. 2005). The environmental and economic costs of invasive plants to natural areas are also extensive, though less well defined. Although the benefits of biofuel production may be great, the socio-economic and ecological costs of certain biofuel crops could ultimately exceed their benefits. Federal agencies must take coordinated action to avoid inadvertently facilitating the introduction (including cultivation escape) and spread of invasive species through its development, subsidization, funding for research, or other support of biofuels programs.

Although most of our food, fiber, and landscape plants are non-native species, relatively few have proven invasive. However, those that are harmful have caused substantial socio-economic and environmental impacts. Among the most well known of these are johnsongrass (*Sorghum halepense*) and kudzu (*Pueraria montana*). Kudzu is one of the species being considered for biofuel production, and there are other proposed energy crops, including reed canarygrass (*Phalaris arundinacea*), giant reed (*Arundo donax*), and miscanthus (*Miscanthus sinensis*), that are currently invasive in regions of the US or elsewhere in the world. In addition, a number of potentially harmful non-native algal species have been suggested for use in the production of biodiesel and jet fuel, which present an unknown risk to freshwater ecosystems.

In the absence of a strategic effort to develop mitigation procedures and policies, the risk of some biofuel crops escaping cultivation and causing substantial harm is greatly increased. The risks are particularly significant where biofuel crops are cultivated or transported among sensitive ecosystems that include forest, prairie, desert, and wetland areas, as well as rangelands and other agricultural croplands.

In response to this issue, the US Invasive Species Advisory Committee (ISAC) approved nine recommendations directed at the Federal government biofuel programs. The recommendation of the committee can be found at (http://www.invasivespecies.gov) and include the following.

Recommendation #1. Review/Strengthen Existing Authorities. Identify Federal authorities relevant to biofuels. Determine their likely influence on biofuel invasiveness (i.e., prevention or facilitation). Identify gaps and inconsistencies in authorities within and among Federal Departments or Agencies. As appropriate, develop policies and programs to minimize invasion risk.

Recommendation #2. Reduce Escape Risks. In order to determine potential biofuel benefits and risks, the invasive potential of each candidate biofuel crop needs to be evaluated in the context of each region proposed for its production. Use/promote species (including unique genotypes) that are not currently invasive and are unlikely to become invasive in the target region. Choose species or cultivars with a low potential for escape, establishment and negative impact. Where appropriate, implement mitigation strategies and plans to minimize escape and other risks.

Recommendation #3. Determine the Most Appropriate Areas for Cultivation. Ideally, biofuel crops should be propagated in containable systems (e.g., terrestrial or aquatic sites constructed specifically to cultivate biofuel crops) and be unable to survive outside of cultivation. Use research findings to identify the most appropriate sites (e.g., unlikely to impact sensitive habitat or create disturbances that will foster invasion) for cultivation of biofuel crops within landscapes. Support for biofuel research and demonstration projects will require site selection that minimizes the potential escape of plant species or cultivars to sensitive areas and the loss of wildlife habitat.

Recommendation #4. Identify Plant Traits that Contribute to or Avoid Invasiveness. Incorporate desirable traits (e.g., sterility or reduced seed production, inability to regenerate by stem fragments) into biofuel varieties to minimize their potential for invasiveness. Use information from plant research, agronomic models, and risk analyses to guide breeding, genetic engineering, and variety selection programs.

Recommendation #5. Prevent Dispersal. Develop and coordinate dispersal mitigation protocols prior to cultivation of biofuel plants in each region or ecosystem of consideration. Implement a comprehensive plan, appropriate to the specific crop, throughout the cultivation period. Examples of dispersal mitigation measures include the use of sterile cultivars, species not likely to genetically mix with other plants (different species or cultivars), harvesting prior to seed maturity, cleaning equipment, and minimizing propagule dispersal throughout the biofuel production cycle.

Recommendation #6. Establish Eradication Protocols for Rotational Systems or Abandoned Populations. Proactively develop multiple year eradication protocols to plan for the rapid removal of biofuel crops if they disperse into surrounding areas or become abandoned or unwanted populations (e.g., those which persist beyond desired crop rotation period).

Recommendation #7. Develop and Implement Early Detection and Rapid Response (EDRR) Plans and Rapid Response Funding. Develop EDRR plans that cover multiple years to eliminate or prevent establishment and spread of escaped invasive populations. A flexible funding source needs to be in place to support EDRR efforts.

Recommendation #8. Minimize Harvest Disturbance. Disturbed environments are especially prone to plant invasion. Minimize the soil disturbance resulting from biofuel harvest by rapidly replanting, using cover crops, or employing other methods that will prevent the potential for future invasion of non-native plants from the surrounding area into the harvested site.

Recommendation #9. **Engage Stakeholders.** Identify and employ cooperative networks (e.g., working groups and councils), communication forums, and consultation processes through which the Federal agencies can work with state agencies, tribes, the private sector, and other stakeholders to reduce the risk of biological invasion via the biofuels pathway.

These recommendations require improved coordination and cooperation among agencies and scientists, research efforts to reduce the risk of invasion into natural environments or other cropping systems, and field-to-process facility mitigation protocols that minimize the potential for propagule escape. Although directed at the Federal government, many of the recommendations are also relevant to state agencies, tribes, scientific institutions, and the private sector. Implementation of the recommendations proposed by the US National Invasive Species Council will help to ensure that the US maximizes the benefits of its biofuel initiatives while minimizing the potential spread of invasive species.

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Recent Developments in Weed Management in Corn and Sorghums

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Introduction

In California, 670, 000 acres of corn is grown, two-thirds of it planted for silage. The acreage grown for grain is very price dependent. No single weed control regime is effective for all growing conditions. An integrated weed management program utilizes a combination of cultural, mechanical, and chemical methods for consistent, effective weed control. It also helps prevent the development of weed resistance to herbicides and the emergence of a few dominant weeds. Some of the major weeds include pigweed, annual morningglory, purslane, barnyardgrass, and nutsedge.

Cultural practices play an important role in corn weed management. In California, a well-managed corn crop is extremely competitive with most weeds. Good cultural practices, including timely cultivations, often control weeds sufficiently to maximize yields and profit.

Growing corn under no-till or reduced tillage also reduces weeds because the soil is not disturbed, thus reducing the number of seeds that germinate. Preirrigation prior to planting and controlling volunteer cereals and emerged weeds will get the crop off to a good start, although this practice delays planting. For weeds that do emerge, postemergent herbicides can be applied.

Preplant, preemergent, or postemergent herbicides are available that will selectively control most species of weeds in corn. Select an herbicide based on costs, weeds present, stage of corn growth, soil type, succeeding rotation crop, and adjacent crops.

Transgenic Corn. Herbicide-tolerant varieties represent approximately 50% of corn grown in California and provide additional options for weed control. The Roundup Ready technology has provided growers with an excellent tool for managing many annual and perennial grasses. Glyphosate can be applied post emergence so growers can wait and see the weeds present. There are no plant back restrictions. There is substantial fuel savings, as tillage operations are reduced. In Roundup Ready varieties, glyphosate can be applied over the top to corn up to the V8 stage of corn or 24 inches. Drop nozzles are recommended for corn taller than 24 inches. Keep spray out of whorls after corn is 30 inches tall. Rates depend on formulation and weed type and size.

The following herbicides are used in corn:

Pre-Plant: Atrazine, Aatrex, Eradicane, Roundup, Dual Magnum, Outlook, Gramoxone Inteon, Micro-Tech

At Planting: Micro-Tech, Aatrex, Atrazine, Dual Magnum, Prowl H2O, Prowl, Roundup, Gramoxone Inteon, Eradicane

After Planting: Accent, Prowl, glyphosate, 2,4-D, Banvel, Clarity, Distinct, Buctril, Gramoxone Inteon, Sencor, Aatrex, Atrazine, Sandea, Shark, ET, Yukon, Option, Outlook

Weeds not controlled by a pre-plant incorporated herbicide or by cultivation can often be controlled with a postemergent herbicide application, depending on the weed species present and its growth stage. Postemergent herbicides are most effective when applied to weed seedlings.

An over-the-top application can be used, but some products or tank mixes require a directed spray on corn larger than 8 to 12 inches in height to keep the herbicide out of the whorl and to minimize the risk of corn injury. Postemergent herbicides commonly used in corn include 2,4-D, bromoxynil (Buctril), carfentrazone (Shark), dicamba (Banvel, Clarity), dicamba/halsulfuron (Yukon), diflufenzopyr (Distinct), halosulfuron (Sandea), metribuzin (Sencor), nicosulfuron (Accent), and foramsulfuron (Option). It is important, however, to pay close attention to application guidelines on the labels to avoid phytotoxicity to the crop, especially with carfentrazone (Shark). Fig. 1 demonstrates the acreage of various herbicides used in California.

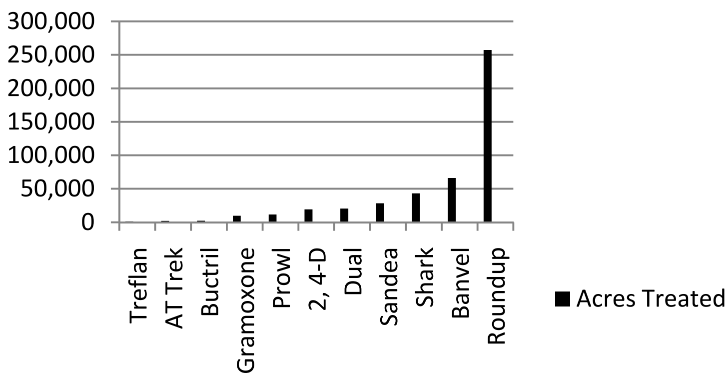

Fig. 1. 2007 Herbicide Usage in California Corn

In Roundup Ready crop systems in other states, weed shifts and weed resistance occurs. Weed shifts occurred when an herbicide program was used repeatedly, resulting in the survival of only weeds that are tolerant of the herbicide. Weed shifts were associated with reduced tillage systems and not rotating herbicides.

A major concern is the development of resistance to glyphosate (Roundup) in lambsquarter, amaranth species, horseweed, and Italian ryegrass in California. Rotating glyphosate-resistant corn with another glyphosate-resistant crop such as cotton or alfalfa will only increase this problem. To help prevent the development of herbicide-resistant weeds and prevent weed shifts from occurring, it is important to incorporate tillage into your weed management practices, as well as alternating herbicides that have a different chemical mode of action.

Grain Sorghum

There are 15,000 acres of sorghum for grain planted in California, while 53,000 acres of sorghum silage is grown as well. Fig. 2. demonstrates the acreage of various herbicides used in grain sorghums in California.

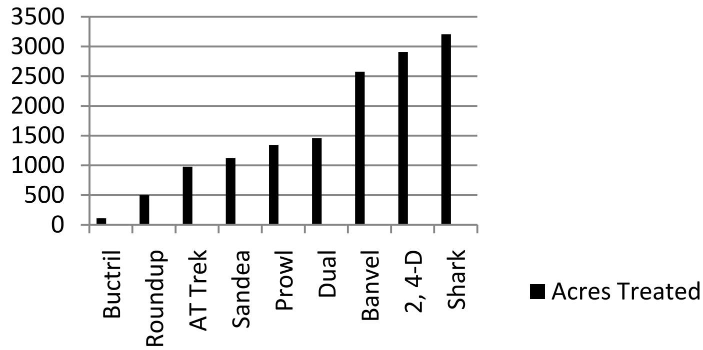

Table 2. 2007 Herbicide Usage in California Sorghum

The following herbicides are registered for use in California.

Pre-Plant Herbicides Used in Sorghum

- *Atrazine*- grasses, broadleaves- (long soil residual)
- *Dual Magnum*- (w Concept treated seed only) barnyardgrass, broadleaves

After Planting

- *Prowl*- preemergent for grasses, pigweeds, lambsquarter, nightshade
- *2,4-D, Banvel, Clarity,* -many broadleaves (watch drift, high temp.)
- *Shark*- contact broadleaves, - some injury
- *Buctril*- contact broadleaves
- *Sandea*- yellow and purple nutsedge
- *Yukon* -nutsedge and broadleaves

Summary

Weed management in sorghums should incorporate resistance management strategies that include, crop rotation, herbicide rotation, and control of weed escapes by tillage or hand.

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Native Grassland Restoration

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Purple needlegrass (*Nasella pulchra*) is a native perennial bunchgrass of lower elevation grassland, chaparral, and oak savannah habitats in California. Heady (1988) states that purple needlegrass, "dominated the valley grassland" and reported that the total extent of this species probably exceeded 9 million ha. Purple needlegrass was designated as the California State Grass in 2004 (http://www.statesymbolsusa.org/California/grass_purpleneedle.html). Today, purple needlegrass is still present in much of its original range, but these landscapes are now dominated by exotic annuals, especially bromes, filarees, and wild oats. The cause of the displacement of purple needlegrass with exotic annuals is thought to be from a combination of intensive livestock grazing, changes in fire regimes, rodent activity, cultivation, and the highly competitive nature of the exotic annual species.

Purple needlegrass is well adapted to California's Mediterranean Climate, which is characterized by mild wet winters and warm dry summers. The annual precipitation within the range of purple needlegrass varies greatly, from 200 cm in the northwestern portion of California to less than 12 cm in the southern San Joaquin Valley (Heady 1988). But even in the wettest areas, the summer drought lasts from four to eight months, causing purple needlegrass to go into a dormancy that is not broken until the fall rains. In the coastal prairies of southern California, purple needlegrass has a relatively short active growing period typically lasting from January until June.

Restoration of grassland habitats in California is often synonymous with restoration of the purple needlegrass population. Research on methods to shift the dominance in grassland from the invasive annuals to purple needlegrass have included fire and livestock grazing , clearing and planting and mowing (Dyer and Rice 1997). All of these methods have had some successes, but none seem to be in common usage. All of these restoration methods are initiated in the late spring or summer. Grazing, for example, requires forage, which means that the invasive grasses or forbs have to be allowed to persist long enough to produce sufficient growth for the livestock. Prescribed fire requires fuel, so again the invasive plants have to be allowed to grow and in this case to be the process of senescence in order to be dry enough to burn. In both of these situations, this does not occur until the end of the rainy season in California. The invasive plants, therefore, have had the benefit of most of the annual precipitation and the purple needlegrass has been deprived.

A basic concept of weed ecology is that competition between plants begins when plant growth starts and that the longer the weedy plants are allowed to compete, the greater their negative impact on the desirable vegetation (Lanini et al 2002). Several authors have described the near impossibility of establishing purple needlegrass in the face of competition from invasive annuals (Nelson and Allen, 1993). Dyer and Rice (1997) showed a strong negative correlation between weed competition and purple needlegrass growth and survival. This response was not affected by grazing with sheep (*Ovis aries*) in April or summer burning.

We designed our research based upon the premise that invasive plant control early in the winter rainy season would benefit an existing but sparse purple needlegrass population by making precipitation available to the native grass instead of the exotic flora. Our research tested the hypothesis that there are specific dosages of POST herbicides that would be sufficient enough to kill the invasive plants but that would not kill or significantly damage purple needlegrass. Testing this hypothesis had two principle components; evaluating the efficacy of POST herbicides on the invasive plants and determining the injury caused to mature purple needlegrass by these herbicides.

Two experiments, both replicated once in time, were established to test our hypothesis. One utilized an established purple needlegrass nursery located in the Cheeseboro Canyon area of the National Park Service Santa Monica Mountains National Recreational Area. At this location, the nursery was kept free of invasive plants; which allowed an assessment of the impact of the POST herbicide treatments without the confounding effects of weed competition. The other experiment was conducted at the California Department of Fish and Game Rancho Jamul Ecological Reserve located near the town of Jamul in San Diego County. This location had a sparse natural population of purple needlegrass in an area dominated by invasive Mediterranean annuals, especially ripgut brome and wild oats. Both of these sites were former livestock ranches for about 150 years.

Field research at the Santa Monica location was conducted in 2007 and again in 2009. For these experiments, individual nursery plots seeded in 2005 with relatively uniform populations of purple needlegrass were used as replicate blocks. Both experiments utilized a Randomized Complete Block Design with four replications in 2007 and three replications in 2009. Purple needlegrass plants on the day of treatment in 2007 and 2009 had an average height of 9 inches. Herbicide treatments were fluazifop-P-butyl at (6 and 12 oz/A in 2007 and 12 and 18 oz/A in 2009); clethodim at 8.5 and 17 oz/A; glyphosate at 16 and 32 oz/A; and triclopyr at 32 oz/A; along with an untreated control. Herbicide applications were made on January 22, 2007 and on February 26, 2009. Herbicide application was made with a hand-held CO_2 pressured small plot sprayer with a single 8006vs flat fan nozzle. Operating pressure measured at the nozzle was 20 psi and spray volume was 34 gpa both years. Herbicide impact on purple needlegrass was measured quantitatively about 4 months after treatment by biomass (green weight) and diameter of the basal area of treated plants.

At the Rancho Jamul location, two field experiments were established that consisted of the same 13 herbicide treatments plus an untreated control. Herbicide treatments were applied twice to each plot; in the year of initiation and the following winter season. Each site had a sparse, non-uniform population of purple needlegrass; each experiment was located so that all plots had some living plants on the day of treatment. Both sites had burned in fall wildfires in 2003 and 2007. Experimental design was a randomized complete block with four replications. Herbicide treatments were fluazifop-P-butyl at 12 and 18 oz/ac, clethodim at 17 and 34 oz/ac, glyphosate at 16 and 32 oz/ac, fluazifop-P-butyl plus triclopyr at 12 plus 32 oz/ac and 18 plus 32 oz/ac, aminopyralid at 7 oz/ac, fluazifop-P-butyl plus aminopyralid at 12 plus 7 oz/ac and 18 plus 7 oz/ac, and clethodim plus aminopyralid at 17 plus 7 oz/ac and 34 plus 7 oz/ac. All herbicides were applied with a hand-held CO_2 pressured small plot sprayer through a boom with five 8002vs flat fan nozzles at an average spray volume of 45 gpa.

There were no differences between treatments for biomass, basal diameter, or the ratio of biomass to basal diameter for the Santa Monica sites. We did not see any visual differences between treatments on the day that we collected the quantitative data. The experiments conducted at the Santa Monica site demonstrate that all of the herbicides tested at these dosages can be used without significant injury to purple needlegrass under these conditions.

At Rancho Jamul, in general, fluazifop-P-butyl and glyphosate appeared to be relatively safe to purple needlegrass. Aminopyralid was also safe to purple needlegrass, both alone and in combination with fluazifop-P-butyl. Clethodim caused significant injury to purple needlegrass across both sites and years. At the end of two years of herbicide treatment, purple needlegrass cover is about four times greater than the untreated control for some of the successful treatments. Of the 13 herbicide treatments investigated in these two experiments, four treatments show promise for use on a broader scale. These treatments include both rates of glyphosate and the two combination treatments of fluazifop-p-butyl plus triclopyr.

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Fusilade for the Control of Filaree

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Annual filarees in southern California wildlands germinate at very high densities after wildfire and other disturbances. They emerge much sooner than most native species, making re-establishment of natives difficult. In plant communities such as coastal sage scrub the natives are predominantly forbs and shrubs, consequently the potential to broadcast spray a selective herbicide to control filaree seemed low. Observations in a desert field study showed that fluazifop applied for grass control also controlled redstem filaree (*Erodium cicutarium*). Studies in Australia have shown *Erodium* species to be sensitive to a grass-specific herbicide not available in the U.S.

Plots were established at two sites in San Diego County, one dominated by broadstem filaree (*Erodium botrys*) and the other dominated by redstem filaree. Multiple rates of two grass-specific herbicides, fluazifop and clethodim, were applied in a single application. Two rates of glyphosate were also applied for comparison. Visual damage ratings performed at 2-, 4- and 8-week intervals after application indicate that redstem filaree is more susceptible to fluazifop than broadstem filaree. Also, the damage ratings decreased at the 8-week intervals for both species compared to the 2-week interval suggesting that regrowth occured.

Percent cover readings were taken near peak flowering time at each site. Initial results show that 0.315 kg ai ha^{-1} of fluazifop decreased the percent cover of redstem filaree from 40% mean cover in the control to 30% mean cover. When the application rate was increased to 0.630 kg ai ha^{-1}, which is 1.5 times the maximum label rate, the mean percent cover of redstem filaree decreased to 5%. The mean percent cover of broadleaf filaree did not decrease significantly at label rates, and only decreased from 64% in the control to 41% mean cover at an application of 1.260 kg ai ha^{-1}, which is 3 times the maximum label rate.

Clethodim did very little damage to either species according to visual damage assessments and did not decrease the percent cover of either filaree species.

Fluazifop may be useful for suppression of redstem filaree in wildland restoration scenarios, however broadstem filaree is much less susceptible. However, season-long control was not achieved using current label rates. Multiple applications may provide better control of both species tested. Plots will be resprayed and remeasured during the 2010 growing season.

Calibration of Non-Crop Sprayers

McGiffen, Jr. M.E., C.E. Bell, C. Wilen, O. Bachie, and K. Weathers.
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Herbicide labels list application rates in terms of surface area sprayed. But many land managers apply herbicides based on percentage of active ingredient in the spray solution. The result often leads to over-application of herbicide.

We conducted several one-day training sessions to educate practitioners on safe, effective, and efficient herbicide application practices. Each class began and ended with a short pre-test on herbicide labels, application, and calibration.
Classroom topics included:

1) Basic principals of pesticide application.
2) Herbicide labels: caution words, formulation, dosage information.
3) Difference between dosage and concentration.
4) Gallons per Acre (GPA) and what it means in practice.
5) Droplet Size, coverage, and drift.
6) Principles and methods of calibration.
7) Adjuvants.

The field session focused on the 1/128 method of sprayer calibration. The 1/128 method is named for the 128 ounces in a fluid gallon. The area used for calibration, 340 square feet, equals 128^{th} of an acre; thus the ounces of spray applied equals gallons per acre. Each participant received a clipboard with a built-in calculator and embossed with easy fill-in-the-blank steps for calibration.

The field session included stations with an orchard spray gun, broadcast sprayer, or spot sprayer. Instructors demonstrated proper application technique and how to calibrate each sprayer. Each participant then used each sprayer and their GPA recorded. GPA varied greatly among individuals and sprayers. The broadcast backpack sprayer applications had the lowest and least variable GPAs, ranging from 11-94 GPA for the 62 participants. Spot sprayer calibration varied wildly, from 71-1561 GPA for the actual area treated. These results indicate orders of magnitude of over-application if these applicators apply herbicide based upon percentage of active ingredient in the spray solution rather than pounds applied per acre.

GPA varied directly with group attitude or experience. Groups insistent on spraying to runoff had very high GPA’s. But GPA’s were greatly decreased when a group of applicators that frequently applied herbicide in hot weather and rugged terrain realized that lower GPA’s would mean far fewer trips to fill up the sprayer or greater need to carry additional water. It was difficult for some participants to realize that increasing the amount of herbicide applied had negative consequences and often did not increase control. Field demonstrations comparing weed control using different GPA’s and application rates may help educate practitioners, but perhaps only over the long term.

WEED MANAGEMENT PROGRAMS
SOLANO IRRIGATION DISTRICT
JANUARY 12, 2010

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Solano Irrigation District Background Information

Solano Irrigation District (SID) was established in 1948 in Solano County. The district is located on the I-80 corridor midway between San Francisco and Sacramento. Napa, Yolo, Contra Costa and Sacramento Counties border Solano County.

SID provides irrigation water for over 80,000 acres of irrigable land. Approximately 70 different commodities are produced, including fruits, nuts, vegetables, grains, seeds, nursery stock and livestock.

SID owns and operates a water delivery system of about 370 miles of pipes, canals and ditches. SID also owns 32 wells, which supplement the surface water deliveries.

SID also operates and maintains the “Solano Project”. This project is comprised of Monticello Dam (forming Lake Berryessa), the Putah Diversion Dam (forming Lake Solano), the Putah South Canal and Terminal Reservoir.

SID has partners in water service under “Joint Powers” arrangements to treat and supply domestic water to the residents and businesses in the Cities of Dixon and Suisun City. SID operates and maintains conventional water treatment facilities such as Cement Hill Water Treatment Plant in Fairfield as well as membrane treatment facilities. SID operates ground water wells and domestic distribution systems in these cities.

Non-Crop Weed Management Programs

Terrestrial Weed Management

Bare Ground Herbicide Program

Canal and Drain Roads*:* The majority of the roads are dirt and are maintained weed free. Primary herbicides to be used in 2010:

- Dimension 2EW and Milestone VM

Inside Banks of the Irrigation Canals: The water season ends October 15 and starts again April 1. During the off-irrigation season, the inside banks are maintained weed free. Primary herbicides to be used in 2010:

- Direx 4L
- Prod amine 60WP (in Ground Water Protection Areas)

Bare Ground Herbicide Program (continued)

Municipal and Industrial Sites: This includes well, tank and pump sites, water treatment facilities, meter and valve sites, manholes, etc. Primary herbicides to be used in 2010:

- Dimension 2EW and Milestone VM

Agricultural and Municipal Pipelines and Facilities: This includes turnouts, vent pipes, air relief vents, fire hydrants, etc. Primary herbicides to be used in 2010:

- Dimension 2EW and Milestone VM
- Surflan AS and Goal Tender

Putah South Canal Fence Lines: Firebreaks are maintained along the Putah South Canal near residential areas. Primary herbicides to be used in 2010:

- Dimension 2EW and Gallery 75Dry Flowable

Vegetation Management Programs

Broadleaf Control on Grassed Slopes: SID maintains many slopes in a grass vegetated state for erosion control purposes. Primary herbicides to be used in 2010:

- Milestone VM
- Milestone VM Plus
- Garlon 3A
- Weedestroy AM 40

Grass Height Control on Grassed Slopes: The purpose of this program is to reduce the fire risk on these vegetated slopes. Primary herbicides to be used in 2010:

- Accord Concentrate (very low rates)

Post-Emergent Herbicide Application

Post Emergent Applications: This includes all weeds during the irrigation season, non-aquatic. Primary herbicides to be used in 2010:

- Accord Concentrate
- Garlon 3A

Aquatic Weed Management

Solano Irrigation District has operated under an NPDES permit since 2002. All aquatic weed herbicide applications are scheduled in advance. All of the customers are notified of the schedule and the operating procedures to follow during and after the application. Irrigation canal “spills” are controlled during the herbicide application to prevent herbicides from reaching canals the have been defined as “Waters Of The United States”. Water that is in these canals is monitored before and after the application for the herbicide that was used. A biological evaluation of the canals is conducted after the irrigation season to demonstrate that no damage to the ecosystem has occurred. A full report is then prepared and submitted to the respective California Water Quality Control Board.

Irrigation Canal Inspection During Irrigation Season

One day prior to a scheduled herbicide treatment, a complete inspection of the system is made. A map is constructed that shows the locations of significant aquatic weeds. A rating system is used to indicate the severity of the weed growth:

Green: No significant growth, no flow restrictions
Yellow: Moderate infestation, treatment is recommended
Red: Heavy infestation, canal flow is impacted, treatment needed

Irrigation Canal Treatment During Irrigation Season

Based on the inspection, a treatment plan is implemented that targets the areas of greatest concern. The herbicide/algaecide selected will be specific to the species that are impacting the canal.

Treatment technique will depend on the situation and the herbicide/algaecide being utilized. Solano Irrigation District utilizes drip application, broadcast boom application and slug treatment. The aquatic herbicides and algaecides include the following:

Nautique: Targets Sago, American, Curly Leaf Pond Weed
Clearigate: Targets all of the above plus Water Speedwell, Algae
Cutrine Ultra: Targets Algae
Copper Sulfate: Targets Algae

Irrigation Canal Treatment During Off Season

Sonar AS Herbicide was utilized in during the winter of 2008-2009 on approximately 23 acres of dry irrigation canal. The herbicide was applied utilizing a boom truck. The treated areas received over 6” of rainfall within one month of the treatment. The results were overall positive. Aquatic weed growth was significantly reduced compared to the prior year without the treatment. Solano Irrigation District will continue the program in 2010 and evaluate the effectiveness of the herbicide over two seasons.

Controlling Difficult Weeds in Right-Aways and Non Cropland

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The unchecked growth of weeds in ditchbanks, fencerows roadsides, and other non-cropland areas can cause several problems for landowners. Poor weed management practices may increase weed seed reservoirs and the potential for weed problems if the land is ever brought into crop production, provide for a source of new weed problems in adjoining fields through seed dispersed by wind, animals or perennials creeping in from field edges, and lower economic land values. Glyphosate resistance of horseweed (*Conyza canadensis*) and hairy fleabane (*Conyza bonariensis*) populations have increased dramatically throughout California orchards, vineyards, and roadsides. This shift has occurred due to the usage of repeated applications of glyphosate, reduced tillage, less usage of residual herbicides, and less use of alternative chemistry.

Glyphosate resistant horseweed, fleabane and other species have shown up throughout the United States particularly in the cotton regions of the United States. From 2006-2009 ditchbank and roadside studies conducted in Tulare County demonstrated good control of horseweed when using Milestone, Transline at 10.6 oz., Krovar + Accord, Karmex + Accord, and Oust + Accord gave up to 100 percent control of horseweed. The higher rates of Milestone at 7 oz. /A was needed to give the most consistent control. Treatment combinations of Glyphosate at 2 lbs. ai. + Indicate, Citric Acid, ET, Shark, or Chateau gave improved control compared to Glyphosate + AMS. In all treatments glyphosate was an important addition for control of grasses that were present.

Sprangletop (*Leptochloa fascicularis*) is increasing rapidly in many ditch banks in the San Joaquin Valley. Research studies in 2009 in Kings County demonstrated that two applications of glyphosate at 44 oz. per acre plus glufosinate at 7 pints per acre gave outstanding control of sprangletop.

Conclusions

In summary, the non-crop weed management approach must incorporate resistance management strategies such as using minimum number of applications of any one herbicide per season. Also rotating herbicides and using tank mixes with different chemistry. Other strategies the non-crop weed management must include are controlling weed escapes by tillage, or hand when appropriate, and monitoring and mapping locations for patterns of weed escapes consistent with developing resistance.

Preemergent Herbicides: How to Make Them Work

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To get the most efficacy out of the herbicide that you apply, there are several factors that need to be considered. Each factor can be the difference between partial control or full control of the weed spectrum in the field. What are these factors and how do they work?

There are several factors to take into consideration:

1) Weed spectrum
2) Properties of the herbicide
3) Timing of Application
4) Placement in the soil
5) Soil Moisture

Weed species react differently to different herbicides (selectivity). Grass seedlings respond differently than broadleaf seedlings. Most grass seeds germinate the first season, whereas broadleaves often have some dormancy factor involved, thus most of the seeds may live over into succeeding years. Weed seed size can also make a difference. The larger seeds because they have more energy, can germinate at deeper depths than small seeds. Also often weed species can have a long germination period, since their germination is not synchronized. Also, the placement of the seed in the seed-bank can affect control. Seeds are often distributed throughout the upper soil layer due to cultivation (shallow tillage or deep plowing) compared to shallow distribution in no-till culture.

Herbicide performance is dependent upon the herbicide properties. These include: chemical properties, water solubility, soil adsorption capability, volatility and degradation characteristics on the soil surface or in the soil.

Timing of application is critical. In general, the herbicide needs to be in place, either on or in the soil, when the seed is germinated. This is especially true when the mode of action is root stunting such as the dinitroanilines. It is also necessary to have a product like oxyfluorfen on the soil as the seedling germinates and starts though the herbicide in a shallow layer at the soil surface.

Soil moisture is critical for the optimum performance of any given herbicide. First there needs to be soil moisture for the seeds to imbibe water to germinate. Secondly, a herbicide can not move into the germinating seed if there is not free water for the herbicide to travel with into cells. Also, there needs to be moisture that distributes the herbicide on the soil surface, or move the herbicide into the upper soil surface where the seeds are germinating. The characteristics of some herbicides also affect the amount of time they can stay on the soil surface before rainfall or irrigation is required to get the herbicide into the germinating zone. The first water event is the most important in moving the herbicide to the proper location in soil. Once the herbicide is adsorbed to the soil particles they are much less prone to move deeper into the soil with the next irrigation. If too much water is applied after application on a light, coarse soil, the water may move the herbicide too far into the soil, and seedlings may survive above the herbicide.

Table 1. Comparisons of common herbicides from different families as to the time before water and the amount of water needed to move the herbicide to the appropriate soil zone.

Herbicide	Surface stability	Moisture regime	Half-life (days)	Concerns
Solicam DF	Stable 4 wks	0.5 in water	45-180	Coarse soil, low areas
Goal 2XL	3-4 wks	> 0.25 in.	35	No soil disturbance
Simazine	2-4 wks	0.5 in	60	Movement in course soils with long use.
Barricade	w/in 14 d	0.5 in. or shallow incorporation	70-120	Slight disturbance OK

Temperature can have an affect on the action of preemergent herbicides, primarily because germination and growth responds to temperature. Each species has their own requirements for germination. Once germination has occurred, maximum growth will occur with the optimum temperature for the species. Relate uptake and growth, if moisture is present, the more growth, the more uptake.

Chemical characteristics of the herbicide will determine activity such as movement in the soil, uptake into the seedling and movement in the plant. Water solubility, volatility, lipophilicity (lipid affinity), resistance to degradation, chemical characteristics, and adsorption characteristics of the herbicide, all affect how the herbicide works. Even though many preemergent herbicides have low solubility (2.6 ppm in water for Surflan, or 0.013 ppm for prodiamine), only a small amount is needed to get to the growing point since they are so efficient in stopping cell division.

Volatility:
When the herbicide is volatile, it can be detrimental since it may be lost to the environment without benefiting herbicide activity (trifluralin or EPTC). Another herbicide that can benefit from its volatility to get a more uniform response is oxyfluorfen. If a herbicide is moved into the soil with water or shallow incorporation it can be beneficial, since it can be taken into the seedling through the vapor phase (trifluralin). This is very apparent when trifluralin is placed in a concentrated band in the soil, where it not only stunts roots but even causes shoot suppression of an established plant like field bindweed.

The primary method of uptake of the herbicide is with water into the root. The greatest absorption area is in the root tip and differentiation zone through the root hairs. These roots have very little obstruction to uptake since they are not like a leaf that has waxes on the leaf surface or a cuticle to pass through to get to a cell that will transport the herbicide. Soil applied herbicides can pass through the cell walls and cell membrane of the root cell into living tissue on the way to the dead cells (xylem) and follows the water. Examples of these herbicides include the triazines, ureas, uracils or norfluorazon. Herbicides may also go through the living part of a cell on the way to the living cells (phloem) as part of the vascular tissue. An example of these herbicides include rimsulfuron. Some herbicides can move into cells at a location on the emerging stem. These herbicides can act as contact herbicides such as the diphenylether, oxyfluorfen or flumioxazin. Others act as shoot and root inhibitors from shoot uptake such as EPTC or metolachlor.

Shoot activity can be a second method of uptake for preemergent herbicides.
Shoot uptake takes place in the coleoptile, lower stem tissues and some root uptake exp. EPTC, Dual, and dimethenamid. These products inhibit leaf growth by the primary leaf failing to grow through the coleoptile sheath, thus the seedlings are stunted and are not competitive.

Thus to summarize one could say something similar to a real estate agent; it is location, location, location. A preemergent herbicide needs to be in moist soil, at the right place, at the right concentration, for the correct length of time, to be effective for control.
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Review of Proposed Groundwater Regulations

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This paper takes a close look at the alternatives being considered for the new proposed Long Term Irrigated Lands Regulatory Program. With the existing ILRP set to expire in 2011, the Regional Water Board is working with a broad range of stakeholders to develop a new program. While final adoption is almost two years away, now is the time to examine closely the options being considered and combine efforts with others to urge changes in aspects that are unworkable for Central Valley agriculture. The outcome will undoubtedly impact the future of irrigated agriculture in the Central Valley.

EIR To Examine Alternatives for Regulating Water Quality

Agricultural groups and watershed coalition managers got their first look this summer at what may be the future of groundwater regulations for irrigated agriculture in the Central Valley.

In mid-September, five alternative approaches for regulating ground and surface water began a six to eight month environmental review process that will put a price tag – for farmers and state regulators alike – on each of the programs. The five alternatives being examined range from slightly more than status quo to comprehensive farm nutrient management plans and extensive groundwater monitoring.

The review process is part of the long overdue Environmental Impact Report (EIR) on the Irrigated Lands Regulatory Program. The EIR process was stalled when the original ILRP was passed in 2003 then restarted in 2008, this time with a groundwater component added to the mix. The EIR is required under California Environmental Quality Act (CEQA) and examines the economics, policy ramifications and environmental impacts of new programs.

When an EIR examines a new regulatory program, it must provide regulators, in this case the Central Valley Regional Water Quality Control Board, a review of a range of program alternatives or approaches to regulate. Each alternative is examined separately on its own merits then summarized for the Regional Water Board members in the final EIR. Meanwhile, the Water Board staff, using information from the EIR, is expected to construct its own program, picking and choosing different aspects from each of the five alternatives to build its "ideal" surface and groundwater program. When the final EIR is presented to the Regional Water Board members, expected in fall 2010, it will be accompanied by a Regional Water Board "staff recommended" program that will have been vetted through a lengthy public process. The nine-member Regional Water Board can chose any of the five alternatives from the EIR but the staff recommended program is the most likely alternative to be passed.

Exactly what will be in the staff recommended program won't be known until spring 2010. But the five alternatives now being examined give an idea of the range of approaches being considered by Regional Water Board staff. The five alternatives were developed by a multi interest "workgroup" made up of local government, industry, agricultural and environmental coalitions from the Central Valley. The workgroup met four times in 2009 to advise and provide comment to Regional Water Board staff as it compiled the ILRP alternatives. Agricultural interests combined efforts to develop and deliver critical comments on the last draft of alternatives in late September. Regional Water Board staff has said they would work with agricultural and environmental stakeholders to adjust the alternatives based on their respective comments.

Regional Water Board staff committed to updating stakeholders on the EIR progress throughout the winter 2009-10 and also to seek input on environmental, economic and policy aspects of each alternative. At its October 8th Regional Water Board meeting, staff will update the Board members on the workgroup process, proposed ILRP alternatives and next steps in the EIR process.

Farm Threat to Water Quality: A Tiered Approach

Alternative 4 uses a tiered approach to regulating ground and surface water. Each field in the Central Valley would be classified, through coordination with the Department of Pesticide Regulation, into one of three tiers based on the field's threat to water quality. The tiers represent fields with minimal (Tier 1), low (Tier 2), and high (Tier 3) potential threat to water quality. This would allow for less regulatory oversight for low threat operations while establishing necessary requirements to protect water quality from higher-threat discharges.

Factors that would impact classification would be site specific and include:

- existing water quality;
- hydrogeologic conditions;
- nitrogen loading;
- crop types;
- irrigation practices;
- pesticides used;
- distance to surface water bodies; and
- whether the field is in a DPR Groundwater Protection Area http://www.cdpr.ca.gov/docs/emon/grndwtr/gwp_regs.htm.

Tier 1 fields would be those where discharge is so minimal that it will not result in any detectable change in water quality.

Tier 2 fields would have a low potential to affect water quality and meet the following conditions:

- Have low-threat pesticide and fertilizer use including *not* using pesticides that have been found in or have the potential to move to groundwater based on DPR's Groundwater Protection Program (Title 3, California Code of Regulations section 6800);
- For surface water, do not use pesticides that have the potential to cause exceedance of applicable surface water quality objectives as defined using monitoring data;
- Have fertilizer application rates that are not expected to result in nitrogen exceedances in groundwater; or
- Are not located in a vulnerable hydrologic environment (groundwater) which is a square-mile section of land where monitoring data from one well confirms any one of the following: (i) nitrate concentrations are greater than the maximum contaminant level (elevated nitrate levels), (ii) have measurable levels of agriculturally used pesticides, or (iii) salts, pathogens (where manure is used), or other agricultural constituents of concern are above an applicable water quality objective. DPR Groundwater Protection Areas would also be considered vulnerable hydrologic environments. For surface water, vulnerable area is subwatersheds where monitoring data confirms two or more exceedances of water quality objective in 3-year period where agriculture is a contributing source.

Tier 3 (high threat) fields would have a high potential to affect surface water and/or groundwater quality and would include fields that have low-threat fertilizer or pesticide use but are located in a vulnerable hydrologic environment. Tier 3 would also include fields that are not located in a vulnerable hydrologic environment, but have high-threat fertilizer and/or pesticide use. A field may move from Tier 3 to Tier 2 or vice versa depending upon changes in fertilizer or pesticide use or available information on groundwater vulnerability.

Growers could be in different tiers for surface water or groundwater discharge. For example, a field may be in a vulnerable environment for groundwater (Tier 3), but minimal threat to surface water (Tier 1) if all applied water immediately percolates, and does not run off.

Growers who do not meet these requirements would work directly with the Central Valley Water Board and obtain waste discharge requirements or an individual waiver of waste discharge requirements.

Farm Water Quality Management Plans

Alternatives 3, 4, and 5 would require that irrigated agricultural operations develop individual farm water quality management plans (FWQMPs). The Water Board would develop a standard FWQMP template, but at a minimum, plans would describe those practices needed or currently in use to achieve water quality protection.

Growers would be encouraged to work with technical service organizations such as Resource Conservation Districts and the University of California Cooperative Extension when developing FWQMPs. In addition to name and contact information, each plan would include:

- Operation description i.e. irrigated acres, crops and chemical/fertilizer application rates and practices;
- Maps of irrigated production areas, discharge points and named water bodies;
- List of water quality management practices used to achieve farm management objectives and reduce or eliminate discharge of waste to ground and surface waters;
- Wellhead protection measures for pesticide and fertilizer use; and
- Identify potential conduits to groundwater aquifers (e.g. active, inactive, or abandoned wells; dry wells, recharge basins, or ponds) and steps taken, or to be taken, to ensure conduits do not carry contamination to groundwater.

Reporting Pesticide and Fertilizer Use

In Alternative 4, all growers would be required to report use of pesticide and fertilizers annually to the Regional Water Board or an approved third-party monitoring group. Nutrient reporting includes:

- All nutrients applied (commercial fertilizers, manure, irrigation water, etc.).
- Ratio of nutrients applied to the needs of the crop(s) (as recommended by the University of California Western Fertilizer Handbook [9th Edition] or from historic crop removal rates).

Long-Term Irrigated Lands Regulatory Program
Summary of Alternatives Proposed for Environmental Impact Report (as of 9-23-09)

Alternatives Being Examined in EIR

The Environmental Impact Report being developed for the Long Term Irrigated Lands Regulatory Program will examine five alternative approaches for regulating surface and groundwater. In the final EIR, each will be weighed for its economic impact to farmers and state regulators, policy ramifications and environmental impacts of the new program. The alternatives were developed using input from a voluntary “workgroup” made up of local government, industry, agricultural and environmental coalitions from the Central Valley. The alternatives are summarized here with the full text available online at www.waterboards.gov/ILRP.

Overview Description	Lead Entity and Responsibilities	Water Board Responsibilities	Grower Requirements	Surface Water Monitoring	Groundwater Monitoring
Alternative 1 No change; continue existing program; coalitions function as leads; where monitoring indicates problems, growers implement management practices.	**Coalitions/commodity groups:** must enroll members; conduct monitoring; implement Management Plan when two or more exceedances of standards; conduct member outreach. Individuals not participating in coalition or commodity organization required to obtain individual coverage from the Regional Water Board.	Require 100% participation; review and approve coalition plans and reports; respond to complaints; enforce ILRP; ensure individuals not participating in Coalition and/or commodity organization obtain individual coverage with the Water Board.	Submit application and pay fees to coalition; implement water quality management practices; prevent nuisance conditions or exceedances of standards; respond to coalition information requests. Or, obtain individual coverage from Water Board.	Watershed based, same as current program	None
Alternative 2 Third- party lead entity (coalitions, commodity group, others); similar surface water requirements of existing program; reduced surface water monitoring in low threat areas/where management plans in place; requires groundwater management plans to minimize waste discharge to groundwater. Option to use local groundwater management plans prepared pursuant to AB 3030/1938 that meet specified requirements.	**Third-party** i.e. coalitions,/commodity group/other: must enroll members; develop and conduct monitoring, management practice tracking plans; implement surface water Management Plan when two or more exceedances of standards; develop Groundwater Quality Management Plans within 4 years adoption of new ILRP; inform, coordinate programs with members. Option to have local groundwater management plans prepared pursuant to AB 3030/1938 that meet specified requirements.	Require 100% participation; review and approve coalition surface and groundwater plans and reports; require additional monitoring and management practices where standards are not met; respond to complaints; enforce ILRP.	Submit application and pay fees to third party entity; implement water quality management practices; prevent nuisance conditions and exceedances of standards; respond to third-party information requests.	Watershed based with option for reduced monitoring where watershed/area management plan is developed. Also management practice tracking.	Regional monitoring for nitrates/salts or tracking use of required management practices. Local requirements associated with AB 3030/1938 plans
Alternative 3 Individual Farm Water Quality Management Plans: growers work directly with Water Board or lead implementing agency.	**Water Board (see next column)**	Enroll growers; require 100% participation; work with Technical Service Providers (TSP); conduct site inspections; certify growers are implementing practices to protect water	Submit application and pay fees to Water Board; within two years develop and implement farm water quality management plan; submit plan to Water Board for approval; update	Monitoring of management practices (e.g. visual monitoring, inspection of proper operation.) Also	Monitoring of management practices (e.g. visual monitoring, inspection of proper

		quality; require additional monitoring and management practices where standards are not met; respond to complaints; enforce ILRP.	plan as needed; prevent nuisance conditions and exceedances of standards; allow inspections by Water Board or its representatives.	management practice tracking. Additional monitoring to be determined on a individual farm water quality management plan basis.	operation.) Also management practice tracking. Additional monitoring to be determined on a case-by-case basis.
Alternative 4 Direct Water Board oversight with regional monitoring: individual growers or "responsible entities" that assume responsibility for waste discharge will work directly with Water Board. If optional third party, they perform monitoring/reporting; requirements would be scaled using tiered, threat-based criteria. All growers must have individual farm water quality management plans. Fields classified under tiered approach (Tier 1-3)	**Water Board or Responsible Entity.** If RE, it must enroll growers; develop monitoring and tracking plans; and conduct monitoring. Responsible entity must be a Joint Powers Authority or some other formal legal entity that accepts responsibility for discharges for its enrollees.	Enroll growers (if no Responsible Entity); require 100% participation; review and approve surface and groundwater plans and reports; assign growers to appropriate threat tier; coordinate with growers to ensure plans/practices are addressing water quality problems; conduct site inspections; require additional monitoring and management practices where standards are not met; respond to complaints; enforce ILRP.	Submit application and pay fees to Water Board; within two years develop and implement farm water quality management plan; submit plan to Water Board upon request; update plan as needed; prevent nuisance conditions and exceedances of standards; allow inspections by Water Board or its representatives; complete 15 hrs of farm water quality education within 2 years; submit annual certified statement to Water Board regarding appropriate tier application. Tier 1 only: submit site specific evaluation to Water Board demonstrating minimal potential impact of waste discharge to SW or GW; Tier 3 only: develop a nutrient management plan and/or implement additional pesticide	Tier 2 and 3 would conduct individual monitoring or participate in regional monitoring with tier 2 operations having reduced monitoring requirements. Also tracking and reporting nutrient and pesticide applications and management practices.	Tier 3 operations would conduct individual monitoring and participate in regional monitoring. Tier 2 operations would chose between individual or regional monitoring. Also tracking and reporting nutrient and pesticide applications and management practices.

			management practices. Maintain records of each field's nutrient budget.		
Alternative 5 Direct Oversight with Farm Monitoring	**Water Board** **(see next column)**	Enroll growers; require 100% participation; review individual monitoring reports; develop prioritization scheme for installation of monitoring wells; coordinate with growers to ensure plans/practices are addressing water quality problems; conduct site inspections; require additional monitoring and management practices where standards are not met; respond to complaints; enforce ILRP.	Submit application and pay fees to Water Board; within two years develop and implement farm water quality management plan; plan to be submitted to Water Board upon request and kept on site; update plan as needed; develop and implement a nutrient management plan if commercial fertilizer or manure is used; allow inspections by Water Board or its representatives; maintain records of each field's nutrient budget.	Individual farm monitoring for constituents of concern in tailwater, storm water and tile drainage. Also tracking and reporting of nutrient and pesticide applications and management practices.	Individual supply well monitoring; installation and sampling of monitoring wells where Water Board requires based on vulnerability factors. Also tracking and reporting nutrient and pesticide applications and management practices.

Groundwater Quality Strategy is Goal of New Effort

It's not a new groundwater regulation and it won't set state policy. The Regional Water Board calls it a "Groundwater Quality Strategy." A resolution by the Regional Water Board in 2008 called on staff and the regulated community to work on a broad strategy to identify issues and concerns, including priorities on how the Board will move forward to address groundwater quality in the Central Valley.

Industry and the public had opportunity for input at a round of workshops in August 2009. The final strategy (first draft set for October/November), will serve as the Water Board's road map for developing new regulations and help in coordinating with other agencies with regulatory authority over groundwater (Department of Pesticide Regulation and Department of Food and Agriculture). The strategy will contain:

- Summary of current conditions and state of groundwater quality throughout the Central Valley;
- Summary of current groundwater regulatory programs being implemented by the Regional Water Board and other local and state agencies; and
- Roadmap for future regulatory and control activities that will be implemented by the Regional Water Board to assure comprehensive, consistent, and coordinated groundwater protection program is being implemented throughout the Central Valley Region.

Another round of workshops for public input on the draft strategy are expected in October or November 2009. A final version could be ready for a Regional Board vote by January or February 2010.

Note: the Water Board emphasized that the strategy would not address groundwater rights or quantity of groundwater use.

Multiple-resistant biotypes of hairy fleabane (*Conyza bonariensis*) documented in the San Joaquin Valley

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Glyphosate-resistant populations of hairy fleabane (*Conyza bonariensis*) were documented in the San Joaquin Valley (SJV) in 2007. However, poor control of these populations is also being observed with paraquat, another common contact herbicide used in the SJV. Therefore, we hypothesized that hairy fleabane had developed multiple resistance to glyphosate and paraquat. A greenhouse study was conducted in 2009 to test the effects of various rates of glyphosate and paraquat on nine populations of hairy fleabane collected from different areas of the SJV. The potted plants were sprayed at the 5-8 leaf stage with 0.5, 1, 2, 4, 8, and 16 fold the recommended label rate of glyphosate or paraquat separately (0.98 lb ae/ac and 0.45 lbs ai/ac respectively). A non-treated control treatment was also included. The herbicide applications were made with a CO_2 backpack sprayer equipped with a Teejet 8002 VS flat fan nozzle at an output of 19 gal/ac during the morning hours. The plants were kept for at least 24h outdoors before and after spraying. The experiment was a completely randomized design with five replications and was repeated. In the second round a mineral surfactant was added to the paraquat treatments at 1%V/V. The plants were evaluated 1, 3, 7, 14 and 21 days after treatment for mortality. On the 21st day, the plants were clipped and oven-dried for 72 hours and the dry weight recorded. Of the nine populations tested, four were selected and coded for easy of data presentation as follow: BH10051, BH10054, BH10055 and susceptible. The populations BH10051 and BH10055 showed the highest survival rate for paraquat. All the plants of these two populations survived even the highest rate of paraquat. For glyphosate, the population BH10055 had a survival rate of 100% and 58% at the 8- and 16-fold the label rate, respectively. However, the survival of population BH10051 plants was 58% at the 4-fold rate and did not survive higher rates. About 91% of the plants of the BH10054 biotype survived the 16-fold rate of glyphosate but only 8% of the plants survived the 4-fold rate of paraquat. Most of the susceptible plants did not survive any application rates beyond 2-fold for both glyphosate and paraquat. Therefore, this study showed that some populations of hairy fleabane in the SJV have evolved multiple resistance to glyphosate and paraquat and some populations to glyphosate or paraquat only. The level of resistance for both herbicides varied according to the biotype.

Treevix Herbicide for Post Emergent Weed Control in Tree Crops

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Treevix is a burndown herbicide for postemergence control of broadleaf weeds in tree nuts, citrus, and tree fruit. The active ingredient in Treevix, is saflufenacil (Kixor). Saflufenacil is a protoporphyrinogen-IX-oxidase (PPO) inhibitor belonging to the pyrimidinedione class of chemistry. Due to increased incidence and spread of glyphosate resistant weeds such as marestail and fleabane, there is need for additional herbicides registered for use in tree crops. Treevix provides postemergence burndown control of many key weeds including marestail, fleabane, cheeseweed, willowherb, sowthistle, and others. Because Treevix does not have grass activity it should be tankmixed with a herbicide that has grass activity. Tank mixtures of Treevix and glyphosate provide both grass and broad spectrum broadleaf weed control. Control of fleabane and marestail was 93 and 100%, respectively with Treevix at 1 oz/A + glyphosate at 0.75 lb ai/A compared to 75 and 65%, respectively with glyphosate alone. In a summary of 9 trials conducted in 2005-2008, Treevix at 1 oz/A + glyphosate at 1 lb ai/A controlled fleabane 98% 2 WAT (weeks after treatment) compared to 58% control with oxyfluorfen at 1 lb ai/A + glyphosate at 1 lb ai/A. In trials where cheeseweed was present, control of cheeseweed - 3-6 WAT was 95% with Treevix at 1 oz/A + glyphosate at 1 lb ai/A, 95% with oxyfluorfen at 1 lb ai/A + glyphosate at 1 lb ai/A, and 98% with flumioxazin at 0.38 lb ai/A + glyphosate at 1 lb ai/A. In other trials, Treevix at 1 oz/A + glyphosate at 1 lb ai/A controlled willowherb 97% and redstem filaree 98% 3-6 WAT. In summary, Treevix in combination with glyphosate provides excellent control of a wide range of broadleaf weeds.

Pindar™ and Pindar GT™: new broad spectrum herbicides for tree nut crops

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Pindar™ (penoxsulam) and Pindar GT™ (penoxsulam plus oxyfluorfen) are new herbicide products for use in tree nut crops. Penoxsulam is an ALS inhibitor in the triazolopyrimidine sulfonamide chemical class. Oxyfluorfen is a widely used PPO inhibitor in the diphenylether class of chemistry. The combination of these two modes of action results in a product which provides long lasting pre and post emergence control of a broad range of economically important species in tree nuts, including horseweed (*Conyza canadensis*), hairy fleabane (*Conyza bonariensis*), cheeseweed (*Malva* spp), redstem filaree (*Erodium cicutarium*), shepherd's purse (*Capsella bursa-pastoris*), coast fiddleneck (*Amsinckia intermedia*), common chickweed (*Stellaria media*), London rocket (*Sisymbrium irio*), sowthistle (*Sonchus* spp), white clover (*Trifolium repens*) and others. Applied during the winter dormant season for control of winter annual broadleaf weeds, Pindar and Pindar GT can provide up to six months control of key weed species.

Four years of extensive field testing has shown that Pindar and Pindar GT are safe to the crops when used according to label recommendations. These trials tested rates up to four times the top label rate, with sequential applications for three consecutive years. All aspects of tree growth, vigor and yield were evaluated. Pindar and Pindar GT are safe to bearing and non-bearing tree crops when used according to label recommendations

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Online Interactive Weed Identification Program

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Pest identification is the first step in the development of an early detection, rapid response, and eradication program. To increase the ability for individuals to identify invasive plants found in California, we have developed a simple, interactive web-based tool. This online invasive plant identification tool is based on the program already developed for weeds of California and Wisconsin. This tool will facilitate training of weed science professionals, land managers, students, and volunteers in each region of the state. It is also easily used by growers, ranchers, and homeowners. The program has been widely tested and has proven to be simple enough to use by individuals with minimal botanical experience.

The program has a central database located at the University of Wisconsin and is set up to allow us to enter weed species information to the database remotely, thus limiting upkeep costs for the database. For California, the current online program is available at the Weed Research and Information Center website (wric.ucdavis.edu) and contains 463 species (338 broadleaf, 95 grasses or grass-like species, and 30 woody weeds). Each characteristic consists of a drop down box with choices and the question marks can be used to provide explanations for characteristics.

While the Weed Research and Information Center houses a more extensive number of weeds within the state, it is possible for any organization or agency to also set up a website for their group that contains specific species of concern to their employees. This could include invasive plant organization, irrigation districts, Departments of Transportation, Forest Service districts, nursery organizations, herbicide manufacturers, and many others that require specific training on weeds for their employees or members. This can be accomplished by contacted the authors and providing a set of weeds of interest.

Troublesome Weeds in San Joaquin Valley Vegetable Crops

Michelle Le Strange, Farm Advisor, University of California Cooperative Extension, Tulare & Kings Counties

<u>What are troublesome weeds? Let's start with the obvious.</u>

1) Weeds that cause harm to humans. Hand weeding and hand harvest is common with many vegetable crops. Weeds that have barbs, thorns, stingers, scratch and itch are troublesome. A few examples are:

Puncture vine	*Tribulus terrestris*
Burning nettle	*Urtica urens*
Cocklebur	*Xanthium strumarium*

2) Weeds that are aggressive competitors. Even fairly competitive vegetables like tomatoes have difficulty fending off these weeds. Some are so aggressive that land values can be decreased because of the loss of productive potential.

Perennial weeds:

Field bindweed	*Convolvulus arvensis*
Bermudagrass	*Cynodon dactylon*
Johnsongrass	*Sorghum halepense*
Nutsedges	*Cyperus spp.*

Parasitic weeds:

Dodder	*Cuscuta sp.*

3) Weeds that mimic the crop. Weeds in the same family as the crop can look so similar that they are missed by hand weeding crews or by selective herbicides. For example,

<u>Mustard weeds growing in cole crops (broccoli, cauliflower, cabbage):</u>

London Rocket	*Sisymbrium irium*
Shepherd's purse	*Capsella bursa-pastoris*
Wild radish	*Raphanus sativus*
Wild mustard	*Sinapsis arvensis*
Black mustard	*Brassica nigra*

<u>Nightshade weeds growing in Nightshade crops (tomato, pepper, and eggplant)</u>

American Black nightshade	*Solanum americanum*
Black nightshade	*Solanum nigrum*
Hairy nightshade	*Solanum physalifolium*
Silverleaf nightshade	*Solanum elaegnifolium*
Lanceleaved groundcherry	*Physalis lanceifolia*
Wright groundcherry	*Physalis acutifolia*

<u>Composite weeds growing in lettuce.</u>

Prickly lettuce	*Lactuca serriola*
Common sowthistle	*Sonchus oleracea*
Common groundsel	*Senecio vulgaris*

Marestail/Horseweed	*Conyza canadensis*
Hairy Fleabane	*Conyza bonariensis*

4) Weeds that are unusually "weedy." Weeds that are known for high seed production and continuous germination throughout the growing season.

Redroot pigweed	*Amaranthus retroflexus*
Tumble pigweed	*Amaranthus albus*
Prostrate pigweed	*Amaranthus blitoides*
Lambsquarters	*Chenopodium album*
Common purslane	*Portulaca oleracea*
Prickly lettuce	*Lactuca serriola*
Common sowthistle	*Sonchus oleracea*
Russian thistle	*Salsola tragus*

5) Weeds that are resistant to herbicides.

Marestail/horseweed	*Conyza canadensis*
Hairy fleabane	*Conyza bonariensis*

<u>What are the less obvious troublesome weeds in SJV Vegetable Crops?</u>

1) Weeds that provide habitat for insect vectors of viruses.
Beet leafhopper vector of Curly Top Virus overwinters on Russian thistle *Salsola tragus*

2) Weeds that are the virus reservoirs. Weeds can serve as hosts for viruses. Some viruses have few weed hosts and others have multiple weed hosts. Weeds can be the source of virus inoculum for crop damaging viruses. In some instances only a FEW weeds can do A LOT of damage to the crop over time. One example that is a current economic problem for the last several years in tomatoes is Tomato Spotted Wilt disease. Vectored by six species of thrips; Western flower Thrips is the predominant vector in California.

TSWV has a very wide host range. It infects over 900 plants, mostly dicots.

Crops	**Ornamentals**	**Weeds**
Beans	Begonia	Chickweeds
Celery	Chrysanthemum	Datura spp.
Cilantro	Geranium	Little Mallow
Eggplant	Impatiens	Lambsquarters
Lettuce	Lily	Morningglory
Peppers	Marigold	Nightshades
Radicchio	Petunia	Pigweeds
Spinach	Snapdragons	Prickly Lettuce
Tomatoes	Verbena	Purslane
	Zinnias	Russian thistle
		Sowthistle

In areas with recent outbreaks of TSWV in the San Joaquin Valley, weeds and plants other than tomato were collected and tested for the virus (Table 1). Most samples tested negative for TSWV, although lettuce, pepper, spinach, London rocket, cardone, malva, prickly lettuce, common groundsel, black nightshade, groundcherry, field bindweed and sowthistle tested positive. However, the incidence of TSWV infection in all these plants was very low (<0.1%). To date, we have not found evidence of any weed that is extensively infected by TSWV.

Due to 2009 water shortages in Fresno County, some old lettuce fields were left fallow and developed high populations of prickly lettuce and sowthistle, weeds known as TSWV hosts. In two such fields, 100 prickly lettuce and 100 sowthistle plants were examined for tospovirus-like symptoms, and weeds with symptoms was tested for *Impatiens necrotic spot virus* (INSV) and TSWV. On 25 March, 6% of the sowthistle plants were infected with TSWV as determined by immunostrips and one was infected with INSV. Flowers from sowthistle plants were examined, and both larval and adult thrips were present. On April 22, weeds from another fallow field in the Five Points area were evaluated. Here, weeds showed symptoms of infection and 2% of the sowthistle and 7% of the prickly lettuce plants tested positive for TSWV, whereas all plants tested negative for INSV. Tomatoes in fields closest to those fallow fields showed earliest development of TSW symptoms, indicating that these weeds were sources of inoculum. Thus, weeds in fallow fields represent a new potentially important inoculum source where both thrips and TSWV can be amplified and then serve as a source for early colonization/infection of nearby processing tomato fields.

Table 1. Weed survey results for TSWV incidence during 2008-09.

Weed	Tested (+)	Weed	Tested (+)
Barnyard grass	27 (0)	Lambs quarters	64 (0)
Black nightshade [ab]	**36 (2)**	**Malva** [a]	**114 (1)**
Bindweed [abc]	**37 (3)**	Mustard	62 (0)
Bur clover	25 (0)	Nettle	25 (0)
Common sunflower	28 (0)	Pigweed	27 (0)
Dodder	25 (0)	**Prickly lettuce** [abc]	**96 (3)**
Fiddle neck	26 (0)	Purslane	25 (0)
Ground cherry [a]	**25 (1)**	Russian thistle	35 (0)
Groundsel [a]	**40 (1)**	**Sowthistle** [abc]	**74 (4)**
Jimsonweed	25 (0)	Tree tobacco	25 (0)

(+) number of plants tested positive for TSWV by Immunostrips and RT-PCR. [abc]**,** Merced, Yolo/Colusa, and Fresno/Kings Counties, respectively

In-Row Weeding in Vegetables with a Machine Vision-Guided Cultivator

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Summary. We are evaluating a robotic cultivator to determine if it can be used to increase the efficiency of vegetable production by removing weeds from between lettuce and tomato plants in the row. Additionally, we will determine if this machine can be used to thin direct seeded lettuce and tomato to desired stands. Hand weeding is a significant expense for vegetable growers because vegetable herbicides do not adequately control weeds. Currently the only way to remove weeds from within the crop row is by hoeing, hand weeding and selective herbicides. The Tillet rotating cultivator (a robotic cultivator), being sold commercially in England, is capable of removing weeds from the crop row. Direct-seeded crops are generally planted at high stands and then thinned by hand to desired stands at $80 to $150/acre. A mechanical crop thinner could potentially reduce production costs for direct seeded crops if handweeding can be reduced or eliminated. The purpose of this project is to test the rotating cultivator in typical California vegetable production systems and determine if it is effective at crop thinning, removing weeds and reducing time of hand thinning and weeding in lettuce and tomato. The rotating cultivator does appear to be capable of thinning lettuce to desired stands if the lettuce is seeded with at least 3 inch spacing between seedlings in the row. If the seedlings are closer than 3 inches then the cultivator is more error prone, so precision seeding is necessary for use with this cultivator. Our tests of the rotating cultivator and subsequent timing of handweeding indicate that less labor is required to hand weed lettuce or tomato cultivated with the rotating cultivator than a standard cultivator.

Introduction. Weeds are among the most common pests of vegetable crops, and present a constant obstacle to profitable vegetable production. Herbicides available to vegetable growers are few in number and those few do not control all weeds. Therefore, vegetable crops almost always require hand weeding and cultivation to maintain cost-effective weed control. Labor costs are increasing, and labor shortages have been reported. Methods to hold down hand weeding costs are necessary if growers are to remain profitable. Stakeholders have noted that weed management in tomato is a major limitation for profitable production. Additionally, stakeholders have stated that the development of "effective economical management techniques for weeds" is a "high" research priority for lettuce. Uncontrolled weeds in vegetables result in lower yields, reduced quality, and decreased harvest efficiency, particularly in hand-harvested crops such as lettuce. Lettuce and tomato are very susceptible to weed competition. Given the scarcity of labor and new herbicides for vegetables, it seems prudent to evaluate robotic cultivators for in row weeding in lettuce and tomato.

Materials and methods. Field studies were conducted in lettuce and tomato to evaluate the potential to improve the efficiency of labor utilization by increasing the mechanical removal of weeds. Lettuce trials were established by direct seeding on 40-inch raised beds with 2 seed lines per bed. Tomato trials were established on 60 to 80 inch beds by transplanting. The herbicide program for lettuce was pronamide at 1.2 lb ai/A applied post plant Preemergence. The herbicide program for tomato was rimsulfuron applied immediately after seeding or transplanting at 0.5 oz ai/A followed by trifluralin at layby at 0.75 lb ai/A. The standard cultivator was a combination of cultivator knives and sweeps that cultivate the entire bed with the exception of 3 inches centered on the crop seedline. The rotating cultivator was also used in combination with the sweeps and knives, but the rotating cultivator also weeded in the seedline.

Approximately 21 to 28 days after seeding, lettuce and tomato were thinned with the rotating cultivator set to cultivate the entire bed top and row middles. The trial design was a split plot arranged in a randomized complete block design with four replicates. Cultivator design, rotating cultivator/standard cultivator, were the main plot, the split plots were herbicide (with or without) and the split-split plot was hand thinning and weeding. Evaluations included stand counts to evaluate the impact of the close cultivation on the lettuce or tomato stand, visual vigor estimates, weed counts prior to and following cultivation, as well as timing of lettuce or tomato thinning and timing of hand weeding operations in lettuce and tomato to support economic analysis. Lettuce yield evaluations were based on fresh weights from 25 ft of plot. Tomato fruit were harvested at commercial maturity from 25 ft of plot. Six trials were conducted in 2009. The data were subjected to analysis of variance and LSD's were used for mean separation.

Results. On June 17, 2009 a commercial direct-seeded lettuce planting at a commercial farm near Gonzales, CA was thinned and weeded with the rotating cultivator and standard cultivator. After thinning with the rotating cultivator and the standard cultivator, the entire trial was hand thinned. Plots cultivated with the grower's standard cultivator required 11.6 hours to thin, while plots thinned with the rotating cultivator required 4.2 hours per acre to hand thin a 64% reduction in labor input required.

A direct-seeded lettuce planting on the Spence research station near Salinas, CA was thinned with the rotating cultivator on June 18, 2009, hand thinned on June 22, 2009 and hand weeded on July 1, 2009. Standard cultivation was also conducted on June 18, 2009. The total hand thinning and weeding in the rotating cultivator treatment was 21.6 hours per acre compared to 31.2 hours per acre in the standard cultivation plots for a 31% reduction in hand weeding effort in the rotating cultivator vs. standard cultivator treatments.

A transplanted tomato evaluation on the Hartnell research farm near Salinas, CA was cultivated with a standard cultivator on July 8, 2009 and the rotating cultivator on July 9, 2009 and hand weeded on July 14, 2009. The handweeding times in the rotating cultivator treatments were 5.6 hours/A and in the standard cultivator were 7.1 hours/A. The rotating cultivator removed most of the weeds around the tomato plants resulting in a 21% reduction in handweeding time compared to the standard cultivator.

Non-Chemical Weed Control in Vegetables

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Herbicides registered for use on vegetables in the southwestern U.S. have always been limited. This is especially true when compared to higher acreage field crops such as cotton, wheat and alfalfa. The development and use of selective herbicides began in the late 50's for all crops and has continued at a pace of about 5 new products every 5 years for cotton, alfalfa and wheat. The development of new herbicides for vegetables, however, has been negligible since about 1970. In head and leaf lettuce for instance, there are only 5 herbicides available and there has not been a new herbicide registered in almost 30 years. The loss of one of these products this year, Kerb on leaf lettuce, has created a situation where over half of the common weeds in this crop cannot be controlled chemically.

The primary reasons for the low number of herbicides available in vegetables are the relatively high value and low acreage of these crops. Additionally, vegetable growers expect high levels of weed control, low levels of crop injury and no potential carryover in the soil to subsequent crops. Many of the new herbicide registrations in vegetables have been for expanded uses of older products or new formulations of older products.

A survey conducted in Yuma, AZ in 2009 indicated that while 100% of the lettuce acreage was treated with herbicides, 93% was cultivated and 82% was hand hoed to control weeds. Non chemical control techniques have always been relied upon to achieve the levels of weed control desired by growers. These include cultural practices, mechanical cultivation, hand labor and other physical practices such as solarization and plastic mulches.

Cultural control techniques have always been used to control weeds in vegetables and include any practice that gives a competitive edge to the crop over the weeds. Most of these techniques have been developed by growers as good farming practices rather than by companies as something that can be sold. These practices are numerous, often only partially effective and used in combination with herbicides.

Hand labor is probably the oldest weed control practice and it is still widely used in the production of vegetables. People from other countries who have come here to work have historically made up the bulk of this labor force. The use of foreign workers has always been marred by conflict, litigation and legislation. One of the earliest groups was made up mostly of people from China (1850-1882). They were willing to work long hours for little money and eventually aspired to advance into farm management and ownership roles. This created much conflict that lead to their replacement with people from Japan after about 1890. The same pattern ensued until this group was replaced in the first half of the 20th century by people from Mexico. This group can more easily enter the country illegally and this has added an additional source of conflict to an already contentious issue. Dependence upon cheap labor has always put vegetable growers in a precarious situation.

In addition to herbicides and hand labor, mechanical cultivation is relied upon to control weeds in vegetables. Precision planting facilitates the use of various mechanical cultivators to remove weeds everywhere but within the planted row. Robotic, vision guided cultivators are being developed and slowly gaining acceptance in Europe to remove weeds within the planted row. These machines will likely be utilized in the U.S. in the years ahead.

Another physical method of controlling weeds in vegetable that has been used effectively is soil solarization. When properly done, this technique has proven effective in controlling many annual weeds as well as other pests including many diseases. Some disadvantages are that the field must be out of production for 4 to 6 weeks, only weeds that are near the soil surface are controlled and some perennial weeds are not controlled.

The use of traditional plant breeding techniques that use methods like tissue culture or mutagenic substances to create herbicide resistant crops have been successful with some field crops and may be useful on vegetables. Crops modified using traditional techniques have a greater likelihood of public acceptance than do those created by genetic engineering.

It is concluded that: 1) because of the costs to develop and register pesticides new herbicides for vegetables are unlikely, 2) reliance on cheap labor has always put vegetable growers in a precarious position and 3) non-chemical cultural practices, automated cultivation equipment and old herbicides will likely continue to be relied upon.

The Future of Weed Control Without Metam

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Due mostly to their specialty crop status, many vegetable crops have a limited number of registered herbicides that can be used in a weed control program. As a result, growers must rely more heavily on cultural methods, such as hand hoeing and cultivation, and herbicide alternatives such as pre-plant fumigants. Metam sodium (Vapam, K-pam) historically has been applied as a pre-plant method to control many hard to control weeds in a variety of crops because it is registered for most crops and can be applied by numerous ways (sprinkler, flood, drip, shank, etc.). Additionally, combinations of metam with other soil fumigants, such as Telone (1,3-D) and Pic (chloropicrin) can enhance weed control efficacy while also providing control of nematodes and plant diseases.

Despite providing excellent weed control and crop safety, the future of metam and most soil fumigants in California is murky. In July 2009, the Department of Pesticide Regulation (Cal DPR) released a first draft for new metam use regulations designed to mitigate and control off-site and bystander short-term exposure. These proposed new mitigation regulations:

1. Cover all methods of application
2. Require buffers up to 2,500 feet from sensitive sites
3. Enact 24 hour acreage limitations (limit number of acres that can be fumigated within a 24-hour period from 24 – 80 depending on the site)
4. Restrict application to November – April, depending on application method
5. Require caps or tarps
6. Require 2 or 3 post application water treatments within 2 – 3 hours after fumigation (usually with sprinklers).

These rules, if adopted, would make use of metam very difficult for most growers. The requirement for post-application water treatments alone would completely eliminate use in sweetpotatoes, for example, since most growers are not capable of sprinkler irrigation. Thus, weed control in vegetable crops will likely be obtained through alternative methods such as improved cultivation equipment (robotic hoes), solarization, and new application methods and/or tank mixes of existing labeled herbicides. Examples given include results from field trials with tank mixes of Sandea (halosulfuron) and Matrix (rimsulfuron) in tomatoes (Figure 1), reduced rates of Valor (flumioxizin) for sweetpotato hotbeds, and post-plant shielded spray applications of Roundup (glyphosate) in sweetpotatoes. While all provided good control of weeds, there is the potential for crop phytotoxicity with all these techniques.

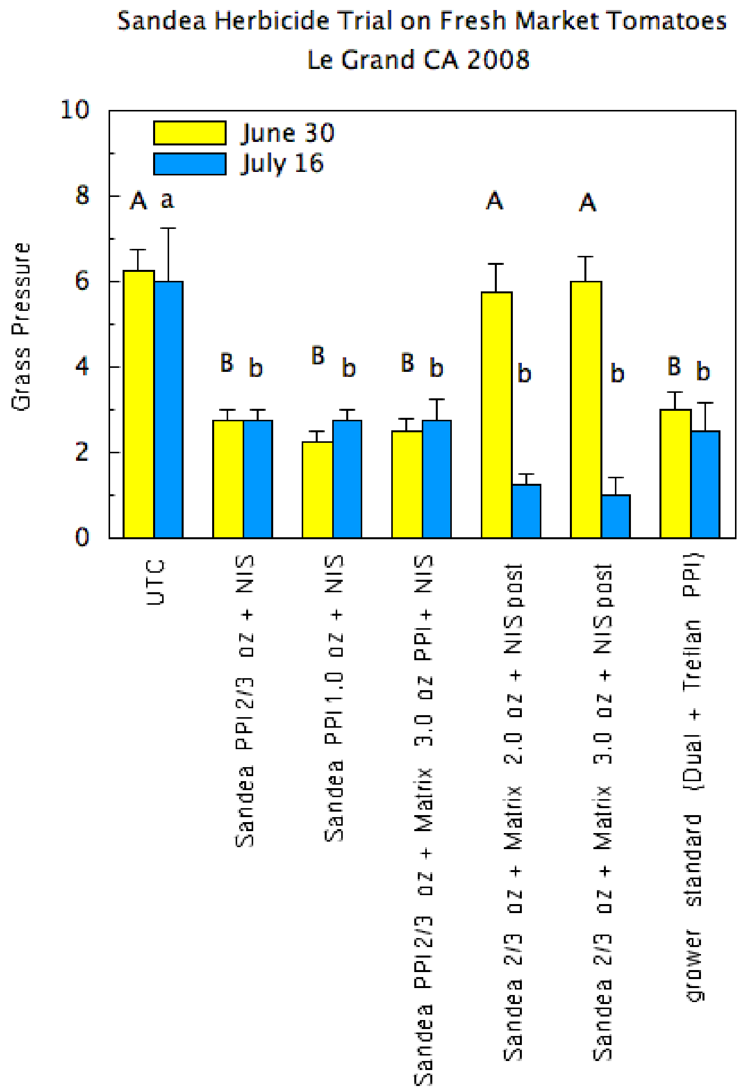

Figure 1. An example of a labeled herbicide combination that provides greater weed control than expected. Post-plant applications of a Sandea + Matrix tank-mix provided excellent control of the non-target weed Jungle Rice in fresh market tomatoes in this trial in 2008 (post treatments had not yet been made on the June 30 application date). Slight crop phytotoxicity was noted one week after application but did not impact crop yield.

Navigating California's NPDES Permit for Aquatic Pesticides: Changes Ahead

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Aquatic weed specialists working for drinking water, flood control, irrigation interests manage algae and a variety of aquatic weeds including submersed, floating, emergent and riparian species. These weeds can create flow restrictions in irrigation canals and flood control structures and pose taste, odor and aesthetic problems in drinking water storage and conveyance facilities.

Use of chemicals to control these weeds in surfacewater in California is limited to the following:

Ingredient
2,4-D
Triclopyr
Glyphosate
Imazapyr
Sodium Peroxyhydrate
Endothal
Diquat
Copper
Acrolein
Non-Ionic Surfactants

In 2002, California began regulating the use of aquatic pesticides in virtually all waters in the state with a National Pollutant Discharge Elimination System (NPDES) permit. The history of the permit can generally be summarized as follows:

Year	Action	Permit Required?
1996	Talent Irrigation District Acrolein/Copper 90,000 juvenile steelhead dead	No
1998	Headwaters Suit; Alleged CWA Violation	No
2001	9th Circuit Court Decision Overturns Lower Court; CWA violation cited; NPDES Permit Required. Permit Required	Yes
2002	CA issues Emergency General Permit for Discharge of Aquatic Pesticides	Yes
2002	Forsgren Case: Permit Required	Yes
2004	New 5 year Permit Issued by CA	Yes
2005	Fairhurst Case: Permit NOT Required	No
2007	EPA states that Permit NOT Required	No
Jan 2009	6th Circuit Court: Permit Required	Yes
June 2009	6th Circuit Court: 2 Year "Stay" Granted = Permit NOT Required	No
Apr 2011	EPA issues final aquatic pesticide permit	Yes

Four conditions are required for an NPDES permit. Discharge (1) of a pollutant (2) from a point source (3) to waters of the US (4). Application, or discharge, of a pesticide from a boom or nozzle can be considered a point source and can not reasonably be done without excess or residual pesticide entering the water. This excess residue is considered a pollutant for purposes of NPDES compliance. For all practical purposes, waters where these applications occur are either waters of the US or are tributary to waters of the US.

Currently, both California and EPA are drafting new aquatic pesticide permits. Although not certain, the following schedule is anticipated:

Date	Action
Jan 2010	California EPA SWRCB releases draft Vector Control Aquatic Pesticide Permit
Apr 2010	USEPA releases draft aquatic pesticide permit
Summer/Fall 2010	California EPA SWRCB releases draft Aquatic Pesticide Permit
Summer/Fall 2010	Potential Supreme Court Decision on the need for an NPDES permit
Apr 2011	USEPA Final aquatic pesticide permit complete

The content of either the USEPA or the California permit is not well understood at this time. However, the following content for each permit is anticipated:

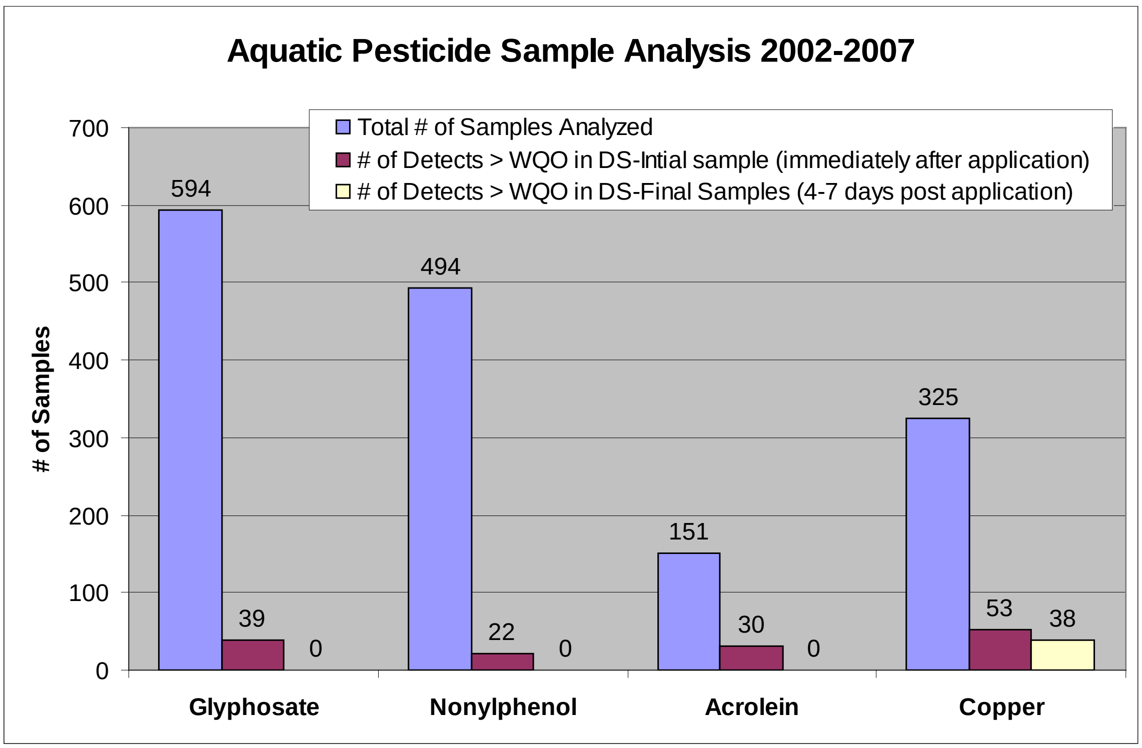
USEPA

- Restrictions on 303(d) listed water bodies
- Permit need may be “triggered” based on acreage/linear miles treated or amount used
- Applicators and dischargers need to file NOI

California

- vector control permit requires toxicity testing
- Group approach maybe reconsidered
- Past compliance data being considered

Past compliance data being considered by California regulators includes the following data gathered from 2002-2007 from irrigation and flood control districts located on Central and Northern California. This data maybe used to evaluate the necessity and frequency of sampling in the new permit.



The current status of both the USEPA and California permits are in flux. Although expired, the existing California permit is still available for use and may provide permittees coverage against Clean Water Act citizen lawsuits. Accordingly, it is recommended that organizations in California that are applying pesticides to waters of the US maintain their existing permit or obtain one.

For more information and to track the progress of both permits, refer to the following:

California

- http://www.waterboards.ca.gov/water_issues/programs/npdes/aquatic.shtml
- Join the SWRCB “aquatic weed control” list serve: http://www.waterboards.ca.gov/resources/email_subscriptions/swrcb_subscribe.shtml

USEPA

- http://cfpub.epa.gov/npdes/home.cfm?program_id=41#water_transfer
- http://www.epa.gov/oppfead1/cb/ppdc/2009/october/session-1.pdf

Additional important information related to the use of aquatic pesticides is associated with endangered species.

In October 2006, the USEPA agreed to a stipulated injunction to restrict the use of 66 pesticides near red legged designated habitat. Of these 66 pesticides, the following 4 are aquatic pesticides: 2,4-D, Glyphosate, Triclopyr, and Impazapyr. Approximately 40,000 acres in 33 California counties are potentially affected. Exceptions include public health vector control and invasive species and noxious weeds.

In 2009, the U.S. EPA was sued by the Center for Biological Diversity regarding the failure of EPA to properly consult with federal fish and wildlife agencies during the registration process for 74 pesticides regarding potential impacts to endangered species. The three aquatic pesticides in the group of 74 are 2,4-D, Acrolein and Diquat. The suit involves the following 11 species: Tiger salamander, Sna Joaquin Kit Fox, Alameda Whip Snake, San Francisco Garter Snake, Salt Marsh Harvest Mouse, Clapper Rail, Freshwater Shrimp, Bay Checkerspot Butterfly, Valley Elderberry Longhorn Beetle, Tidewater Goby and the Delta Smelt.

Major Changes to Aquatic Weed Management at Lake Tahoe: A Tale of Two Regulatory Agencies

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Abstract:

The development of the shoreline at South Lake Tahoe in the late 1960's to early 1970's led to the destruction of extensive natural marsh and wetland habitats that were replaced by dense, urban housing and marina development. Between the early 1970's and mid-1980's, aquatic plant growth within the marina areas created sufficient impacts to warrant use of mechanical harvesters to create navigable access to and from home owners' docks and Lake Tahoe. In 1995 and continuing to 2006, USDA-ARS conducted lake-wide aquatic plant surveys and documented the spread of Eurasian watermilfoil over the past 15 years, and the establishment of curlyleaf pondweed in 2003. Due to a long-standing regulatory prohibition against using any aquatic pesticides (including aquatic herbicides), attempts to manage this growing invasive weed problem have been limited to harvesting and minor efforts at physical removal. However, in the past 2 years (2007-2009), the Tahoe Regional Planning Agency (TRPA) and the Lahontan Regional Water Quality Control Board, with the urging of stakeholders, have begun to address this problem in concert with a wide range of state, federal and local government agencies. TRPA and LRWQCB together provide multi-state (CA/NV) environmental oversight through permitting processes. Both agencies have recently allocated resources to address aquatic invasive species for the first time, and most significantly in 2010, LRWQCB will propose changes in the "Basin Plan" that will allow for uses of certain aquatic pesticides (including aquatic herbicides) for control of invasive aquatic species. These changes in regulatory stance should greatly assist environmental mangers in their efforts to reduce the impact of existing AIS and in the continuing efforts to prevent the introduction and establishment of other species, including the quagga and zebra mussels, that would not doubt pose an extremely serious threat to Lake Tahoe's ecosystem and ability to sustain economic vitality from recreational activities.

Managing Algae and Cyanobacteria in California Rice Fields

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Mat-forming green algae (e.g., *Hydrodictyon*) and cyanobacteria (e.g., *Nostoc spongiaeforme*) are problematic for rice growers. Their abundant growth may affect rice yields by increasing mortality of rice seedlings. For example *Nostoc* mats may dislodge seedlings when they float upward from the soil surface where they initially form or the mats may smother seedlings when they accumulate due to wind action and then settle back to the soil surface. These problems have been typically addressed by the application of 1 part per million or less copper sulfate. However, recently this approach has not been as successful as in the past.

This may in part be explained by rice field conditions immediately following field flooding in spring. Specifically, rice straw from the previous growing season may affect the efficacy of subsequent copper sulfate treatments for algae control. We measured the copper binding capacity of rice straw and found that from 0.8 to 1.2 ppm of copper can be bound by the straw present in four of six fields examined. This is a significant portion of the 1 ppm copper that may be applied for algae control. These results suggest that straw management may be integral to reducing algal problems in the following growing season.

We have also evaluated several commercially available algicides for ability to reduce growth of *Nostoc spongiaeforme*. To date we have not found an algicide that can give the results that growers would anticipate.

Another approach to managing excessive algal growth is to alter environmental conditions that support this growth. One strategy involves reducing the amount of what is often the limiting nutrient for algae in freshwater systems, inorganic phosphorus (phosphate). Results from field studies comparing two phosphorus fertilizer application methods (P fertilizer applied 19 to 30 days after flooding, or surface applied liquid phosphate fertilizer followed by a roller prior to flooding) indicate that phosphate water concentrations were lower in fields where P fertilizer application was delayed. In most cases, algal abundance was also lowest for fields which received the delayed P fertilizer treatment. These fields had less “algae” than fields which received the conventional phosphate application, i.e., surface application of a liquid phosphate fertilizer followed by a roller. The results of these measurements clearly show that phosphate water concentrations and algal abundance were reduced by the delayed P fertilizer application. Delaying P fertilizer application until rice seedlings have emerged from the water may be an alternative “algae” management method for some growers.

Endothall Use in Irrigation Canals for Sago Pondweed Control

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The task of controlling aquatic vegetation in irrigation canals is an extremely important venture, especially in the western United States. The waters supplied by these canals are the primary, and in some locations the only, source of water for irrigating agronomic crops. In other locations, these waters supply industrial water users as well. Therefore, aquatic weed control in irrigation canals becomes extremely critical; however, the tools available to canal managers for weed control are limited. Sago pondweed [*Stuckenia pectinatus* (L.) Börner] is a native aquatic perennial that forms dense troublesome infestations in irrigation canals and drainage ditches; thereby, not allowing for proper water delivery or flow. On June 16, 2009, the Twin Falls Canal Company applied endothall to their main canal to control sago pondweed. An initial application was made for 2 ppm endothall for 12 hrs followed by a secondary application of 1 ppm endothall for 12 hrs approximately 40 km from the initial application, when the initial application had reached the location; thereby, providing a total treatment of 3 ppm endothall for 12 hrs. Endothall concentrations moved throughout the entire canal system (2.8 to 3.1 ppm at 107 km from the initial application site) at concentrations targeted to achieve sago pondweed control. Sago pondweed control 11 weeks after treatment is greater than 90% for the entire system. At 15 weeks after treatment, sago pondweed control had decreased to approximately 75% throughout the system. Results from these trials indicate endothall will provide a safer, more effective tool for controlling aquatic weeds in irrigation canals compared to other alternative control methods.

Proposed Mitigation Measures for Methyl Isothiocyanate Generating Pesticides

Linda P. O'Connell and Rais U. Akanda[1]

Abstract

The purpose of metam sodium, metam potassium, and Dazomet mitigation is to reduce bystander short-term exposure due to off-site movement of methyl isothiocyanate (MITC) from treated fields. MITC is a breakdown product of metam sodium, metam potassium, and Dazomet, which can pose a significant human health hazard. Department of Pesticide Regulation identified three potential areas of mitigation: buffer zone, application timing, and post-application water treatment. Buffer zones and buffer duration are determined by: the acres treated the application rate, and the number of post application water treatments. Buffer zones range from 100-2640 ft, and buffer zone durations range from 24 – 48 hrs. There are daytime and nighttime applications. Daytime applications require only general requirements. However, in addition to general requirements, special requirements are required for nighttime applications.

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Personal Information:

I am working with the Worker Health and Safety Branch, Department of Pesticide Regulation, Sacramento. My work involves reviewing: registration data package, volatile organic compound (VOC) emission studies, pesticide efficacy studies, dislodgeable foliar residue studies, transfer coefficient studies, and other studies related to VOC to develop mitigation proposals, and mitigation recommendations.

Adulticides Permit Processing in California

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California Weed Science Society
January 13, 2010

The State Water Resources Control Board (State Water Board) and Regional Water Quality Control Boards have the responsibility to preserve and enhance the quality of the State's waters through the development of water quality control plans and the issuance of waste discharge requirements (WDRs). WDRs for discharges to surface waters also serve as National Pollutant Discharge Elimination System (NPDES) permits.

The NPDES Permit Program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. On March 12, 2001, the Ninth Circuit Court of Appeals held that discharges of pollutants from the use of pesticides in waters of the United States require coverage under an NPDES permit. [*Headwaters, Inc. v. Talent Irrigation District, (9th Cir. 2001) 243 F.3d 526.*] In response to the Talent decision, the State Water Board adopted Water Quality Order No. 2001-12-DWQ, Statewide General National Pollutant Discharge Elimination System (NPDES) Permit for Discharges of Aquatic Pesticides to Waters of the United States, on an emergency basis to provide immediate NPDES permit coverage for broad categories of aquatic pesticide use in California.

Order No. 2001-12-DWQ expired on January 31, 2004. In May 2004, it was replaced by two general permits: a vector control permit for larvacides and a weed control permit. The vector control permit does not cover spray applications of pesticides to control adult mosquitoes. The State Water Board found that these two permits were adopted consistent with the Ninth Circuit decision.

On November 20, 2006, USEPA adopted the Aquatic Pesticide Rule which codified that NPDES permits are not required for pesticide applications as long as the discharger follows FIFRA label instructions. Thereafter, both the pesticide industry and environmental groups filed lawsuits in 11 of the 13 Circuits, including the Ninth Circuit Court, challenging USEPA's Aquatic Pesticide Rule. The petitions for review were consolidated in the Sixth Circuit Court.

On January 7, 2009, the Sixth Circuit Court determined that USEPA's Aquatic Pesticide Rule is not a reasonable interpretation of the CWA and vacated the Final Rule. USEPA did not request reconsideration of the decision, but did file a motion for a two-year stay of the effect of the decision in order to give agencies time to develop, propose, and issue NPDES general permits for pesticide applications covered by the ruling. On June 8, 2009, the Sixth Circuit granted the motion, such that the USEPA Aquatic Pesticide Rule will remain in place until April 9, 2011.

In February 2009, State Water Board staff met with members of the Mosquito and Vector Control Association of California (MVCAC), which represents the vast majority of governmental mosquito control programs in the state. California Department of Pesticide Regulation (DPR) and California Department of Public Health (CDPH) representatives were also present at the meeting, the purpose of which was to discuss MVCAC's need for a mosquito adulticide permit as a result of the Sixth Circuit Court's ruling. In subsequent meetings, representatives of these groups, including State Water Board staff, formed a technical committee to facilitate drafting of the adulticide permit. Representatives of USEPA Headquarters and Region 9 joined the technical committee after its initial formation. Before the Sixth Circuit granted USEPA's motion for a stay, there was an urgency to expedite the permitting process. Thus, the technical committee agreed to screen adulticide products qualitatively using the following procedures:

1. Permit only the most commonly used adulticide products in California. CPDH and MVCAC provided staff with a list of 30 products;
2. Exclude from the permit all adulticide products that contain priority pollutants as active ingredients and inert ingredients because having priority pollutants would add more complicated requirements; and
3. Exclude products with inert ingredients that have water quality concerns.

On November 23, 2009, staff posted a preliminary draft permit on the State Water Board's website for comments, which are due by January 25, 2010. Staff anticipates taking a final draft for the State Water Board's consideration at its meeting in December 2010.

Oversight and Regulation of Invasive Species and Weeds in California

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The Invasive Species Council of California (ISCC) is a voluntary group made of the agency Secretaries of six California agencies. They came together because of a common interest in keeping invasive species, including aquatic weeds and pests, out of California. The six agencies are as follows: California Department of Food and Agriculture, California Natural Resources Agency, California Environmental Protection Agency, California Health and Human Services Agency, California Business, Transportation, and Housing Agency, and California Emergency Management Agency. The ISCC is supported by the California Invasive Species Advisory Committee (CISAC) and associated working groups. The CISAC is made of 24 non-state specialists in invasive species and advises the ISCC. The CISAC includes weed specialists from the US Fish and Wildlife Service, and the University of California. Several national environmental groups with interest in weeds and pests are also represented. The first work product of the CISAC will be a list of the greatest invasive weed, insect, vertebrate and disease pests threatening California's environment, agriculture, forest, and water resources. This will be followed with invasive weed and pest management plans, including terrestrial and aquatic weeds. The working groups are informal support to the CISAC on weeds and pests. The working groups are looking for volunteers. CWSS members are encouraged to volunteer

Analysis of Herbicide Detections and Use from 1996 – 2007

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Beginning in 1990, California has required full reporting of all agriculture use pesticides. Agriculture use in California is broadly defined, Non-production agriculture uses as landscape maintenance, structural pest control, and rights-of-way applications are included in this definition of agriculture use. The agricultural use data is stored in the Department of Pesticide Regulation (DPR) Pesticide Use Reporting (PUR) database and verified data is ava ilable for public use (CDPR, 2009a). In addition, DPR maintains a surface water database through its Environmental Monitoring Branch. This database has voluntary submissions; DPR actively collects all surface water monitoring data from any organization that conducts pesticide monitoring studies in California surface waters. Like the PUR database, the surface water database also contains data since 1990. Currently the surface water database contains data from over 9,500 samples taken in 54 studies (CDPR 2009b).

Using both the PUR and surface water databases, frequency of herbicide use and frequency of herbicide detections in surface waters were determined. For herbicide use, greater than 15 million pounds of herbicides are applied annually. Twenty-four herbicides have had at least 100,000 pounds active ingredient (lb a.i.) applied at least in one year in the past twelve years between 1996 and 2007 (Table 1). Although nearly 100 herbicides are used in California, these 24 herbicides account for greater than 90% of all herbicide use in California (CDPR 2009a).

Glyphosate is the most frequently used herbicide in California, and accounts about 40% of all herbicide applications (CDPR, 2009a). Glyphosate use has increased steadily since 1996, from over 4 million lb a.i. in 1996 to over 7 million lb a.i. in 2007. However other herbicides have had higher percentage of increases during this twelve year period; these include propanil, pendimethalin, metolachlor, and bensulide. Glufosinate use has increased from no use in 1996 to 131,634 lb a.i. in 2007. Three other herbicides also have increased use during this time period: paraquat, oryzalin, and oxyfluorfen.

As the above mentioned herbicides have had their use increase, other herbicides have had decreased use. The most dramatic decrease in use has been molinate, which has declined from 1.4 million lb a.i. to 75,241 lb a.i.; 2008 data also shows further decline. Several other herbicides had their use cut in half or greater; these include thiobencarb, DCPA, EPTC, prometryn, and norflurazon. MCPA and hexazinone use decreases were slightly less than half. Diuron, trifluralin, simazine, acrolein, and 2,4-D also had less use over this twelve year period (Table 1).

As previously mentioned, the DPR surface water database houses data from greater than 9,500 environmental samples. In this analysis, 83 herbicides were monitored and 46 herbicides were detected between 1997 and 2006. The most frequently detected herbicides in the surface water database are simazine and diuron, with 1,110 and 698 detections, respectively. Simazine and diuron also have the highest detection rate of any of the monitored herbicides, with a 30% and 40.4%, respectively, detection rate. Metolachlor has the third highest number of detections (510); it also has the third highest detection rate (28.9%). Nine other herbicides have had between 100 and 500 detections, and 18 herbicides had between 10 and 100 detections (Table 2). Sixteen additional herbicides have had less than 10 but at least one detection; 37 other herbicides have been monitored but not detected (data not shown).

The rice herbicides molinate and thiobencarb had 431 and 302 detections, respectively. The use of these herbicides has been decreasing. Propanil use in rice has been increasing; however this herbicide is less frequently detected in surface waters. Propanil has only been detected 68 times. Although it has had less monitoring, its detection rate (4.3%) is much less than either molinate or thiobencarb (17.4% and 10%, respectively). These herbicides are mainly detected during the rice growing season, May through August.

Generally, herbicides have been detected with their agricultural use. For many herbicides, like diuron, simazine, and pendimethalin, most detections occur in the rainy season (December through April), which is also their high use period. However, these herbicides also have numerous detections during the irrigation season (approximately April through August) when their use is less. With other herbicides, as EPTC and metolachlor, which are generally applied during the growing (irrigation) season, most detections occur during this time period. Trifluralin has a slightly different detection sequence; most trifluralin detections occur in April through August whereas use in manly January through June. However, both trifluralin and metolachlor have a high detection peak in February. Thus, both rain and irrigation tend to move herbicides into surface waters.

Environmental scientists are interested in herbicides in surface waters because of their potential to harm aquatic life. Phytoplankton are the bottom level of the food chain; reduced growth of these organisms may have an effect on organisms higher up on the food chain, and may be one of the causes of pelagic organism decline (Sommer *et al.*, 2007). However, more work is needed to determine the effect of herbicides on phytoplankton (Edmunds *et al.*, 1999). The US EPA has listed aquatic benchmarks for many herbicides; if herbicides are known to exist in surface waters above the EPA benchmarks, there is a concern that these herbicides may cause toxicity to aquatic life (US EPA, 2009). In this analysis, eight herbicides were detected at concentrations above their EPA aquatic benchmarks. Of these eight herbicides, thiobencarb, diuron, and metolachor had the most detections above their respective benchmarks. The herbicides that have been detected above their EPA aquatic benchmarks are shown below:

Herbicide	Benchmark (ppb)	Detections > Benchmark
Thiobencarb	1.0	142
Diuron	2.4	63
Metolachlor	1.0	19
Simazine	36	5
Oryzalin	15.4	4
Oxyfluorfen	0.29	3
Bromacil	6.8	2
Atrazine	1.0	1

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Table 1. Herbicides that have had 100,000 pounds a.i. (active ingredient) of use in California in at least one year from 1996 through 2007.

Herbicide	1996 Use	2007 Use	Increase or Decrease from 1996 to 2007	Lowest use[1]	Highest Use[1]	12 Year Average Use
Glyphosate	4,181,967.7	7,236,786.5	173%	4,089,690.0	7,777,941.4	5,605,715.2
Diuron	1,265,426.4	859,909.0	68%	859,909.0	1,504,731.0	1,213,017.9
Propanil	89,366.8	1,801,607.1	2016%	89,366.8	1,801,607.1	1,131,424.5
Trifluralin	1,143,694.9	898,976.0	79%	898,976.0	1,261,482.0	1,088,361.4
Paraquat	891,165.4	966,583.0	108%	752,605.0	1,144,220.0	950,050.5
Molinate	1,356,257.6	75,241.0	6%	75,241.0	1,356,257.6	698,025.0
Simazine	839,208.9	538,627.0	64%	538,627.0	839,208.9	685,667.3
Thiobencarb	618,411.8	289,046.0	47%	289,046.0	1,007,249.0	634,709.5
Oryzalin	568,940.9	656,439.0	115%	110,714.0	912,715.0	571,946.5
2,4-D[2]	669,063.7	442,318.9	66%	442,318.9	669,063.7	523,763.2
Pendimethalin	429,945.8	1,124,396.0	262%	312,561.0	1,124,396.0	519,688.1
Oxyfluorfen	429,904.0	644,523.0	150%	347,589.0	712,370.0	506,508.7
EPTC	703,996.4	152,707.0	22%	108,209.0	703,996.4	312,163.5
Metolachlor[3]	186,092.7	352,193.0	189%	186,092.7	392,880.6	310,457.8
Acrolein	322,578.4	201,112.0	62%	201,112.0	341,245.0	270,972.8
DCPA[4]	522,861.0	205,377.0	39%	133,627.7	522,861.0	250,604.2
MCPA	363,534.0	186,988.0	51%	170,579.6	363,534.0	233,688.3
Bensulide	94,586.9	258,164.0	273%	94,586.9	284,533.0	209,163.6
Prometryn	162,673.0	69,525.5	43%	69,525.5	307,634.0	183,337.9
Norflurazon	196,141.9	77,615.0	40%	77,615.0	286,214.0	181,880.7
Triclopyr	153,740.8	131,037.7	85%	102,099.1	177,330.6	150,195.2
Hexazinone	137,536.1	81,170.2	59%	81,170.2	137,536.1	107,756.5
Pronamide[5]	108,929.0	114,400.9	105%	101,267	120,804	109,659
Glufosinate	0	131,634.0	--	0	131,634.0	24,201.9

[1]Lowest and highest use during the 12 years from 1996 to 2007.

[2]All formulations and salts of 2,4-D.

[3]Includes both metolachlor and s-metolachlor.

[4]DCPA is the WSSA approved name for chlorthal-dimethyl.

[5]Pronamide is the WSSA approved name for propyzamide

Table 2. Monitoring data from the Surface Water Database (1997 – 2006) of herbicides with 10 or more detections.

Herbicide	Number of Detections	Number of Samples Collected	Percentage of Detections
Simazine	1110	3695	30.0%
Diuron	698	1727	40.4%
Metolachlor	510	1765	28.9%
Molinate	431	2474	17.4%
Thiobencarb	302	3014	10.0%
Trifluralin	261	2159	12.1%
Pendimethalin	249	2162	11.5%
EPTC	219	1822	12.0%
Cyanazine	157	2563	6.1%
Prometon	149	3165	4.7%
Atrazine	144	3433	4.2%
Triclopyr	100	370	27.0%
Bromacil	89	1228	7.2%
Norflurazon	87	701	12.4%
2,4-D	72	305	23.6%
Propanil	68	1572	4.3%
Metribuzin	56	2253	2.5%
Napropamide	50	1367	3.7%
Prometryn	40	1509	2.7%
Tebuthiuron	37	1712	2.2%
DCPA	33	1851	1.8%
MCPA	32	270	11.9%
Oryzalin	27	431	6.3%
Pebulate	27	1365	2.0%
Ethalfluralin	21	1366	1.5%
Bentazon	17	251	6.8%
Hexazinone	16	670	2.4%
Glyphosate	14	456	3.1%
Pronamide	13	1516	0.9%
Oxyfluorfen	10	156	6.4%

DPR's Respiratory Protection Regulations

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The presentation reviews changes to the previous respiratory regulation. The regulation has been renumbered and stands alone as 3 CCR 6739. In 1998 Federal OSHA and shortly after Cal OSHA adopted changes to their respiratory regulations. State regulations must be at least equivalent to Federal requirements. The regulation has been expanded to more clearly define the requirements of a respiratory program. Employers must provide approved respiratory equipment in the workplace when respirators are required. The regulations require a written respiratory program and record keeping requirements. Also included are procedures for respirator selection, medical evaluation of employees required to use respirators, fit testing of respirators, procedures for proper use in routine and emergency situations, scheduling cleaning, disinfecting, maintenance, storing, inspection and repair of respirators, requirements for air quality when self contained breathing apparatus are required, training of employees in atmospheres immediately dangerous to life and health, training in proper use of respirator that include how to put on the respirator and limitations of their use. The respirator program must have procedures for evaluating the effectiveness of the program along with record keep. There is a provision in the regulation for voluntary use of respirators when they are not required. The regulation includes a confidential medical evaluation form that is to be filled out by the worker and evaluated by a physician or other licensed health care provider (PLHCP). The employer must have a medical recommendation report on file for the employee before work requiring a respirator can be performed.