5 Easy Steps To Reducing Lawn Weeds Naturally

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Everyone wants to have a great lawn without weeds—and there are a few things that you can do that create a great lawn without weeds. These include selecting the best-adapted turf species, appropriate irrigation, fertilization, mowing and thatch management.

Most weed problems develop either because of inappropriate maintenance, poorly adapted turf species or extremes in weather conditions. Some weed problems occur no matter how good everything else is. But in order to prolong the weed-free honeymoon period of a lawn, it is important to pay attention as many factors that make a great turf as possible.

Species selection is based on a number of factors including climatic adaptation of the species, the use and traffic the turf will receive and the management level that is desired. We generally divide turf into cool or warm season grasses depending upon the temperatures that they do best in and they are in their most active growth period. By selecting species best adapted to the climate, we avoid stress on the plants and reduce susceptibility to weed problems. There are three zones in California for turfgrass. They include the Transition zones in which most all species can be grown but none are ideally adapted, the Coastal and northern regions in which cool season grasses are best adapted and the Desert and interior valley areas are where warm season grasses are best adapted.

The desired uses for the turf area will also affect species selection. Some grasses have an ability to handle a greater amount of wear and tear. Some have better recuperative ability and can recover quickly. The degree of maintenance a turf will require is another important consideration. You need to decide how much effort you want to put into a grass and how nice you want it. Some grasses require much less maintenance than others do, but typically the greater the maintenance input the better to quality turf. You have to decide how nice a turf you want and what quality you can live with.

We divide grasses primarily by the seasons in which they grow best. Cool season—perennial/annual rye, creeping and red fescues, blue grasses and Tall Fescue-this grass is the number one grass in the San Joaquin valley and is appropriate in most of California for a number of reasons: it has deeper roots than other cool season grasses and is disease resistant. The deep roots keep roots cooler, are able to mine water over a larger area, and its structure increases resistance to many diseases common to other cool season grasses.

The next most popular grasses are the warm season grasses—they include both common and hybrid Common Bermudas. Common Bermudas are primarily seeded varieties. Many nice new cultivars are less course than the old Arizona Common. Some of the higher scoring varieties in the National Turgrass Evaluation Project trials include: OKS 95-1, Princess, Savannah Majestic and Numex Sahara. Numex Sahara received a lower score (4.5) and Arizona common received a 4.7 in California though it rated higher nationally.

Hybrid Bermudas are much finer textured generally and are most often seed sterile so they have to be propagated vegetatively. Some of the higher rated varieties in CA include Tifsport, Tifway, OKC 1804 and Tifgreen. Hybrid Bermudas have a much higher maintenance requirement than other grasses because they generally require more nitrogen and more frequent mowing.

Zoyzia grasses are another group of warm season grasses we should be looking at. They have more shade tolerances that other warms season grasses have. On the negative side, they tend to be slow to establish, thatchy and have a longer dormancy period than other grasses. Some of the newer cultivars now available include Emerald, El Toro, De Anza and Victoria.

After you have selected the best species for planting, then prior to establishing the turf, take the time to improve soil drainage, and control the shallow weeds just prior to planting using the sprinkle, spray, sprinkle spray techniques.

The remaining easy steps to reducing weed problems deal with cultural practices including irrigation, mowing and thatch management. These management factors influence how your turf responds to the environment. In some cases these factors can favor the development of weeds either because the lawn becomes weak or opens up to allow weed seeds to germinate.

Irrigation is probably one of the major issues for turf and development of weeds. How we irrigate determines the quality of turf roots. With a poor root system, turf has difficulty overcoming other stresses on the turf such as heat stress. As turf declines, open areas develop in the turf and allow weeds to invade. Some weeds are favored by under irrigation and other weeds are favored by over irrigation.

Focus on irrigation efficiency. Provide uniform coverage and water deeply and infrequently--focus on a twice a week irrigation event. Avoid run-off and use less water in shade. Install separate valves for the different areas in your garden. Dethatch when the thatch is great than 1/2 inch to improve water penetration.

There are a number of irrigation guides to give you the amount of water you need to apply each week in your area and they vary depending upon the climate zone you live in. Check soil profile to see if water is moving into the soil and check sprinklers often for broken or plugged heads, Sometimes poor water distribution can be a problem and is usually due to lack of or changes in water pressure, or nozzle wear. Sometimes water can’t move into the soil because of compaction problems that develop. When soil is compacted water cannot move through it which then favor the development of standing water and then water mold organisms can invade.

Mowing is another important factor in weed free lawns. Frequency and height are the two things besides irrigation that you most control over in terms of how quickly weeds invade you lawn. Follow the golden 1/3rd rule which means that you mow when the grass is 1/3 higher than the desired height of cut. For example, if you mowing tall fescue at 1-1/2 inches to 3 inches, then you would need to mow when it is between 2-1/4 to 4-1/2 inches. Try to mow at the optimum mowing heights. Note that in warm climate areas, the mowing heights should be raised slightly in summer.

How fast the lawn is growing and the height of cut determines the mowing frequency. The shorter you mow the more frequently you will need to mow. The rate of growth is influenced by water, fertilizer, weather etc. If you do mow too infrequently scalping occurs and the turf is opened to weeds. The other advantage to mowing following the 1/3rd rule is that grasscycling works well. Grasscycling is where the clippings are left on the lawn and become an organic amendment to the turf. Grasscycling can reduce mowing work by about 50% over then season as compared to bagging.

Fertilization can also influence weed growth. There seems to be a very direct correlation to nitrogen fertilization rate and weeds. The less fertilizer, the more weeds. It is important to have the correct balance of NPK and Sulfur, which can be important in our soils, pH. The key to proper fertilization is related to when you apply it. The ideal time is during periods of active growth. How much you put on is dependent upon the turf species and time of year. Nitrogen is most often the critical nutrient and cool season grasses need about 4-6 pound Nitrogen per 1000 per year during active growing periods. Warm season grasses need about .5-1 pound per growing month.

Thatch can be a problem in turf when it is deeper than about a 1/2 inch. Thatch is comprised of roots, stems, rhizomes, crowns and stolons all of that contain the slow-decomposing substance lignin. Thatch can be removed by verticutting and it should be done when the turf can recover quickly. Otherwise, it is open to weed seeds invading for too long. Core aeration is another way to remove thatch over time and can be done anytime.

Monitor for weeds in winter, spring, summer to determine what species are present, how many there are and if the composition is changing. This is important because changes in cultural practices will change the weed composition. It is the only way to know if your cultural practices are working correctly. For example, White clover can be a common weed when the turf is deficient in nitrogen. By increasing the amount of nitrogen fertilizer, you favor the development of stronger Bermuda and less white clover.

Specific Weed Problems

The first weed we will discuss is crabgrass. There are two species of crabgrass (smooth and hairy) that commonly develop in lawns with shallow frequent irrigation. It also develops where there is early season dethatching, renovating or edging.

What does this tell you about management? Avoid frequent shallow irrigation, fertilize more to create a more competitive turf, don’t dethatch or edge in the early season.

In trials conducted by Geisel and LeStrange, crabgrass activity was reduced in Bermudagrass by 50% or more by adding compost as a topdressing several times a year 1/4”x4 times. This result was likely due to a mulch effect as well as an increased nitrogen application in a slow release form as well as soil improvement.

Spotted Spurge and prostrate spurge are two more weeds home gardeners’ struggle with. Spurge is an annual weed that germinates in open spaces from March to October.

It is usually a problem in closely mowed turf in open sunny areas. Increasing the mowing height and following the 1/3rd rule will make a difference as will increased fertility.

Bermudagrass can be an important weed in landscape as well as an important turf. Bermudagrass is a perennial weed that spread not only by seed but also by stolons and rhizomes. It mostly is a problem because it invades into tall fescue and other cool season turfgrasses. To reduce Bermuda invasion it is important to manage the turf like tall fescue and not Bermuda.

Another weed common in home gardens is dandelion. Dandelion is a perennial weed with a heavy taproot. Removing the leaves and 1-2 inches of taproot will not control it because it will regenerate from the remaining portion of the taproot. Poorly maintained open turf areas allow the establishment of dandelion. Frequent mowing will remove the flowers and reduce its spread. Prevention is critical. If you notice a source of dandelion seed in nearby lawns and your lawn is just beginning to get a few, you need to hop on right away to prevent further spread. Careful hand weeding can help but you must be persistent.

These are just a few weeds that home gardeners must manage. But application of the correct culturally practices will reduce most weed problems naturally without the use of pesticides. In some cases however, there are just some weed problems that cultural practices alone won't control. Oxalis or creeping woodsorrel is one of them. It is a perennial weed that just can invade easily. It has exploding seedpods that allow it to spread quickly. Usually, herbicides are required for its control. In the early stages, I have hand weeding and a competitive turf can reduce is spread.

Kikuyugrass has also become a dominant lawn species in southern California. There many turfgrass managers have decided to learn to manage it as a "selected lawn species. Researchers have found that a sequential application of an herbicide called Turflon (trichlopyr) is an effective control.

Nutsedge is another serious weed problem. Usually excessive irrigation favors its development. Once established it is very difficult to control without the use of judiciously applied herbicides.

In conclusion you can reduce or prevent weed problems in 5 easy steps:

1. Select the right species.
2. Water correctly.
3. Mow appropriately
4. Fertilize correctly
5. Keep thatch to less than .5".

Allergy-Free Gardening

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http://www.allergyfree-gardening.com

Allergy, on the rise in the United States and throughout the world, is worst in urban areas. In the past thirty years in the US the percentage of people with allergies has rapidly climbed from 10 percent, to a staggering 38 percent now affected. There are many factors involved in this epidemic of allergy including an increase in the total amount of urban airborne pollen.

In urban areas much of the increase in allergy can be tied to the over-use of staminate (male) dioecious cultivars in our urban landscapes. There is much evidence though, that from years of constant exposure to pesticides and industrial pollutants, that people in general have become more susceptible to developing allergies. As such, people are now often more sensitive to allergens such as pollen than they were in the past. In most US cities, especially on the West Coast, some 70 to 80 percent of the total yearly pollen load has consistently been found to come from the area's urban landscaping, especially from the trees. Weeds and grass pollens make up the rest of the yearly pollen load, however in many cases, the pollen from some of these weeds and grasses is especially allergenic and causes more than its share of actual allergic response. Much of the grass pollen in urban areas comes directly from lawns that are not kept regularly mowed. Bermuda grass in particular is often the cause of grass pollen allergy in cities.

There are now some very interesting and useful new types of grass that have been developed that do not produce any pollen whatsoever. In particular, certain pistillate (female) cultivars of Buffalo Grass (Buchloe dactyloides) are proving to be of great use. Female Buffalo Grass cultivars grow shorter than male clones and as such, require much less mowing. Because they are female they produce no pollen and cause no allergy. Buffalo Grass is also winter hardy, easily grown under a wide range of soil and climatic conditions, and is available as sod or from plugs. Because this native grass is especially deep-rooted it requires much less fertilizer and water than most sod lawn species more commonly in use.

There is another important reason for the use of cultivars such as female Buffalo Grass- because they need to be mowed less often, fewer VOC's (volatile organic compounds) are released into the air. The whole issue of VOC production and methods for its limitation is one that will become increasingly important in the future as we seek to find more methods of limiting air pollutants of all types, whether organic or inorganic.

Certain types of weeds and the pollen they shed are of great importance as the cause of allergy. In much of the Southern, Midwestern, and Eastern US the worst allergy weeds of all are the species of Ambrosia, or the Ragweeds. There is a certain amount of ragweed in the Western states and it is most commonly found growing alongside highways. Ragweed is a monoecious species that produces huge amounts of small, very light and buoyant pollen. The individual grains of pollen are spiked with many sharp points and under a microscope resemble tiny balls of cactus. This pollen can and does cause hay fever, asthma, itching, and rash. The number of people allergic to ragweed pollen is very high. Although there is a species of ragweed native to

Europe, in Europe now, there are many species of ragweed present, most of them unwanted imports from America. Likewise, in California we now have many non-native species of ragweed growing. In the past there have been a few examples of successful civic actions taken against ragweed. In several areas of Europe local crusades to wipe out ragweed have had mixed success. In the 1930's in the Montreal area of Canada the local citizens banded together to destroy ragweed. Farmers were encouraged to eradicate it. School children were taught how to identify it in its juvenile stages and contests were held for many years: to see who could pull up the most ragweed seedlings. Eventually ragweed was actually eliminated from large areas due to this combined civic attack. Unfortunately after many years passed, attention was not paid to seeing that ragweed did not regain a foothold and today it is again common in the Montreal area.

It is the feeling of this author that in California, where so much of our ragweed is concentrated alongside highways, that with a concerted effort, we could come close to eradicating it here. At any rate, even partial success at ragweed elimination would result in large increases in cleaner air and would be appreciated by the estimated 10 million people in California who suffer each fall from pollen allergies. There are a number of other weeds common in California that cause more than their share of allergies, in particular the Pigweeds (*Chenopodium* species.), Groundsel (*Senecio* spp.), Plantain (*Plantago* spp.), Poison Oak, (*Rhus toxicodendron*), and the Castor Bean (*Ricinus communis*).

Poison Oak is a dioecious species and is both insect and wind-pollinated. As such this pollen is often abundant in Spring in all areas where Poison Oak is common.

Pollen from Poison Oak can land on people's skin and can cause the exact same symptoms as contact with the leaves of the plant. Inhalation of Poison Oak pollen can be dangerous for people with asthma who are also susceptible already to the contact affects of this species. Castor Bean is a fast-growing annual or perennial plant with very large, often colorful leaves and stems. It is monoecious and the female flowers are above the male flowers, a system that ensures a large amount of wind-pollination. Native to central Africa, Castor Bean is now grown as an oil crop or as an ornamental in many areas of the world. During World War Two a large amount of acreage in the US was planted to Castor Bean as an oil seed crop and within two years of these plantings allergy to the pollen suddenly became both common and severe. Castor Bean is especially common along highways in many of the coastal communities of California. The pollen is shed for many months during the year, from early in the season to late. Whereas most species' pollen usually triggers hay fever symptoms in people, Castor Bean pollen almost always directly causes severe attacks of asthma. Castor Bean is a Euphorbia Family member and as such its pollen is especially dangerous for certain individuals.

Over the years in the US and in other urbanized areas of the world, millions of cars and trucks have been driving down the roads and their rubber tires have been breaking down, due to simple friction between the tires and the roadways. Billions of tiny particles of this latex rubber constantly go airborne and in the process millions of people are exposed to breathing in these minute particles of rubber. The rubber that the tires are made from comes from the collected sap of the tropical tree, *Hevea brasiliensis*, which is also a member of the notorious Euphorbia family. There has been another recent addition to allergies from rubber and this has been caused by the huge increase in the use of latex gloves. With the spread of AIDS, the wearing of these rubber gloves has increased rapidly. The gloves are dusted with powder so that they will not stick together and when they are put on or taken off, this same powder, now "rubberized," goes airborne. In the process many more people are exposed to latex particles.

In allergy studies, cross-reactive responses are frequently seen. People who are allergic to one particular type of plant, often become allergic too, to the pollen of that plant's close relatives. With the huge increases in latex allergies we are now seeing, it is not surprising that allergy to Castor Bean pollen is also on the increase. Latex allergies are almost always severe. Common symptoms include terrible swelling of the face and head, difficulties in breathing, cough, head ache, skin rash, and all too often, anaphylactic shock. This is one allergy that can and does kill.

At this conference we have assembled here many of the finest minds in our State, people with the most experience at controlling weeds. If from this talk I could somehow trigger a systematic, coordinated attack on just one of these highly allergenic weeds, then I would certainly feel that my time here today was well worth it. If I were to pick two weeds in California to zero in on to improve air quality and quality of life for us all, I would pick ragweed and Castor Bean. Were I to have to pick just one for starters, Castor Bean would be my weed of choice to see it eliminated from our Golden State.

How To Manage Invasive Aquatic Weeds in Home Garden Ponds

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Management of small ponds and reservoirs is a very complex issue. While you might want to manage for one problem you might create another. For example, if you have an algae or floating aquatic weed problem, when you remove the algae or floating plants, you open up the pond to light and submerged aquatic weeds could explode in population and create another problem. Or you might treat submersed aquatic weeds, releasing nutrients back into the pond and have an algae bloom. Waterfowl may come in and eat the aquatic vegetation, which you think is great until you find out their excrement put nutrients back into the system, creating another problem. Mechanical harvesting of submersed weeds will remove some weeds, but can kill fish, by physically killing them, or creating turbidity, killing more. However, mechanical removal of plants should reduce some of the nutrient levels within the water body.

Before any weed control measures are taken, the weed or weeds must be identified. In addition, limitation of control measures may be affected by water uses, not only by you but by downstream users. For example, if you or your neighbors irrigate turf or gardens from the body of water, some herbicides may not be used. Knowing the correct identification of the plant, and the registered herbicides you can use, may not be enough to prevent a problem. For example, if you treated a pond/reservoir for submerged aquatics with a registered material, at the recommended rate, you could still experience a fish kill, if you did not pay attention to the water and ambient air temperatures, pH, dissolved oxygen, etc. A contact herbicide may say if dense weed growth, treat only 1/3 of the pond, however, if the pond was in stress due to high summer temperatures, or some other factors, you could create a loss of oxygen due to plant decomposition and still kill aquatic organisms, such as fish or invertebrate species.

If your pond is near and dear to you, you might contemplate using a professional pond or lake management specialist that can monitor the temperature, pH, water hardness, etc., prior to treating with certain herbicides.

If your pond is treated with contact or systemic herbicide it will require either the surface area to be treated or the volume of water to be treated, depending on the herbicide. Calculating measurements on irregular shaped ponds of variable depth may require a specialist.

First, once the weed problem has been identified, lets look at the alternatives. Usually one of the following control mechanisms will have to be used: Chemical, Mechanical/Physical, Cultural or Biological.

Looking at Mechanical/Physical you can remove some plants with rakes, weed hooks or other devices, such as harvesters, mowers, cutters, draglines and dredges, etc. The positive side to this is that the nutrients within the plant are removed from the water body, sometimes with little or no effect to other organisms. The negative sides are repeated treatments are needed, costs can be prohibitive, other organisms can be affected, such as non-target plants, fish, etc. Mechanical removal of surface floating plants or floating algae could also open the pond/reservoir up to more light, causing submersed weeds to proliferate.

Cultural control can sometimes be effective, but have a negative side. If you deepen the pond to prevent plant growth in the littoral zone, or shallow areas, where many plants proliferate, you can create a danger to people or small children falling into the pond and drowning. Manipulating water levels, by drawing down in the winter or summer can manage some weeds, but may kill fish or be advantageous for another species of problem weed. Aeration may control algae, but controlling algae may make submersed weeds proliferate, as more light is available to them. Non-toxic dyes may help decrease submersed aquatics and submersed algae, but some less photosensitive species may proliferate.

There are some biological controls available for some aquatic species. You must find out what is allowed in California, where to get them, and if they are effective. Biocontrols can reduce some plant populations, but seldom eradicate them. A non-specific biocontrol, like the triploid grass carp, costs money to buy and to get the necessary permits from Fish and Game and are not available for use in all areas. In addition, they might remove all aquatic vegetation, or not touch the one you want to control. Also they can muddy the water causing other problems, like releasing tied up nutrients, etc.

Chemical control is usually the most inexpensive route for pond/reservoir management. Again, there can be drawbacks. Pesticide laws in California are more stringent than the other 49 states. A good material could become available in the rest of the nation, but we might have to wait another 5 – 10 years before the herbicide is registered in California, especially if there would not be a good market for the material. Pesticide manufacturers are hesitant about spending the extra money to register limited use materials in California, due to the added costs of registration. Some materials are restricted use and can only be applied by certified applicators. Questions on pesticides can be answered by your County Agricultural Commissioner.

Contact herbicides would include copper formulations such as Komeen and Natique. Of the different weeds we are going to discuss, algae, if you consider them a weed, are usually controlled by copper based algaecides. These would include material such as K-Tea and copper sulfate, most of these have limited herbicidal activity on regular plants. Other contact aquatic herbicides are Endothal and Reward. Endothal is not used that much in California, but Reward is widely used, the active ingredient is diquat in Reward.

Systemic herbicides include fluridone (Sonar), glyphosate (Rodeo), dichlobenil (Casoron) and 2, 4-D (Weeder 64). In using glyphosate and 2,4-D, various formulations are available, you must use one with an aquatic registration. Of these, 2, 4-d is selective for broadleaf plants, the others are broad-spectrum herbicides, but may be selective depending on rates used.

Weeds of aquatic importance to the California Department of Food and Agriculture include hydrilla (hydrilla verticillata) and alligator weed (Alternanthera philoxeroides) also Salvinia (Salvinia molesta) and Frogbit (Limnobium laevigatum not Limnobium spongia) are Q rated species, and treated as “A” rated species. “A” rated noxious weeds are under statewide control, suppression or eradication.

In addition to contact and systemic herbicides, soil fumigants or sterilants might be used to kill aquatic weeds, providing the water body has been drained first. Check with your local County Agricultural Commissioner to find out what is legal to use.

Weed Or Waste: Problem Older Herbicides

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Introduction

Some herbicides are used in small amounts in landscape maintenance and tend to sit around for a long time. Many of us are aware that many pesticides have been taken off the market for a variety of reasons. Some are alleged to cause cancer or harmful effects to wildlife. We also are generally aware that disposal of pesticides including herbicides has gotten more regulated than ever before. If, in reviewing our inventory of chemicals we have some materials that may be in these categories what are we to do that would be best for our family, our neighborhood, our business or agency?

Here are some examples of older herbicides. Which of these could you want to use?

Vapam	Triox	Brush-B-Gone	Weedone Brushkiller
Amitrole	10-10-4 with Trimec		Grass-B-Gone ready-to-use

Research

We have already determined that we wish to maximize control and minimize costs. So what happens when we have a discovery of an herbicide in our storage area that we are unsure whether it's OK to use it? This is an opportunity to define an process.

First comes research. Check the Internet sites of the Department of Pesticide Regulation (www.cdpr.ca.gov). Learn to use the database base. Links found on DPR's web page will take you to all the major sites for pesticide laws and regulations.

If you decide to try to use the material apply the milk test to emulsifiable products. Does it mix with water a milky substance? This test is of no value to water-soluble products such as glyphosate.

Another test would be to make up a small amount of the product and apply it to an out of view portion of the area that might be treated. Wait a few days for any phytotoxic results to show up. If weeds are damaged bit non-targets are not, then go ahead with a larger trial until you are confident of safety and effectiveness.

Today's Situation: Catch 22

There is a climate of uncertainty and criticism about pesticides. Pesticides are being removed from the market at a fairly accelerated pace. Most of the activity involves insecticides but the degree of uncertainy is a problem. Most of us have a rational fear of wrongdoing. We don't want to do something illegal, harmful to environment or dangerous to ourselves or our employees.

We have a dilemma. We may fear we can't use a pesticide in our inventory but we may be aware of the problems of disposal. Perhaps we think because we have not budgeted for disposal fees we cant get rid of it. Most persons, even frequent users of herbicides don't have extensive knowhow about the regulatory issues involved in pesticide use. A knowledge base is rare even among local regulators. The internet could be a resource for you. Certainly just asking someone in government is not sufficient to provide the answers a prudent person would need.

How Did We Get Here?

It's in the Book! DDT was banned in 1973 because of persistence in part. All pesticides were believed potential contaminants of groundwater. Environmental textbooks still define pesticides in terms of persistent chlorinated hydrocarbons or dioxins. Pesticides are painted with a very broad brush as environmental threats. Pesticides also get painted with the legacy of the organo-phosphates such as Parathion and mevinphos, which were highly toxic to handlers, mixers and persons accidently exposed. These are the materials that are usually linked to gas warfare. Agent Orange did a lot to sour the public opinion about phenoxy herbicides and tends to be a lindering obstacle behind prohibition of some phenoxy use on public areas.

A strategy of minimizing waste and maximizing weed control needed on job sites is appealing but may be difficult.

Options: Use, Recycle Or Toss

Use it first. This can be done successfully in most cases. A key would be help from someone knowledgeable about the product and its regulatory status. This person could be you or someone you trust.

Recycling-or giving the product away-is the next best choice. Someone else may well be able to use the product. They may have a suitable site, weed problem or permit to use the material. They may not have limitations of an agency policy, contract requirements or lack of suitably trained employees to handle and use the herbicide. Under NO circumstances should any hazardous material be tossed into domestic trash, dumpster or taken to a landfill hidden in ordinary non-toxic refuse.

What can be done to minimize the need for this process? First, inventory what you have. Are you a pack rat? Do you have pesticides "just in case?" Have you taken over someone else's mess? Consider how you buy new products? Are you in a rush to be the first try the latest answer to the weed problems? Do you have more that one or two materials that you tried but they didn't work out as planned? Do you buy large amounts that you can't really use in a year or two but you need to save money? A more cautious approach is strongly recommended. Business professionals will be quick to point out the expensive nature of this inventory carry-over. Remember though, the most costly approach that we all pay for is to dump your unused material in the trash.

Sprayer Comparison for Weed Control Efficacy in Rice

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This study evaluated three new application technologies with the goal of reducing herbicide rates in California rice. The three technologies are electrostatics, air inclusion and nozzle-induced air-entrainment. There were two electrostatic sprayers used in the study. The ESP® electrostatic spraying process (Wolf et. al 96) that electrically charges the spray solution prior to being discharged from standard nozzles, and the ESS® sprayer that uses an imbedded electrode in the nozzle to charge atomized spray droplets as they are propelled from the nozzle by an air stream (Gebhardt 87). The air inclusion, or venturi nozzles use air induction in the spray stream to form spray droplets with air inclusion (bubbles)(Wolf and Johnson 00). The third technology is the double nozzle system that utilizes nozzle-induced air-entrainment and kinetic energy to increase dose transfer (Chapple et. al 97). The three technologies were first screened as small-scale versions on rice and weed plots at Cal Poly University (CPU), San Luis Obispo, CA and again at the Rice Experiment Station (RES), in Biggs, CA. In the first trial at CPU standard flat fan nozzles were used instead of TurboDrop® air inclusion nozzles because the TurboDrop® nozzles were unknown by the author at that time. When their popularity with growers was ascertained, they were used instead of the flat fan nozzles in the trials at RES. Comparisons were later made with full-scale versions of each sprayer using larger plots in a fallow rice field, near Richvale, CA that was irrigated to germinate a weed cover.

In the first two trials the sprayers were evaluated for reduced rate potential using propanil herbicide and watergrass as a target weed. In the large scale trial reduced rate potential was measured with propanil and small flower umbrella sedge. Results in the first two trials showed that the ESS® electrostatic sprayer would have to be eliminated because of drift potential. The double nozzle sprayer out-performed the others in the first two trials. There were significant differences in watergrass control between the sprayer types at the P= .0001 level and there were significant interactions between sprayer type and rate at the α=.05 level (Figure 1). The double nozzle sprayer maintained control of watergrass at the 1/2X rate at the RES trial while the others were unable to control watergrass at the full rate (Figure 2). In the large-scale trials the ESP® sprayer was substituted for the ESS® sprayer and it out-performed the other two. The double nozzle sprayer was not competitive with the ESP® because of propanil's propensity to settle out of suspension, clogging small strainers and tips. There was no significant difference between the performance of the double nozzle sprayer and the TurboDrop® nozzle sprayer. There were significant interactions between sprayer type and rates at the P= .0003 level. The electrostatic sprayer maintained adequate control of sedge at the 3360 g/ha rate of propanil, with 4480 g/ha as the label rate (Table 1)(Figure 3, Figure 4).

With greenhouse-grown pots of rice and watergrass the TurboDrop® nozzle showed increased control of watergrass when operating pressures were increased from 276 kPa and 414 kPa to 552 kPa, with 552 kPa demonstrating 80% control of watergrass versus 66% average control for the other two treatments. Comparison was made to TurboTee® nozzles operated at 138 kPa giving 59% control. The difference between watergrass control at 552 kPa and the three other treatments was statistically significant, P=.00066 (Figure 5). There were no significant differences in watergrass control between the other three treatments. Three different surfactants were used with propanil and compared at 552 kPa, yet control of watergrass was not significantly different between treatments.

Non-replicated drift studies using the ESP® electrostatic sprayer indicated a reduction in propanil drift when measured by residue deposited on mylar targets placed downwind at 9.15 m and 76.25 m (Fig 6)(Steinke and Smith 99).

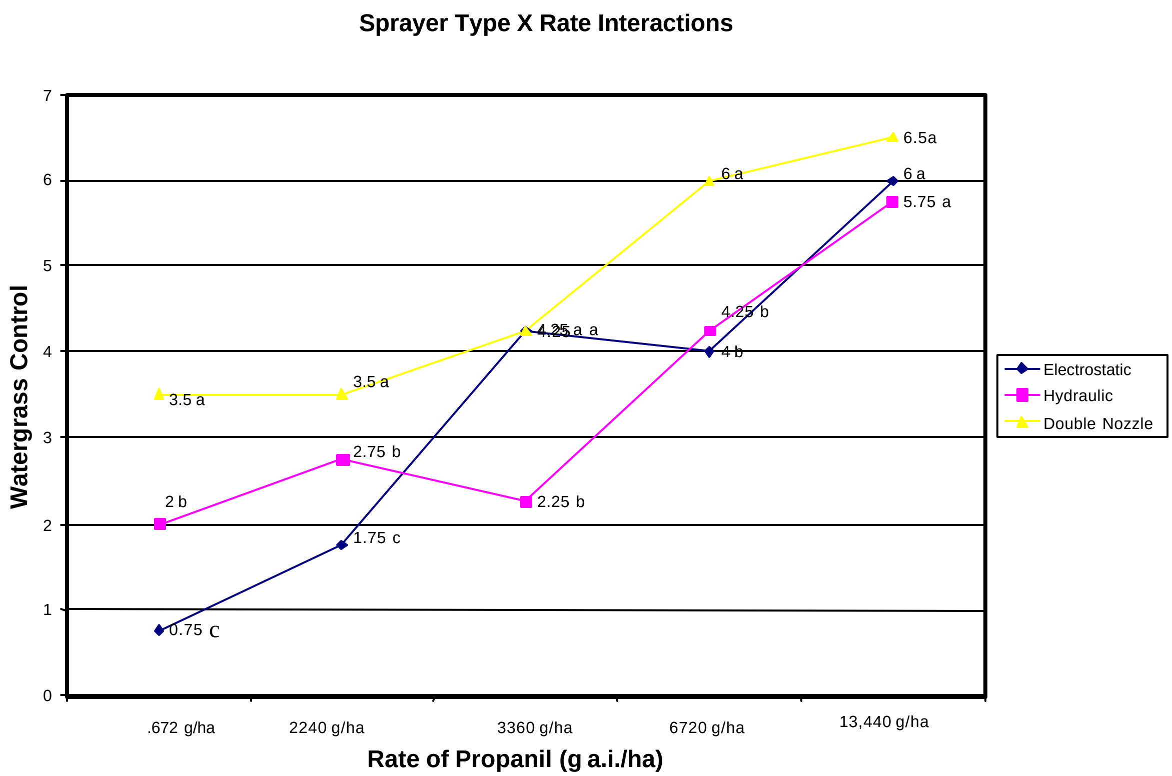

Figure 1. Small scale sprayer trial at CPU. Sprayer type x rate interactions. Points above the same rate, sharing common letters are not significantly different. P=.0001.

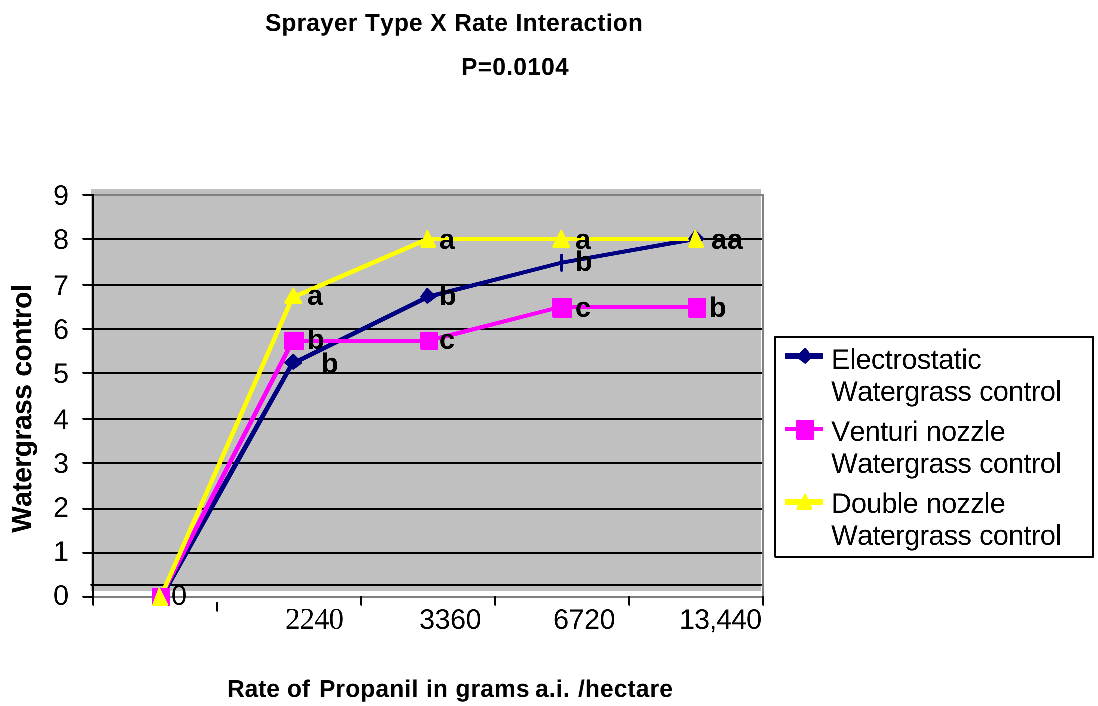

Figure 2. Sprayer type x rate interaction for RES small scale plots. Watergrass control based on scale of 0-10 with 0 being no effect and 10 being complete control. Any points above the same rate value sharing common letters were not significantly different. P=0.0104.

Least square means for sprayer x rate. Large scale sprayer trial.
Standard error of the mean was 1.79.

Sprayer type	Rate grams a.i./ha	Mean %dead sedge	
Electrostatic	0	1.25	**d**
Electrostatic	1120	18.02	**c**
Electrostatic	2240	62.77	**b**
Electrostatic	3360	83.60	**a**
Electrostatic	4480	95.8	**a**
Double nozzle	0	0.0	**b**
Double nozzle	1120	35.85	**a**
Double nozzle	2240	40.15	**a**
Double nozzle	3360	47.88	**a**
Double nozzle	4480	46.22	**a**
Venturi	0	0.75	**c**
Venturi	1120	19.85	**b**
Venturi	2240	52.13	**a**
Venturi	3360	44.13	**a**
Venturi	4480	68.43	**a**

Within **sprayer type** means with the same letter are not significanly different. P=0.0006

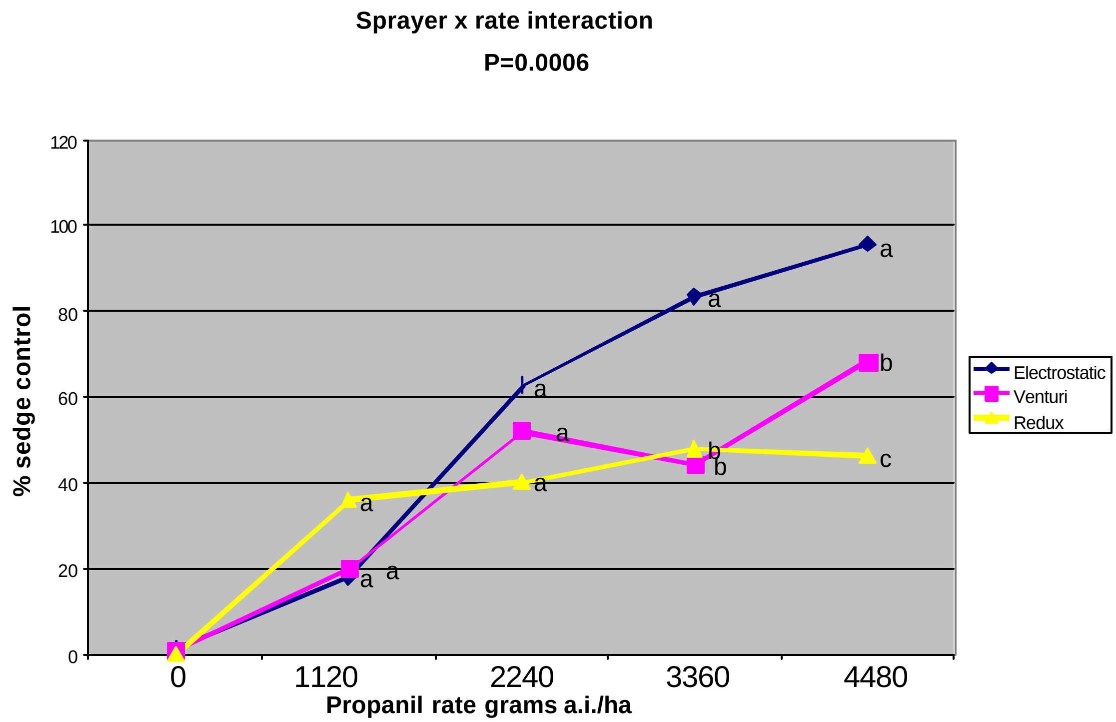

Figure 3. Sprayer type x rate interaction for large-scale sprayer trial. Any points in the same rate column sharing common letters were not significantly different.

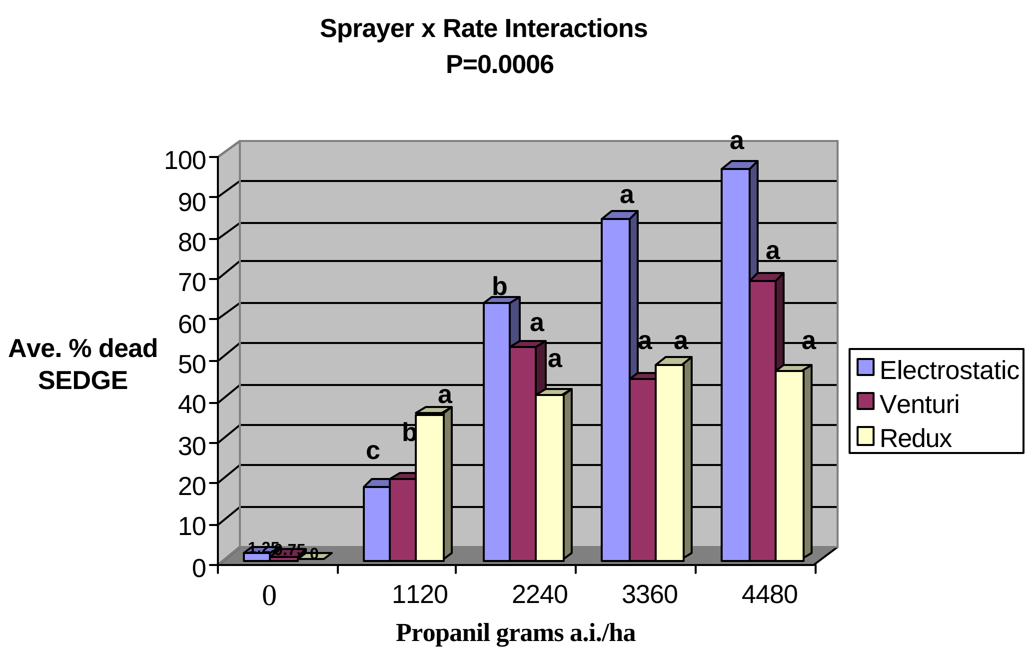

Figure 4. Sprayer type x rate interactions for large scale sprayer trial. Any bars of the same sprayer type sharing common letters were not significantly different.

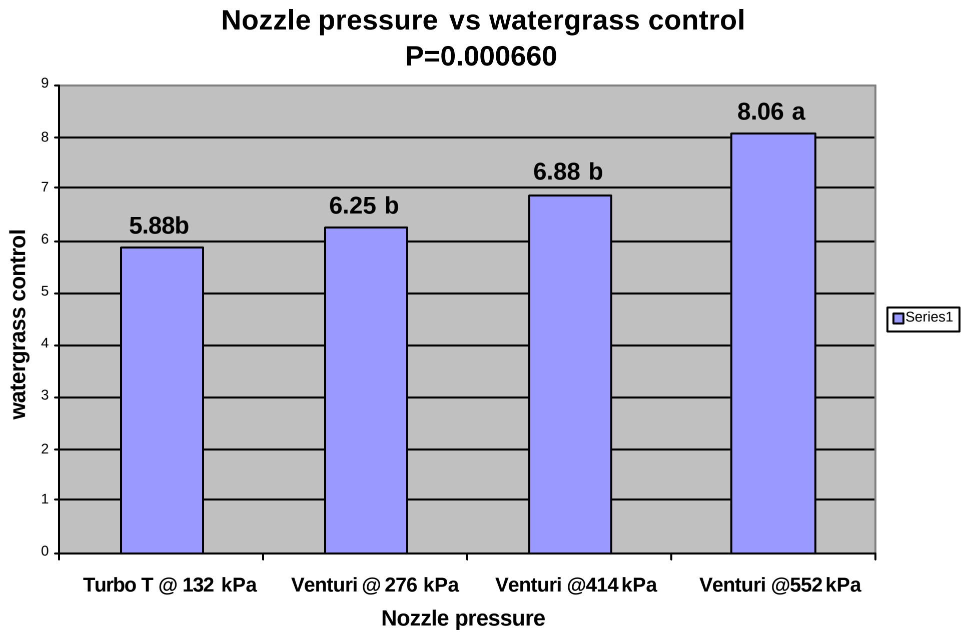

Figure 5. Nozzle pressure vs. watergrass control. Watergrass control rated on scale of 0-10 with 0 being no effect and 10 being total control. Bars sharing common letters were not significantly different.

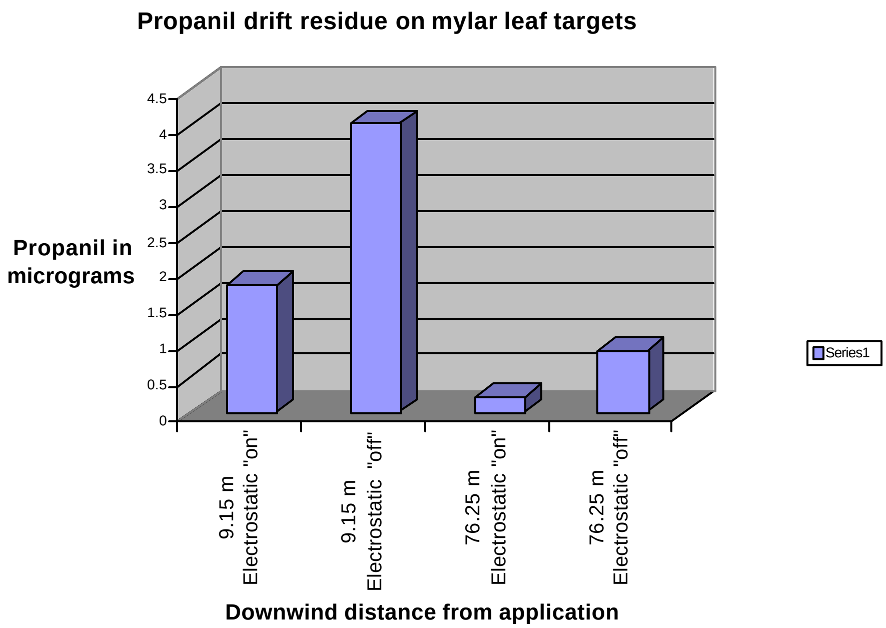

Figure 6. Propanil drift residue on mylar leaves, comparing electrostatic spayer in "on" and "off" condition at two downwind distances.

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Ecological Deception: Pulling the Trigger on Yellow Starthistle Seed Germination.

Stephen F. Enloe and Joseph M. DiTomaso, Graduate Research Assistant and Rangeland Weed Ecologist, University of California, Davis, CA 95616

There is an increasing body of evidence indicating yellow starthistle seedbanks may be depleted by over 95% with three years of intensive management (DiTomaso et al. 1999; Enloe, unpublished data). With this in mind, current research directives are aimed at developing techniques to facilitate seed germination in the first and second years of management to accelerate the depletion process. A better understanding of the ecology of yellow starthistle seed germination may aid in developing accelerated seedbank depletion techniques.

The phenomenon of field abortion of yellow starthistle following late summer thunderstorms has been documented in Europe (Sobhian 1993) and has been observed in Northern California (Enloe, unpublished data). This may occur when yellow starthistle seeds are induced to germinate following rainfall but subsequently die for a lack of further available moisture. We attempted to apply this idea as a seedbank depletion strategy for yellow starthistle. Studies were conducted on both grazed and ungrazed plots near Davis and at the Sierra Foothills Research and Extension Center (SFREC) near Marysville, California during the month of September 2000. We applied 0, 0.5, 1.0, and 1.5 inches of irrigation to 0.25 m^2 circular plots either as a simulated thirty-minute evening rainstorm or in split applications over a twenty-four hour period. We continuously monitored soil temperature within the germination zone (1-2 cm) and soil water potential with a potentiameter for sixty-six to ninety hours following irrigation. Five days after irrigation, we counted and individually marked all emerged yellow starthistle seedlings with colored toothpicks. We monitored seedling survival weekly until either complete seedling mortality or the first sustaining rainfall, after which no further mortality occurred. At the end of the experiment we quantified the soil seedbank by sampling five-1.75 cm diameter cores in each plot. Soil water potential and seedling emergence and survival data were analyzed using repeated measures analysis of variance.

Maximum daily soil temperatures generally exceeded 35° C and minimum nightly temperatures averaged 15° C across locations. Prior to irrigation, baseline soil water potentials were less than –40 MPa at all study sites. With 0.5 and 1.0 inches of irrigation, soil water potential initially increased to greater than –0.5 MPa, but rapidly declined to below –1.0 MPa. Larson and Kiemnec (1997) determined that –1.0 MPa was the low end for yellow starthistle germination. This was reflected in the fact that very few seed germinated in these treatments at either location. Additionally, soil water potential decreased much more rapidly in grazed than ungrazed sites. Irrigation applied at 1.5 inches maintained soil water potentials favorable for germination in both ungrazed sites. Complete mortality of emerged seedlings occurred at both Davis locations within three weeks. However, few seedlings died at SFREC before the first sustaining rains and monitoring was then discontinued. In terms of the seedbank, the best treatment (1.5 inches of irrigation) induced roughly 20% of the seedbank to germinate at SFREC, and less than 15% at Davis. In contrast, the first sustaining rains for germination in mid-October induced 65% and 45% of the seedbank to germinate at Davis and SFREC, respectively.

These results suggest several key points for biology and management. Maintaining adequate soil moisture within the germination zone may be very difficult when temperatures are extremely hot during the early fall. Additionally, applying excessive water to induce germination may also sustain seedling survival until fall precipitation occurs. However, irrigation techniques may be refined to improve the success of this technique. The low percent of the seedbank that was induced to germinate compared to the first fall rains may also suggest some dormancy mechanisms are working to prevent mass field abortions when late summer precipitation does occur. This has been shown for several annual grass species in California (Jain 1982). Laboratory experiments are being initiated to further examine this issue with yellow starthistle.

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Climatic Prediction of an Invasive Plant in California: *Ulex europaeus* (Gorse)

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Introduction

Invasive plants reduce the biological diversity and productivity of all ecosystems. However, not all introduced exotic plants become problems. Climate modeling can be used in predicting which of these exotic plants have the potential to become problems. Also, once introduced, climate models can be used to predict which areas are susceptible to invasion. This information can be used in deciding where to concentrate management efforts.

This project was concerned with taking an invasive plant that already occurs in California and predicting whether or not a currently unoccupied area is susceptible to invasion. This area is San Luis Obispo County and the plant in question is *Ulex europeas*, more commonly referred to as gorse.

Gorse is native to western and central Europe. It can not survive in arid climates. Nor does it tolerate extremes of heat and cold (Zabkiewicz 1976; Hoshovsky 1986). Gorse was introduced into Marin County 100 years ago from Ireland. The Irish traditionally planted gorse on the graves of their dead and brought this tradition with them to "The New World". Since that time gorse has spread to occupy every coastal county in California from Monterey to the Oregon border (CalFlora Database).

There are several characteristics that make gorse successful as an invasive plant. It has the ability to fix nitrogen from the air into the soil. It can also acidify the soil to increase the site suitability for itself while excluding most other plants. In addition gorse is able to survive on a variety of soil types. Another invasive characteristic is that it produces copious amounts of seed with long term viability. Finally, gorse regenerates rapidly from seeds and stumps after disturbances (Hoshovsky 1986).

The infestations that result from this invasiveness cause several problems. Gorse is an extreme fire hazard. The plant itself has oils that are very flammable and large amounts of dead dry matter are produced. In 1936, the town of Bandon, Oregon burned to the ground. 14 people died and only 16 buildings were left standing. The fire that caused this was fueled by heavy gorse infestations. Also, due to its competitive nature, gorse is able to displace many native plants. It also forms impenetrable thickets that can exclude many forms of wildlife.

Methods And Materials

To make my predictions I used a dynamic simulation model called CLIMEX. This is a climatic modeling program that is available through CSIRO in Australia. CLIMEX predictions are based on: (1) Meteorological data from about 2500 different locations worldwide, (2) and climatic preferences and limitations of a species which can be inferred from an observed distribution. To enhance the program, I added weather data from 328 additional locations to the database. This data consisted of long term averages for precipitation and temperature from locations all over California. It was available through the National Oceanic and Atmospheric Administration (NOAA).

CLIMEX gives its predictions as an ecoclimatic index. An ecoclimatic index describes the climatic suitability of a location for a species, based on population growth, as a single number between 0 and 100: 100 being the most suitable location and 0 being unsuitable for population growth. This number is derived from an interaction of a growth index and a stress index.

The growth index measures the potential for growth at a location based on temperature and moisture preferences of a species. The growth index is what determines the abundance of an organism at a particular location. The stress index measures the potential for death at a location based on the accumulation of stress for a species and determines the distribution of a population.

Results

To obtain predictions a model was fitted that inferred many of the growth and stress parameters. This was achieved by fitting the model to gorse in its native range. The main assumption made was that in its native habitat, gorse has had every opportunity to occupy all its suitable climates in that region. With this in mind a model was fitted by increasing the stress from heat and cold from the original temperate template provided in CLIMEX. The dry stress parameter was also increased. This provided a model that closely resembled the actual distribution of gorse (Flora Europea Database). For the abundance, the temperature preferences was set to match information from a seed germination experiment (Ivens, 1983). The resulting model for Europe (Figure 1) was then run for California using the 328 new locations from NOAA (Figure 2). The final model shows *U. europaeus* able to grow in every coastal county in California from Santa Cruz north to Oregon.

Discussion

Why was Monterey unsuitable for the growth of gorse even though populations are currently found there? Dry stress is what is killing gorse populations for Monterey in my model. Given the location of the majority of *Ulex* populations in Monterey it is safe to assume that they are receiving water from sources other than direct precipitation. One population is an ornamental in somebody's yard. Another is on the edge of a golf course and yet another is in a drainage ditch. There is also more evidence to support this assumption. These populations have existed for at least 20 years and have not significantly expanded their range.

Conclusions

The above discussion suggests that *U. europaeus* has reached its ecoclimatic limits in Monterey. Earlier in this paper we asked the question: Is San Luis Obispo County susceptible to invasion from gorse? The results of this research suggest the answer is no. However, because of the diversity of microclimates in S.L.O. County it is possible that there will be some isolated populations occurring in the county, if they don't already exist.

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Flora Europaea Database: http://www.rbge.org.uk/

Figures

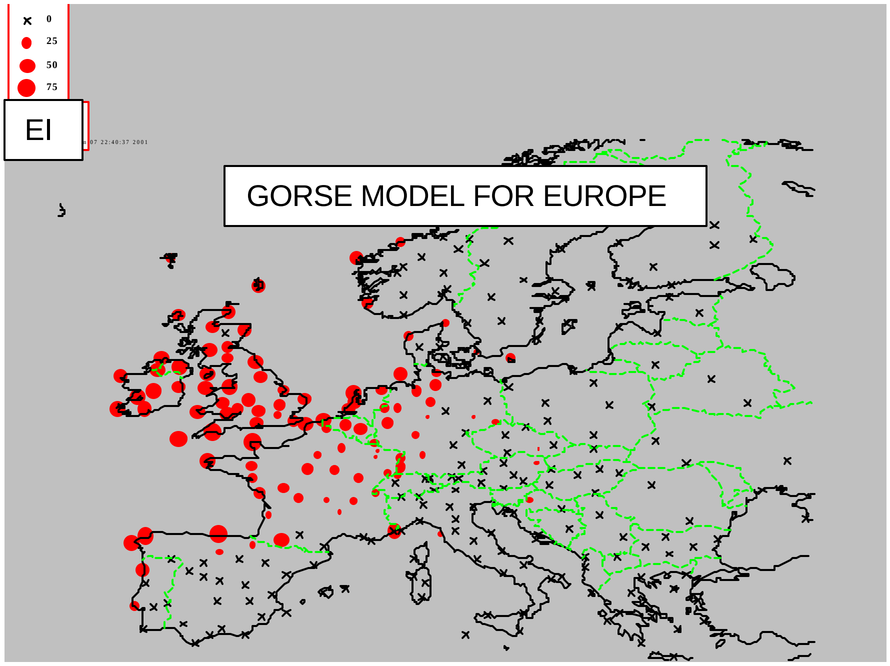

Figure 1.

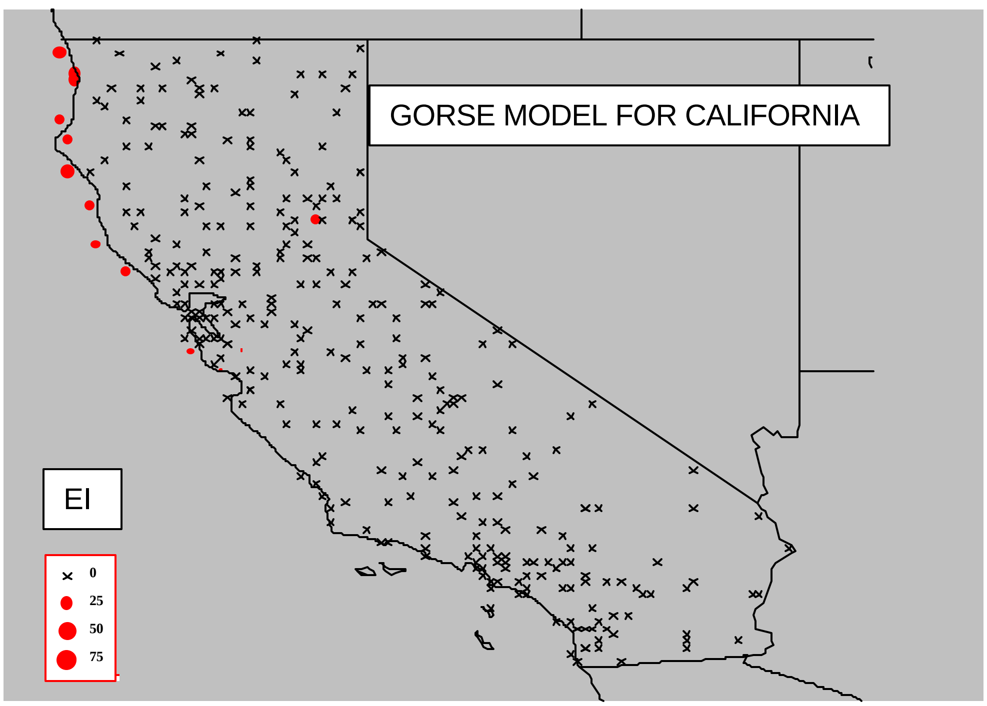

Figure 2.

Ecological Factors Affecting the Growth and Distribution of Pampas Grass and Jubata Grass

Alison E. Tschohl and Joesph M. DiTomaso, Graduate Student and Extension Specialist
University of California, Davis

Introduction

Two species of *Cortaderia* are widely distributed weed problems in California. Introduced from South America to Santa Barbara in the mid 1800's, both species escaped cultivation and spread rapidly throughout the state. It is difficult to determine the individual pattern of spread for each species because jubata grass (*C. jubata*) was not recognized as a separate species until the 1960's when it was identified as a weed in cut over redwood forest in Humboldt county (Cooper, 1967). Jubata grass is thought to have been an accidental introduction because the Victorians favored the creamy white plumes of female pampas grass (*C. selloana*) for their dried flower arrangements over the more pinkish plumes which are characteristic of jubata grass (Costas-Lippmann, 1977).

Jubatagrass is a dominant coastal weed species in Northern California while pampasgrass is most prevalent south of Santa Barbara. Jubatagrass occupies a narrow band along the entire coast, restricted to the influence of coastal fog. The distribution of pampasgrass overlaps heavily with jubatagrass in the central coast but the species has also escaped to inland regions, especially riparian zones in Sacramento and San Bernardino counties. Once established, both species are strong competitors.

We hypothesized that differences in environmental tolerances in the seedling stage of both species may play a role in their geographic distribution. The fact that *C.selloana* tolerates the long hot dry summers inland stands in stark contrast to the cool foggy moist conditions on the coast where both species thrive side by side. Our objective was to determine how water, light, and temperature influence seedling growth of both species. Understanding the ecophysiological aspects of seedling growth is important because these weeds compete with native vegetation for available resources. Knowing how the plants interact with different environmental factors can help us to better formulate control strategies and identify regions that are at risk for invasion.

Materials and Methods

C. jubata seed was collected in Santa Barbara County in October, 1999. *C. selloana* seed was purchased from the Mistletoe Seed Co. in Santa Barbara County. For all experiments, seed were planted on the soil surface of containers filled with Yolo Fine Sandy Loam. Seedlings were thinned to one per pot.

For the drought experiment, 40 day old plants in one gallon pots were separated into three treatments: no drought, 27 days, or 41 days of drought. At the conclusion of each drought treatment, six replicates of each species were used for relative water content (RWC) determination. The remaining six replicates were returned to field capacity and monitored for recovery for one week. A variety of growth parameters were measured and compared for both species.

For the light experiment seedlings were grown in one gallon pots in the greenhouse at four different light intensities. Full light intensity in the greenhouse averaged 1600 $uEm^{-2} s^{-1}$ photosynthetic flux photon density (PPFD) as measured with a quantum light sensor (Lambda Instruments Model LI-170). Shade treatments were applied 21days after planting . Black nylon mesh shade cloths were fitted to PVC frames to reduce light intensity to 60, 30, and 15% of available light (960, 450, and 230 $uEm^{-2} s^{-1}$ PPFD respectively). 10 replicates of each species were harvested from each of the four treatments for the baseline, at 4 weeks, and again at 8 weeks.

To test the effects of temperature on plant growth, seedlings were grown in 51 count black plastic pro-trays in controlled environments across a range of six temperatures (10,15,20,25,32,37° C). Plants were measured at two week intervals and mortality recorded for a two month period.

Results and Discussion

Overall the data indicate that *C. selloana* is a much more vigorous species. Under optimal conditions of ample light, water, and moderate temperature, pampasgrass grows significantly faster and taller then jubata grass.

Drought is often a critical factor in plant establishment in the Mediterranean climate in California and both species are quite drought tolerant. They were able to survive drought of 41 days with only partial mortality. Under fully watered conditions, the species dry weights were not statistically different. However, moderate drought of 27days had a greater effect on jubata grass, reducing dry weight by 55% compared to a 33% reduction in pampas grass (Figure 1a). This difference was traced to the pattern of leaf production. *C. selloana* produced between 12-13 leaves when fully watered or with moderate drought. After moderate drought, *C. jubata* suffered a serious decline in leaf production , dropping 50% from 18 leaves per plant with full water to only 8 leaves per plant (Figure 1b).

In the presence of adequate water, nutrients, and moderate temperature, light availability places restraints on plant growth. Some shade tolerance is an important factor in species invading undisturbed habitats with more closed canopy. In the light experiment, growth of the two species was nearly identical under conditions of low light (15 and 30% of available). However, at full sun, *C. selloana* produced nearly two and a half times greater biomass than did jubata grass, 2.42 grams compared to 1.0 gram.

Light had a greater effect on pampas grass. Dry weight of pampas grass increased in a linear fashion with each incremental increase in light intensity. Dry weight was 164% greater in plants grown in full sun than plants grown with moderate shade (60%). In contrast, jubata grass achieved optimal growth at 60% available light. The dry weight did not increase with the additional light supplied in the full sun treatment.

The difference in dry matter corresponded to the relative growth rates (RGR). Relative growth rates of *C. selloana* increased linearly with increasing light (Figure 2a) while the RGR of *C .jubata* reached a plateau at 60% light (Figure 2b). Under full available light, pampas grass grew at a rate of 21 mg/mg/day, 1.7 times greater than jubata (12 mg/mg/day). RGR is the mathematical product of a physiological component (NAR) and a morphological component (LAR). The net assimilation rate (NAR) gives an estimate of the apparent photosynthetic efficiency of the plant, taking into account losses due to respiration. The LAR leaf area ratio indicates the leafiness of the plant, or the amount of tissue available to do the work of photosynthesis. The increases in RGR were brought about by a concomitant increase in NAR and decrease in LAR. In pampas grass, RGR increased with increasing light intensity because increases in NAR were greater than declines in LAR at each light level. In jubata grass, this was not the case. Increased light intensity did not significantly affect any of the growth factors.

In the temperature experiment, optimal growth for both species occurred at 20 C (68F). However, at high temperatures above 32 C (98F) *C. jubata* had significantly greater mortality. Taken together with the light data, this may partially explain the failure of *C. jubata* to establish in inland. Both species do equally well in the cool, foggy coast, but jubata grass is apparently unable to utilize the higher light intensities or tolerate the hot temperatures in the summer in interior regions,.

Taken together, the growth responses of both ornamental grasses suggest that there are fewer ecological limitations to spread of pampas grass than jubata grass. *C. selloana* seedlings survive higher temperature, tolerate moderate drought, and utilize higher light intensities than *C. jubata* seedlings. Today, there are more naturalized pampas grass populations in the Central Valley than were reported 30 years ago. Pampas grass is clearly suited to the climate and it may be that pampas grass is beginning to expand its range as a weed in inland areas. However, it is important to mention two other factors which may also play a role in the geographic distribution and potential spread of both species: 1) reproductive strategy and 2) trade in the nursery industry.

The main difference in the two species lies in their reproduction. Populations of *C. jubata* consist of entirely female plants which produce genetically identical seed through an asexual process called apomixis. This selfing strategy is advantageous in establishing founding populations when colonizing new areas, but there is little opportunity for adaptation to new environments through genetic recombination. In contrast, *C. selloana* populations have separate male and female plants that reproduce sexually. Outbreeding species have the ability to react to selective pressures and it may be that *C. selloana* is slowly adapting to interior climates. One possible explanation for the current geographic distribution is that *C. jubata* has saturated its climatic range on the coast, but *C. selloana* is still in an expansion phase, poised to expand throughout the central part of California.

As a final footnote it is important to note that pampas grass is still widely available in the horticultural industry. Repeated introductions through this pathway serve to increase genetic variation in escaped population and facilitates extensive seed dispersal.

See Appendix A For Figures

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Appendix A

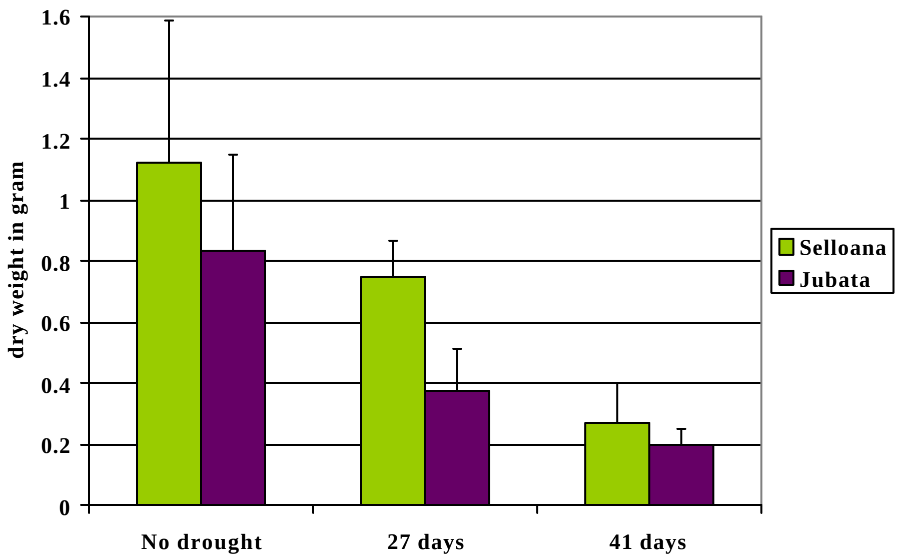
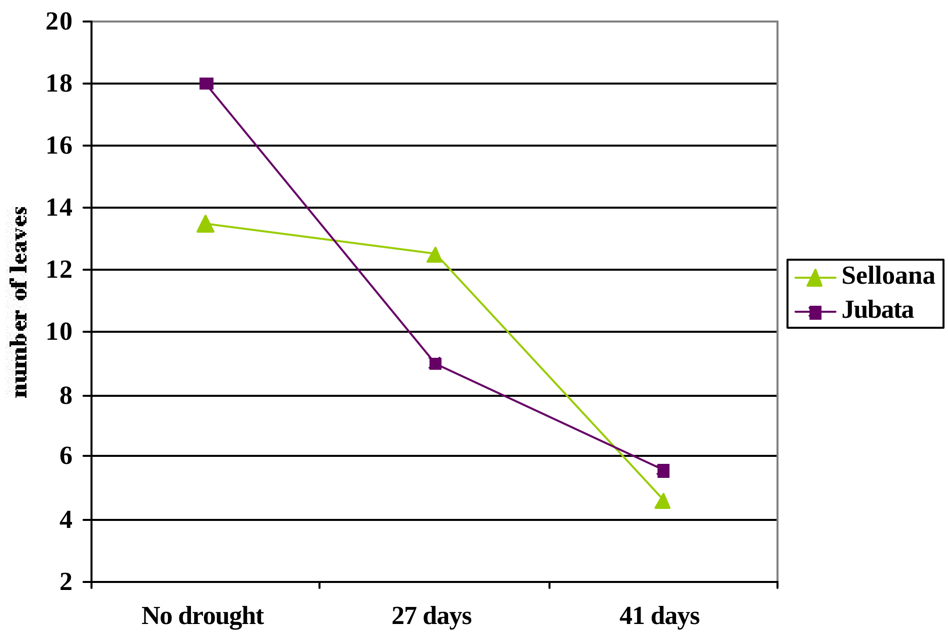
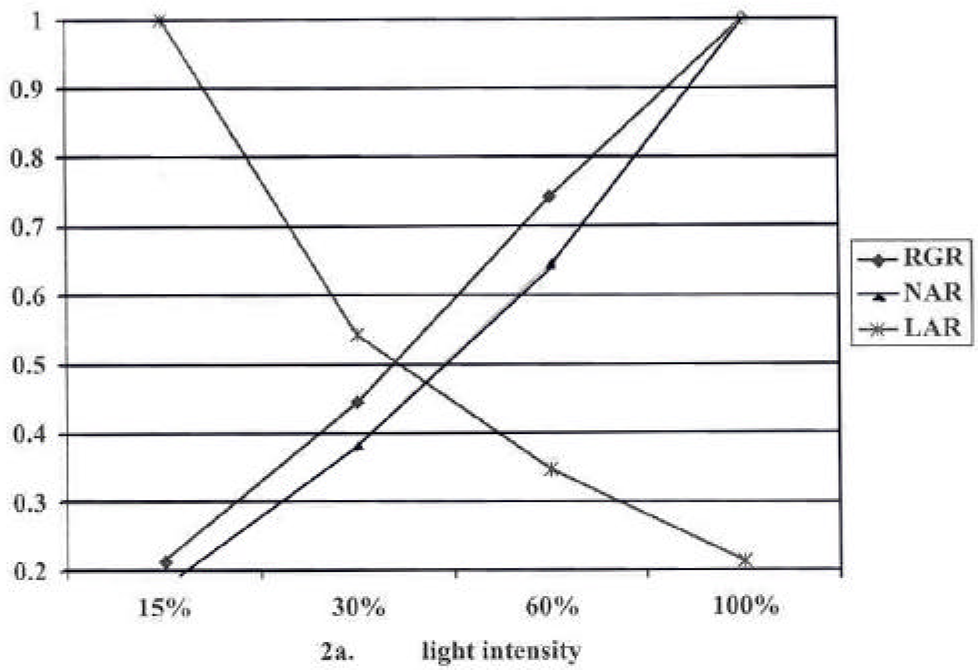
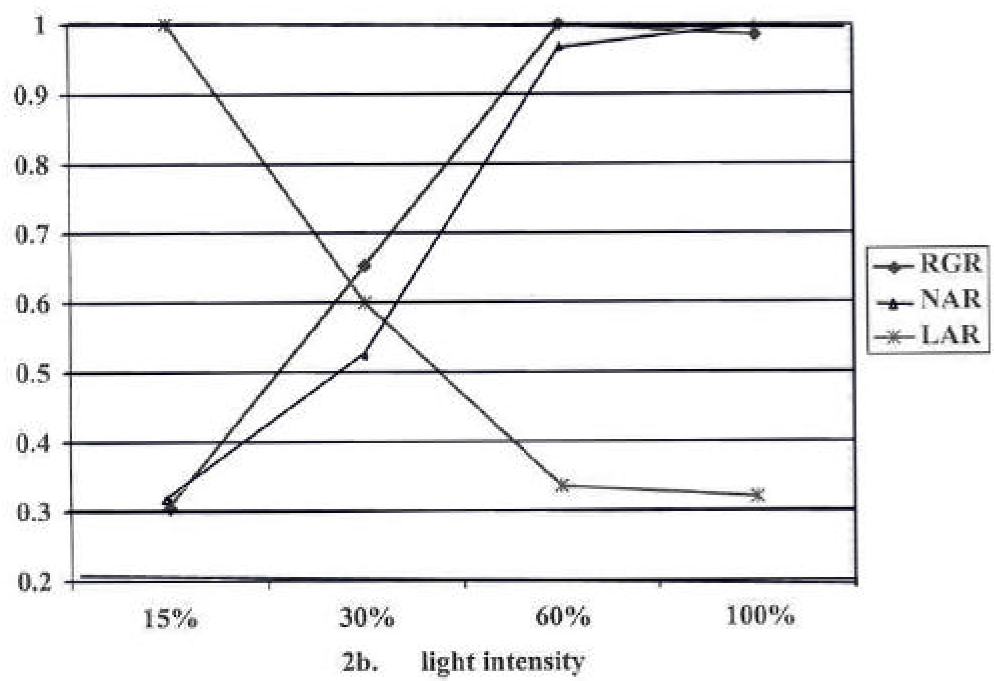


Figure 1a and 1b. Effect of drought on a) dry weight and b) leaf production of Pampas grass and Jubata grass seedlings.







Figures 2a and b. Influence of light intensity on relative growth rate (RGR), net assimilation rate (NAR), and leaf area ratio (LAR) in a) pampasgrass and b) jubata grass after eight weeks. Values for each parameter are shown as a percent of the maximum value to show trends.

Rimsulfuron Efficacy Trial
Cal Poly, San Luis Obispo

Kevin R. Winn, Cal Poly

The rimsulfuron efficacy trial was completed to evaluate the effects of eight different surfactants combined with rimsulfuron to get the best possible formulation to control *Malva neglecta* without injuring the tomato plants. The experiment was aimed toward finding the best formulation to lower herbicide use yet receiving effective control. Previous experiments (1996) with rimsulfuron, claim that it is most effective with the addition of surfactants (Green 508). There was no claim to which surfactants worked best or were used.

The surfactants that were used in this trial are as follows: Activator 90®, Herbimax®, LI 810®, LI700®, Phase®, MSO®, Freeway® and Choice®. Shadeout®, a product from Dupont was the herbicide used. Its active ingredient is Rimsulfuron. The trial was completed on the Cal Poly Campus, San Luis Obispo on August 1st, 2000. There was an adjustment in rates for the inquisition that there might be a difference in control. There were two rates for LI810, LI 700, and Phase. The two rates are 0.25% V/V and 0.50% V/V. The tomato transplants were Pik Ripe variety, from Petoseed. We used a CO_2 sprayer calibrated at 25 gallons of pray solution per acre. Shadeout® was applied at 2 oz per acre, which is the recommended rate. Soil type was clay loam

For evaluation purposes, a plastic quadrant was used with an area of $.25m^2$ and it was randomly placed in each treatment plot. There were five categories in which evaluation took place: Density, % Cover, Control, Biomass and Crop Vigor. Density was the actual count of live weeds in that quadrant. Percent cover was a percentage of biomass above the ground that is covering the ground inside of the quadrant. Control was the value from 0-10, 0 being no control and 10 being full control of the weeds. Biomass was a harvest of the live biomass inside the quadrant, then weighed in grams and recorded. Crop vigor was a value from 0-10, 0 being dead and 10 being vigorous.

There was an evaluation on 7, 14 and 21 days. We mainly focused on the 21-day interval to receive accurate data. We focused mainly on the control and Biomass because they were the most accurate. Control data showed MSO and Herbimax with the best performance. These are both in the crop oil category. The study showed that Goosefoot was not controlled effectively by rimsulfuron with a range of 0-4. Below is a graph showing the data.

Biomass was evaluated on the last day because we had to harvest foliage. There was a significant difference from the control plot compared to the rest of the treatments. The amount of biomass accumulated by Malva amounted to 384.25 grams. The next value close to that are less than 25, which there is a significant difference there. We noticed a big change in value on both tests for Phase, though not significantly different, due to the change in dosage.

In conclusion, there may be a significant difference in surfactants if the rate of rimsulfuron was decreased. There may also be significant differences in treatments if the control plot was not included. The values from the control are so high that it requires the other treatments to raise their means to be significantly different.

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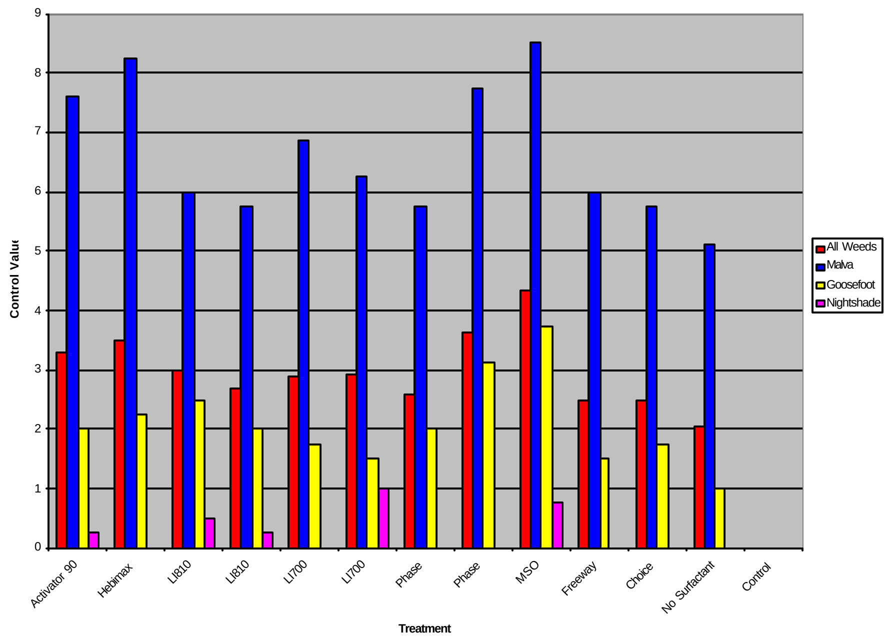

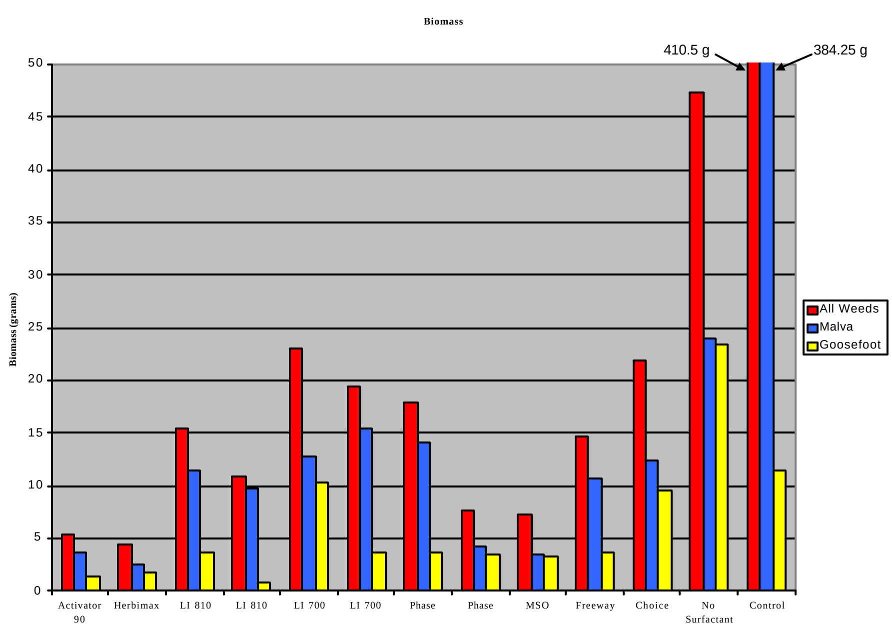

Presidential Address
Changing Times in Weed Science

Matt Ehlhardt, Aventis CropScience

Good afternoon and happy new year. I hope everyone had a good holiday. Now that we can finally say that the new millennium has arrived we would hope that all the positive visions we had for the future would be in place. That the world would be working towards the utopian goal of eliminating hunger, poverty and who knows how many diseases. While great strides have been made to minimize many problems, many of our lofty goals still seem far off. In last years presidential address, Steve Wright, outlined major scientific achievements that have allowed growers around the world to increase yields. Improved varieties, improved cultural practices, improved weed control techniques have all contributed. Modern weed management can be traced from the development of chemical weed control that began in the 1920 - 1930's to the advent of biotechnology introduced towards the end of the last century. The use of a modern weed management program in agriculture has allowed us to reduce poverty and increase the quality of our food both leading to an increase in the average life span and a general increase in the quality of that life span. During this time, though, our growers have been intelligent and resourceful enough to know, or to have realized, that chemical weed control alone did not always solve problems and that intelligent cultural, biological and chemical control measures incorporated into an integrated weed management program was needed to sustain our ability to provide a safe and sufficient supply of food and fiber.

We know the path we have traveled, what can we now predict for our future. I want to preface any remarks by saying I am not predicting doom and gloom. But that we do have work to do in order to maintain the level of comfort most of us have become use to and also so that we will live up to the expectations many around the world have of us. For the immediate future practices in weed management will be dictated by our past. During the 1960's and 70's new tools, as far as chemical weed control were being developed at a rapid pace. I had the fortunate experience to have began my career helping to develop the first Hoelon registration. Selective grass control in wheat and barley was looked on as a marvel but of course today is looked on as old hat. The pace of development slowed in the 1980's but did bring other new modes of action which allowed us to move from the older high use rate herbicides to those with low use rates and very selective sites of action. The sulfonyl ureas, imidazolinoes, the lipid biosynthesis inhibiting grass herbicides and PPO inhibitors brought new and exciting tools for growers. These enabled us to reduce the use of old chemistries which in most cases also reduced the total pesticide load in the environment. Because of the specific target site of action with many of these new chemistries, though, weed resistance also has become more of a problem. Again, however, ingenuity from growers, PCA's, applied university researchers and chemical manufactures have solved or mitigated many of these problems through cultural practices, crop rotations and in some cases taking a step back by rotating with older chemicals. New active ingredients while coming quickly in the 60's and 70's (71 herbicides registered) slowed downed in the 80's (19 herbicides registered) before picking back up slightly during the 90's (31 herbicides registered). Several reasons can be considered for this reduction in registrations since the 1970’s. First would have to be the cost of working through the costly registration requirements. Any new herbicide would have to prove itself superior to the older effective molecules to undergo this rigorous schedule. Second , the advent of biotechnology and herbicide resistant crops in the mid to late 80's left many companies with little reason to spend their resources on screening and developing new herbicides that would be hard pressed to compete commercially with the broadspectrum activity of a Liberty or Roundup. Increased yields, lower input and fewer herbicides looked very attractive to growers. But as we saw the anti-biotech sentiments move from Europe to the U.S. the number of acres planted to transgenic crops has steadily decreased. What was once thought to be the future of agriculture and weed control currently finds itself in a battle for public acceptance. This battle will continue for the immediate future but most of us know that this technology is too important and will move forward helping to improve agricultural and therefore our standard of living. A third reason for the decline in discovery of new molecules perhaps can be found in the trend of business consolidation. Chemical manufactures seemed to have spent less time on discovery than on working on mergers and acquisitions. If you go onto the Oregon State University web site and surf around until you find Dr. Arnold Appleby's site for herbicide company genealogy you'll see an illustration of this trend. From the early 70's until now we have gone from 65 manufactures of herbicides to the present day 13. Every time two groups combine it is doubtful that all the herbicide development projects survive. While you would expect the "dog" projects to be dropped you never know if one eliminated project might have solved a crucial weed problem. Of course not all of the 65 companies in the 70's worked on synthesis and early screening but it does make one wonder what we may have potentially lost with all these mergers and acquisitions.

To now I have spent time focusing on private industry. In the future, weed science in the public sector of California may also find itself changing - or is now presently changing. The role or future of the on campus weed researchers may be in jeopardy. In the next few years we will unfortunately lose to retirement several outstanding weed researchers in the UC system. The UC administration seems to be leaning towards not replacing these positions with that of an equal job description. Like private industry the university appears to be putting most if not all of its eggs into one basket by placing its research emphasis on molecular biology. Granted molecular biology, genetic engineering, will probably not only play a role but be the major method for varietal development and crop protection in the future. Weed science undoubtedly will find a place from these efforts but in the mean time the association between the university and the grower, one link where practical knowledge is generated and disseminated, will be reduced or lost.

So now we come back to the question, "What is the future and how will weed science change?" I have discussed biotechnology, corporate mergers, and the changing direction by the university away from basic and applied research. In addition we are facing the review of several herbicides under FQPA. At this time its is hard to say how many could be lost or their use curtailed by this federal activity. So is there anything positive for us in the future? As I earlier indicated, I do believe that transgenic crops will be accepted in California (and I do mean outside of the present use of transgene cotton). That for herbicide tolerant crops, manufacturers, seed companies, millers and handlers of the commodities and consumers will all find a mutually acceptable conclusion to the questions of identity preservation and labeling of products. But because of this delay in transgenic crop acceptance, chemical manufactures hopefully have realized it can or will pay to develop new chemistries that are not necessarily involved with genetic engineering. That new tools will be needed to work in an effective resistance weed management program. And finally and perhaps most important are the people working in this science. As we know the future of this science, this industry lies in the development of new ideas and tools. That the only way to move forward will be with young people who have elected to study and practice weed science. While it must be difficult to make a commitment to this discipline in light of today's business climate, one thing I believe is certain; that any slow down we are experiencing at this time is only part of a circle and that agriculture business will see better days. After all we do have to eat! We should recommend to any young student or old student for that matter that weed science can lead to an exciting and profitable career. Currently in the UC and CSU system there are approximately 20 graduate students studying at the Masters or Ph.D. level in weed science. In addition we have undergraduates who are in the process of studying under some of the best professors and teachers this field has to offer. For the past three years some of the bests students have participated in the student paper sessions on Monday mornings, which hopefully you did not miss today. Or if you have not visited the student posters please do so. And when your there, don't just look, take the time to visit with the students and learn more about their projects and expertise. While these times may seem tough for agriculture and related disciplines, the one thing that can be counted on are the people involved with this industry and science. Collectively working and volunteering in groups such as the CWSS will help in the education and development of these new ideas and technologies that will improve the standards of living for us and the rest of the world.

Thank you for coming today. Lars and his program committee have put together an outstanding agenda I hope you find educational and interesting. Again have a good new year and enjoy this 2001 conference.

The Future of Weed Science and Extension at the University of California

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Research in the area of Weed Science has a long and distinguished track record at the University of California and has collectively made an enormous contribution to effective management of weeds in agricultural, urban, and natural environments. However, we are coming to a point where decisions have to be made as to whether resources should continue to be invested in this area. On the surface this would seem to be an easy decision to make. There are more than 600 species of plants classified as weeds in California of which 140 species cause more than $1 billion in crop losses annually. Herbicides comprise the majority of pesticide applications in California (in some surveys as much as 70%). In addition, because of the impact of weeds on agricultural production and the extensive use of herbicides in agriculture around the world, the most prevalent application of biotechnology has been the deployment of herbicide resistant transgenic crops. Clearly then, weed science has entered into the area of genomics research which is the darling of many academic institutions across the US (including UC). Finally, research in the area of exotic pests has taken on urgency and there is new funding in this area at both the Federal and State levels. Many of the most prominent invaders in agricultural, urban and natural ecosystem (especially aquatic environments) are weeds. Given all these facts about the importance of research in the area of weed science, there is no question that it will continue in the UC system. However, investment in this area has to be balanced with other priorities -- there are many serious needs and deficiencies within the system. In this brief article, I will provide a short history of weed science research in California, discuss current efforts, describe positions we anticipate filling in the near future and then discuss the long range plans for Weed Science on the UC Davis campus.

Current and Historical Weed Science Efforts

The research/extension/teaching efforts in Weed Science can be broken in several categories: faculty with research and teaching appointments (located on campuses); extension specialists with either 100% extension appointments or with an extension/research split (located on campuses); IPM specialists (usually based at Centers such as Kearney or at County offices) hired within the UC IPM program – a program within the Division of Agricultural and Natural Resources (DANR); and advisor positions based in the counties under the direction of DANR. Collectively these individuals make up the research/extension/teaching arm of the University of California. Unfortunately, a large cohort of similar-aged individuals entered the UC system in Weed Science and we will be losing many of these individuals through retirements over the next few years. If the planned retirements take place and no new positions in Weed Science are filled, there will be only one faculty member with a research/teaching position within the University of California. We cannot let this happen, although the University has a track record of ignoring important areas of research. For example, research in the area of biological control of weeds in the UC system was very strong and had a worldwide reputation. In fact, much of the reputation that UC enjoys in the area of biological control has come from the research efforts in biological control of weeds. Today there is only one scientist working on biological control of weeds within the University of California. It is frustrating to understand how the university could ignore filling positions in this area when the research was extraordinary and critical to the state of California. Fortunately, the USDA-ARS and the California Department of Food and Agriculture continued to recognize the importance of biological control of weeds and have invested heavily in personnel to address research and regulatory issues related to solving weed problems in California.

We are committed to keeping Weed Science strong on the Davis campus, although any planning must be consistent with campus, college and divisional priorities. We have recently authorized the hiring of a new faculty member who will teach and do research in the area of weed science. The position, which is currently being advertised, is for a Physiological Weed Geneticist who could work in the following areas: 1) genetics of weed biotypes and inheritance of traits that impart weediness on plants, 2) the genetics of herbicide resistance in weeds, and 3) the potential for gene flow between transgenic crops and weeds for herbicide resistance. We expect to have someone on board within the next year.

The campuses control research/teaching positions while extension positions are largely the domain of DANR with oversight of the Program Planning Council. This council has representatives from the campuses, counties and DANR. As extension positions retire, they are pulled back by DANR and then subsequently re-allocated based on a series of guiding principles. The Davis campus has placed a priority on refilling Dr. Clyde Elmore's position (100% Cooperative Extension Specialist) when he retires next year (2002), but we must petition for this position from the Program Planning Council and be successful before we can hire someone. It is vital to have grass-root support from stakeholders and clientele groups interested in seeing these positions filled.

The Future of Weed Science on the Davis Campus

Weed Science is a division (not a department) on the Davis campus and is administratively connected to the Department of Vegetable Crops. Most of the faculty and extension specialists are located in Robbins Hall. Our weed science program is very important to the overall effort in the Pest Sciences on the Davis campus and the Dean's office is interested in showcasing these programs as the most comprehensive and solid Pest Science Group in the US. In a recent special issue of California Agriculture (Nov-Dec. 2000) completed devoted to IPM, almost all the articles were by UC Davis scientists. Three of the articles were on weeds, and these were co-authored by UC Davis and DANR extension specialists and advisors. We are committed to making Weed Science and the Pest Sciences stronger on the Davis campus and there are several items under consideration to accomplish this. These include: strengthening the Plant Protection and Pest Management Master's program and possibly offer a Ph.D. in this discipline; consider co-locating the Weed Science group with another Pest Science discipline such as Plant Pathology and/or Nematology; and 3) carefully examine each open position in Weed Science with the idea of justifying it in the context of the College's Academic Plan and within the mission of the Agricultural Experiment Station. In addition, examining potential teaching roles of any new positions and developing linkages with other Pest and Plant Science Departments on the Davis campus are critical elements that will play an important role in determining whether a position is filled.

Milestone Tm *: A New Broad Spectrum Preemergence Herbicide for Tree Fruit, Tree Nut and Vineyard Crops. (*pending registration)

Ronnie G. Turner, Hugo T. Ramirez, R. Erick Seay,
Wayne J. Steele II, Norm D. McKinley, and Gil E. Cook
DuPont Crop Protection, CA, OR, WA

Milestone TM (azafenidin, DPX-R6447) is a new broad spectrum preemergence herbicide for use in tree fruit, tree nut and vineyard crops. Milestone is currently under development in the

U. S. and registration is pending further EPA review. Field testing continues in citrus, grapes, sugarcane, vegetation management (rail roads, road sides, industrial weed control, hybrid poplar, eucalyptus and Christmas trees), pome fruit, some stone fruit, tree nuts, blueberries, coffee, asparagus, grass seed and sunflower.

Milestone is an N-phenyl heterocycle triazolone herbicide developed by DuPont Crop Protection. Milestone acts by inhibiting the porphyrin biosynthetic pathway at a site that causes the accumulation of a photodynamic porphyrin intermediate, protoporphyrin IX. Protoporphyrin IX absorbs light and transfers this energy to O_2, creating a highly reactive singlet oxygen species that indiscriminately reacts with cellular components, resulting in cell membrane disruption. The diphenyl ether, oxadiazole, iso-urazole, N-phenylpthalimides and triazolinone herbicides also act as inhibitors of protoporphyrinogen oxidase (1, 2, 3).

The toxicological and ecotoxicological studies completed thus far indicate that Milestone presents a very low risk to humans, animals and the environment. In mammals, the technical active ingredient in Milestone has shown to have low acute oral (rat, >5000 mg/kg) and dermal (rabbit, >2000 mg/kg) toxicity. It is not an eye irritant or skin sensitizer and was negative for the Ames mutagenicity test. A study done in fish with the technical active ingredient indicates that Milestone does not bioaccumulate. In chronic toxicological tests with the formulated product (80 WG), Milestone was shown to be non-oncogenic (mouse), and not a teratogen (rabbit).

The primary mode of degradation is by soil microbes. The soil degradation half-lives (disappearance time in days) for several locations within the US were: CA – 129 days, FL – 4 days, MD – 47 days and WA – 72 days. Soil photolysis plays a minor role in the degradation process. The soil photolysis half-life was 79 days. In laboratory studies, Milestone is stable in water for 39 days at pH’s of 5, 7, and 9 at temperatures of 77° F and 98.6° F. Although Milestone is stable to hydrolysis it rapidly photo degrades in aquatic systems with a half-life of 1.5 - 2 days (natural sunlight equivalents). Milestone is not volatile.

Milestone provides very effective weed control at lower than current standard herbicide use rates. The labeled use rate will vary from 4 – 16 ounces active ingredient per acre (oz ai/a) depending on either the crop, weed species or application program (single or sequential applications). The maximum single application rates are 12 and 16 ozai/a (16 ozai/a only in citrus, all other crops will have maximum single application rate of 12 ozai/a). The maximum yearly use rates are 24 and 32 oz ai/a. At use rates of 8 – 16 oz ai/a applied preemergence, Milestone provides four to eight months residual control of some of the most important broadleaf weeds and grasses in orchard crops and vineyards. A partial list of weeds controlled include: wild radish (*Raphanus sativus*), cheeseweed (*Malva parviflora*), pannicle willowherb (*Epilobium paniculatum),* common groundsel (*Senecio vulgaris*), puncturevine (*Tribulus terrestris*), Russian thistle (*Salsola australis*), barnyardgrass (*Echinochla crus-galli*), witchgrass (*Panicum capillare*), annual bluegrass (*Poa annua*), large crabgrass (*Digitaria sanguinalis*) and seedling johnsongrass (*Sorghum halepense*).

At suggested use rates Milestone has provided excellent selectivity across a wide range of tree fruit, tree nut and grape cultivars. These tests have included Milestone at the proposed X and 2X use rates applied in single applications, sequential applications and multi-year application programs for the proposed labeled crops. Further field tests are underway to evaluate the potential for Milestone use in young orchards and vineyards and to refine use rates and programs for crops grown in very sandy soil conditions.

In summary, Milestone applied preemergence is an excellent broad spectrum, residual herbicide for use in many fruit and nut crops grown in the US. Its low use rate, low soil mobility and good toxicological profile make it an excellent herbicide choice for weed management programs in the proposed crops.

References

[1]Prather, T.S., J. M. DiTomaso, and J. S. Holt. 2000. History, mechanisms, and strategies for prevention and management of herbicide resistant weeds. Proceedings of the California Weed Science Society. 52:155-163.

[2]www.psu.missouri.edu/agronx/weeds/herbinjsymptoms/cellmem.html

[3]www.ext.nodak.edu/extnews/weedpro/hma/herbcm03.txt

Shark™ 40 Df – A New Herbicide for California Agriculture

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Introduction

Carfentrazone-ethyl is a new herbicide from FMC Corporation that has been reviewed by the US Environmental Protection Agency as a reduced risk pesticide. Section 3 labels have been approved for post fallow or preplant burn down, and the cereal crop group which includes field corn, sweet corn, grain sorghum, rice, wild rice, wheat, oats, and barley. Carfentrazone-ethyl is marketed as Aim™ Herbicide except in California where it will be offered as Shark™ Herbicide. These products are formulated as a 40 percent dry flowable.

Carfentrazone-ethyl is a new active ingredient in the aryl triazoline class of chemistry and was discovered in FMC laboratories. The mode of action of carfentrazone-ethyl is the inhibition of protoporphyrinogen oxidase (commonly abbreviated as *protox* or *PPO*); hence, carfentrazone-ethyl is sometimes referred to as a *PPO inhibitor*. Inhibition of the protox enzyme induces lipid peroxidation and results in disruption of cell membranes. The herbicidal action on susceptible plants is rapid, depending on environmental conditions, with initial symptoms appearing as quickly as one day after treatment and plant mortality generally occurring within seven days of application.

Currently, registrations are pending at the California Department of Pesticide Regulation for the use of Shark™ Herbicide on rice and wild rice. Future California registrations will include post fallow or preplant burn down, the cereal crop group, cotton, tree, and vine crops.

General Characteristics

Shark™ Herbicide is a rapid acting, post-emergent, contact herbicide. The product controls broadleaf and sedge weeds in a variety of crops including corn, sweet corn, wheat, barley, oats, rice and wild rice. It is safe to grass and cereal crops. Minor necrotic speckling of leaves can occur under cool, cloudy, moist environmental conditions and can be exacerbated with adjuvants. Broadleaf plants are generally susceptible to Shark™ Herbicide; however, by the use of directed sprays and seasonal timing, the product can be used in many broadleaf crops. Shark™ Herbicide is also being developed as a defoliant for cotton and as a desiccant for potatoes. Shark™ Herbicide can be used alone against susceptible weeds, or it can be tank-mixed to obtain broader weed control. Shark™ Herbicide can be mixed with glyphosate, paraquat, or similar burn down products for total vegetation control in fallow land and crop systems.

Shark™ Herbicide is not cross resistant to other classes of herbicides, and it controls economically important weed species that may have developed resistance to other herbicide products, such as the imidazolinone and sulfonylurea acetolactase synthesis (ALS) inhibitors.

Shark™ Herbicide has a favorable toxicological and environmental profile that was instrumental in the Environmental Protection Agency's decision to review it as a reduced risk product. The label signal word is *Caution.* Carfentrazone-ethyl is rapidly degraded in both the soil and aquatic environments. The significant routes of environmental degradation are hydrolysis, photolysis, and microbial metabolism. The overall characteristics of Shark™ Herbicide indicate a low risk potential for leaching into ground water. Carfentrazone-ethyl is slightly lipophilic and rapidly penetrates the leaf cuticle and is rainfast within one to two hours following application. It has low water solubility and a vapor pressure of 1.2×10^{-7} mm Hg at 25ºC. These latter characteristics indicate a low propensity for secondary off-target movement through co-distillation or volatility. Carfentrazone-ethyl is non-systemic.

Shark™ Herbicide has been widely tested in California on many crops and cropping systems. Shark™ Herbicide is currently being tested in tree and vine crops. Some of this work is discussed below.

Materials and Methods

In the spring of 2000 Shark™ Herbicide was tested for phytotoxic effects on tree and vine crops under field conditions in the San Joaquin Valley. One year old, dormant grape vines, fruit trees, and nut trees were planted as bare root seedlings on February 15, 2000. Shortly after the trees and vines had initiated growth, a spray application of Shark™ Herbicide was directed to the trunk and low shoots or suckers that were present. Applications were with hand equipment with common settings (three 8003 nozzles, 30 PSI, 30 GPA). Rates tested were 0.03 and 0.06 lb ai per acre (1x and 2x maximum use rate). Thirteen different types of trees and vines were tested and observed for phytotoxic effects at 7, 15 and 30 days after treatment (DAT).

In the winter and spring of 1999 and 2000, Shark™ Herbicide was tested alone and in combination with other herbicides for efficacy evaluations against common orchard weeds. There were six replicated field trials in California and one in Oregon. Weeds were approximately two to eight inches tall when sprayed. Applications were with hand equipment with common spray parameters (25 to 42 PSI, 20 to 27 GPA, flat fan nozzles). Percent control was determined visually at 7, 15 and 30 DAT.

Results and Discussion

The results of the phytotoxicity testing indicated that Shark™ Herbicides caused desiccation and death to suckers or low foliage directly sprayed. Otherwise, there was no adverse effect to the bark, to untreated foliage, or to any growth parameters of these trees and vines. The plants grew vigorously, except for foliage directly sprayed. There was no rate affect. These results indicate that Shark™ Herbicide is safe, even around young trees and vines, as long as desirable foliage is not sprayed.

The results of the efficacy tests are given in the accompanying table. In orchard situations or in any fallow situation, Shark™ Herbicide will be recommended in combination with such products as glyphosate and paraquat. As noted in the accompanying table, Shark™

Herbicide increased the speed of burn down, broadened the weed spectrum, and provided overall better weed control.

Shark™ Herbicide has many potential uses for California agriculture including use on rice and other cereals, cotton, corn, and tree and vine crops. While it may often be used in combination with other products, it may be used alone where susceptible weeds predominate.

Weed control with Shark™ alone and in combination

		% Control*** – 7 DAT								
Treatment*	lb ai/A	MALPA	EROCI	AMSIN	SSYIR	MEDSS	SENVU	CHEAL	HORJU	POANN
Shark+COC	.02 + 1%	80	61	83	93	32	35	80	14	2
RU+COC	.5** +1%	39	31	48	43	10	0	41	85	10
RU+Shark+COC	.5+.02+1%	78	62	87	95	58	33	85	85	14
Gramoxone+COC	.31+ 1%	40	55	76	71	80	80	84	93	90
Gram+Shark+COC	.31+.02+1%	81	73	93	94	92	90	95	94	93
Check		0	0	0	0	0	0	1	0	0
	n	4	5	4	2	1	1	5	1	3
		% Control*** – 15 DAT								
Treatment*	lb ai/A	MALPA	EROCI	AMSIN	SSYIR	MEDSS	SENVU	CHEAL	HORJU	POANN
Shark+COC	.02 + 1%	89	69	96	93	27	28	94	21	4
RU+COC	.5** +1%	74	66	99	95	50	42	88	100	67
RU+Shark+COC	.5+.02+1%	78	94	98	100	92	90	98	100	90
Gramoxone+COC	.31+ 1%	19	50	84	60	52	60	83	95	91
Gram+Shark+COC	.31+.02+1%	81	88	100	100	33	94	91	96	99
Check		0	0	0	0	0	0	0	0	0
	n	3	3	2	1	1	1	3	1	2
		% Control*** – 30 DAT								
Treatment*	lb ai/A	MALPA	EROCI	AMSIN	SSYIR	MEDSS	SENVU	CHEAL	HORJU	POANN
Shark+COC	.02 + 1%	70	46	86	94	7		76	0	0
RU+COC	.5** +1%	55	57	96	89	94		84	100	98
RU+Shark+COC	.5+.02+1%	72	69	97	98	96		84	100	99
Gramoxone+COC	.31+ 1%	15	47	84	63	17		76	95	98
Gram+Shark+COC	.31+.02+1%	56	62	93	97	33		79	95	99
Check		3	0	0	0	0		0	0	0
	n	4	5	4	2	1		5	1	2

*COC = crop oil concentrate; RU = Roundup ULTRA®; Gram = Gramoxone®. ** = to 1 pint of Roundup Ultra;
*** mean data from 7 trials with number of data points indicated by *n* value shown.

Caltrans and Roadside Weed Control

Larry Shields, Caltrans

The California Department of Transportation (Caltrans) maintains approximately 15,000 miles of highway and more than 230,000 acres of right-of-way. The maintenance effort also includes 26,000 acres of planted landscape areas, 86 Safety Roadside Rest and approximately 500 Vista Points and Park and Ride facilities.

California is a geographical and environmental diverse state. Annual rainfall can vary from two inches in Death Valley to over one hundred inches on the North Coast. Highway elevations range from below sea level to over eight thousand feet. Vegetation control strategies vary from region to region. Adjoining land use influences vegetation control requirements for roadside maintenance. When communities develop along a highway corridor, higher levels of vegetation control are needed.

Caltrans utilizes the Integrated Vegetation Management (IVM) philosophy. The idea of IVM is to use the right tool at the right time. The control methods in Caltrans vegetation control program are as follows: Chemical, Mechanical (mowing), Manual, Cultural, Biological, Thermal and Structural.

Objectives of Vegetation Control Program

- provide fire risk control
- sight lines to safety devices
- visibility around curves and at intersections
- protecting the pavements edge from weed damage
- control noxious weeds

Environmental Impact Report (EIR)

In 1992 Caltrans completed an EIR on its vegetation control program. The document included a risk assessment of chemical vegetation control. The findings of the EIR indicated that the chemical program did not pose an environmental risk. However, the department set goals for reducing the use of chemicals because of public concerns: A 50% reduction by 2000 and an 80% reduction by 2012.

Caltrans achieved the first herbicide reduction goal in July 2000 with a 51.6% reduction. The second reduction goal, 80% by 2012, will be achieved by improvements in highway design.

Caltrans new design program, called the “New Perspective” will minimize the need for vegetation control thus reducing the need for chemicals. The new design strategies are in the development stage but may include establishing desirable grasses at the pavement edge that will not need mowing and stay green thus creating a fire break. For more information on the design program, you may visit Caltrans web site, http://www.dot.ca.gov/hq/maint/roadside/.

Reduction strategies

The 50% reduction was accomplished in stages using the following strategies:

Site specific planning - assessing fire risk based on site conditions, keeping the chemical control to a minimum

Better equipment – smart sprayers, WeedSeeker technology senses weeds and applies the required amount of herbicide to achieve control, computerized spray rigs mix precise amount of herbicide

Low volume technology, control droplet application (CDA)

Increase manual control effort:

California Conservation Corps (CCC)

Court referrals (County)

California Youth Authority (CYA)

Department of Corrections

Searching For Herbicide Alternatives

Caltrans is committed to reducing the use of herbicides to control vegetation and is diligently searching for alternatives. The search has been ongoing for several years and will continue into the future. The following list reflects several control devices or strategies that have either been tried or is still being evaluated.

Aqua-Heat

- Diesel fired burner heats water to over 200 degrees
- Hot water applied from a boom a few inches above the ground followed by a tarp shroud to retain heat
- Speed of travel 3 MPH, uses 2000 gallons of water per acre and about 50 gallons of fuel
- Hot water cooks the weed and the weed lays over

Corn Gluten

- A corn byproduct that has weed suppressing value
- 600 to 800 pounds per acre
- repeated application needed

Super Heat (Ag Industrial Manufacturing, Inc, Lodi CA)

- Modified steam cleaner, dry steam
- Heats air to temperatures 400 to 600 degrees
- Travels 1-3 MPH
- Hot air destroys plant tissue, plant yellows and lays over
- Controls annual weeds

Roofing Foam (Polyurethane foam)

- Foam is applied under guardrail as a layer, shuts off sunlight to prevent weeds growth
- Fire and ultraviolet resistant
- Hard surface, can be colored or covered with mulch to blend into the roadside

Fabric (Weed-Ender, by Uteck)

- Fabric is placed in strips under guardrail to shut off sunlight to prevent weeds growth
- Not a landscape fabric – a non-woven material, multi-directional needling of synthetic polyester fibers
- Long lasting, 10 year
- Guardrails – signs - delineators

Vegetative Covers (Road Edge Treatment)

Select vegetation covers that will be planted at the road edge, will be self-sustaining, low growing and will crowd out weeds.

Organic Mulch

Apply a layer of mulch 4 to 6 inches over bare soil to shut off sunlight to weeds

Thermal

Flaming equipment delivers propane fired flame heads over the selected weeds. The heat destroys the green tissue. Flaming is an effective tool for controlling Yellow Starthistle by killing small plants and stopping seed production.

Hard Scape

Hard Scapes is a term designers use to describe the placement of stone, concrete or other inorganic materials used to pave areas in landscape plantings or at the road edge to eliminate bare soil.

Control Burns

The heat from the fire destroys unwanted weeds. (Yellow Starthistle)

Extra Paving

Pave under guardrail, around signs and in narrow bare soil areas to eliminate weed growth.

New Highway Mower Development

The standard highway mowers that are available today do a good job where the terrain is not too steep and where it is permissible to leave the cuttings in place. New mowers are needed that can mow closer to highway obstacles, follow a variety of uneven terrain and move or pickup the cuttings.

University of California, Davis – Hopland Research Center – Steve Young

Caltrans has contracted with the university to conduct research to fine viable alternatives to synthetic herbicides for controlling vegetation. The research project will be conducted over a three year period and will includes the evaluation of the following:

- Bioherbicides (fatty acids – Scythe, acetic acid – vinegar & lemon juice)
- Barriers/mats (polypropylene fibers block out weeds, water, air and nutrients pass through)
- Steam
- Cultivation
- Mechanical and chemical combined (brush mower that applies herbicide as it mows)
- Natural plant products (glucosinolates – compounds in plants that have biological activity)
- Ultra violet light (removing weeds with uv light)

Control of Eurasian Watermilfoil in Mesocosms at Lake Tahoe

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The introduction of Eurasian watermilfoil (*Myriophyllum Spicatum*) to the United States is thought to have occurred in the 1940s or earlier (Mullin *et al.* 2000). This submersed plant can spread rapidly within and between bodies of water primarily because of its ability to reproduce by vegetative fragments (Smith & Barko 1990). Eurasian watermilfoil is perhaps the most common aquatic weed problem in North America. Unfortunately, one of the problem sites is in ultaoligotrophic Lake Tahoe CA/NV. The introduction of Eurasian watermilfoil to Lake Tahoe probably occurred 35 years ago in the Tahoe Keys Marina (Walter 2000). Today, the plant is continuing to spread to bays and other marinas.

Negative impacts on recreational activities such as swimming, boating and fishing as well as ecological threats such as the displacement of native species and habitat loss are cited as reasons for management in most situations where nuisance growth of Eurasian watermilfoil is a problem. While this is also the case for Lake Tahoe, extraordinary efforts underway to save the lake from eutrophication make the management of Eurasian watermilfoil particularly important and difficult. The continued spread of Eurasian watermilfoil may increase the problem of eutrophication, especially locally, by leaking sediment-derived phosphorus into lake water from its shoots (Walter 2000).

Despite recent evidence that Eurasian milfoil is spreading and negatively impacting Lake Tahoe, there is currently no plan to implement an effective management or eradication strategy. Current management is limited to harvesting in the Tahoe Keys and may be contributing to the production of fragments and spread of the plant. Opposition to the introduction of any biological or chemical agent currently prohibits the development of an integrated approach. A basin-wide water quality control plan establishes a zero tolerance for the addition of any pesticide to the lake, including EPA registered aquatic herbicides. Hopefully, this study will start a discussion on the possibility of using an integrated strategy to effectively manage and stop the spread of Eurasian watermilfoil in Lake Tahoe. The purpose of this study is to provide and discuss efficacy and dissipation data for Aquathol K®, Sonar AS® and Sonar SRP® used in isolated mesocosms containing Eurasian watermilfoil, water and sediment collected from Lake Tahoe.

Methods and Materials

This research was conducted at the Tahoe Keys Water Treatment Facility in South Lake Tahoe, CA during the summer and fall of 2000. Eurasian watermilfoil fragments, water and sediment were collected from Tallac Lagoon located at the south end of Lake Tahoe and transferred to 20 separate 80 liter plastic barrels. Each barrel was filled with approximately eight liters of sediment after removing any plant material. Ten 20 cm Eurasian watermilfoil fragments with a combined fresh weight of 27 g were then planted in the sediment of each barrel. The barrels were then placed in 1500 liter fiberglass tanks in which lake water was pumped through at a rate 810 liter h^{-1}. Each fiberglass tank served as a water bath for five barrels so that herbicide treated water could be isolated from lake water and maintained at the ambient lake water temperature. The water temperature ranged from 18 to 22 °C in August, 14 to 19 °C in September and 8 to 14 °C in October.

Plant fragments were allowed to grow from July 31, 2000 to September 11, 2000 before treatment. Individual plant fragments grew from 10 cm each to a height of about 30 to 50 cm each. During this time, standpipes in the fiberglass tanks were set at 86 cm so that the 58 cm barrels were completely submerged. Standpipes were lowered to 43 cm three days before treatment to isolate herbicide treated water in the barrels from circulating lake water. Shade screen covers were placed over the fiberglass tanks in order to maintain light levels inside the barrels at approximately 650 μmol m^{-2} s^{-1} which is similar to the amount of light penetrating to a depth of one to two meters in Tallac the lagoon.

Herbicides used in this study were fluridone (1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4(1*H*)-pyridinone) with the trade name Sonar AS® and Sonar SRP® and dipotassium salt of endothall (C8H8O3K2) with the trade name Aquathol K®. These herbicides were applied at the following application rates: 5 μg L^{-1} fluridone as Sonar AS® (0.0135 quarts per acre-foot), 10 μg L^{-1} fluridone as Sonar AS® (0.027 quarts per acre-foot), 10 μg L^{-1} fluridone as Sonar SRP® (0.56 pounds per acre-foot) and 1.5 mg L^{-1} dipotassium salt of endothall as Aquathol K® (1.0 gallon per acre-foot). The Sonar AS® and Aquathol K® treatments were applied by first diluting the liquid herbicides into a larger volume of water and then pouring this solution into the respective barrel. The Sonar SRP® treatments were applied by first breaking pellets into smaller pieces and then spreading these pieces evenly over the surface of the water in each barrel.

Each herbicide treatment and a non-treated control were randomized in a complete block design and replicated four times. Herbicides were applied on September 11, 2000. Water samples were collected from mid-barrel with disposable pipettes before treatment, 24 and 48 hours after treatment and weekly thereafter. Samples were immediately frozen on dry ice after collection and maintained at –80 °C until they were shipped to SePro Corporation for FastTEST™ analysis. Additional fluridone applications were made 22 days after treatment to bring concentrations back up to the target concentrations of 5 or 10 μg L^{-1}. Plants were harvested ten weeks after herbicide application. Living root and stem material was separated from dead material and filamentous algae. All plant material was weighed fresh and then dried at 70 °C for 48 hours before weighing dry biomass. Statistical analyses of treatment means were performed using Bonferroni/Dunnett ANOVA in Stat View version 4.5 by Abacus Concepts, Inc. © 1996.

Results & Discussion

Fluridone concentrations in the barrel water were close to target concentrations of 5 and 10 $\mu g\ L^{-1}$ for the two Sonar AS® treatments, AS 5 and AS 10 respectively (Figure 1). Concentrations in the water were lower than target concentration of 10 $\mu g\ L^{-1}$ for Sonar SRP® treatments. This was expected as the pellet formulation is intended to release fluridone slowly over time near the roots and sediment-water interface. Fluridone concentrations in the water following treatment with Sonar SRP® were likely higher in this small-scale experiment than would be expected in the field because small pieces of pellets had to be used.

The contact herbicide Aquathol K® provided excellent control of Eurasian watermilfoil and by ten weeks after treatment had reduced living biomass to zero (Figure 2). Necrotic symptoms from the Aquathol K® treatments were visible in the milfoil one week after treatment. Ten weeks after treatment, the mean filamentous algae and *Chara* biomass in the Aquathol K® treatment was significantly ($p < 0.005$) larger than the three Sonar® treatments and the non-treated control (data not shown).

Both formulations and rates of the systemic herbicide Sonar® provided less dramatic but significant ($p < 0.005$) reductions in biomass compared to the non-treated control (Figure 2). Injury symptoms, chlorosis of apical growing tips, were visible 14 days after treatment. More dramatic reductions in biomass relative to non-treated controls would probably have been observed if the plants were harvested a few weeks later or if water temperatures in the month of October were warmer. Because of the concern for mixing treated water with lake water in the flow-through system in the event freezing temperatures, the experiment was completed on November 4, 2000 when minimum water temperatures reached 4 °C.

This study demonstrates significant reductions of Eurasian watermilfoil biomass with Aquathol K® and all tested rates and formulations of Sonar®. Currently, additional analyses of water and sediment samples as well as milfoil recovery are being conducted. A similar study is planned for spring/early summer. Larger scale, field studies should be conducted in conjunction with current management practices in order to develop an effective and integrated strategy to manage and stop the spread of Eurasian watermilfoil in Lake Tahoe.

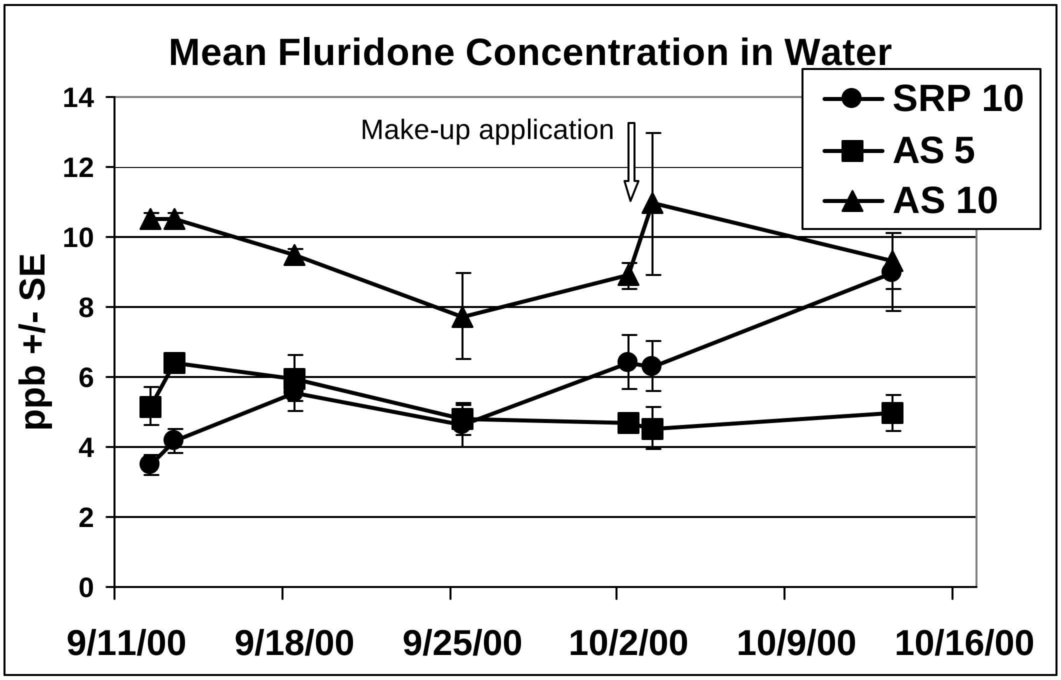

Figure 1. Mean weekly fluridone concentrations (ppb or mg L^{-1}) in barrel water at 5 and 10 ppb rates for Sonarâ AS (AS 5 and AS 10, respectively) and 10 ppb Sonarâ SRP (SRP 10). Means and standard errors (bars) of four replicates.

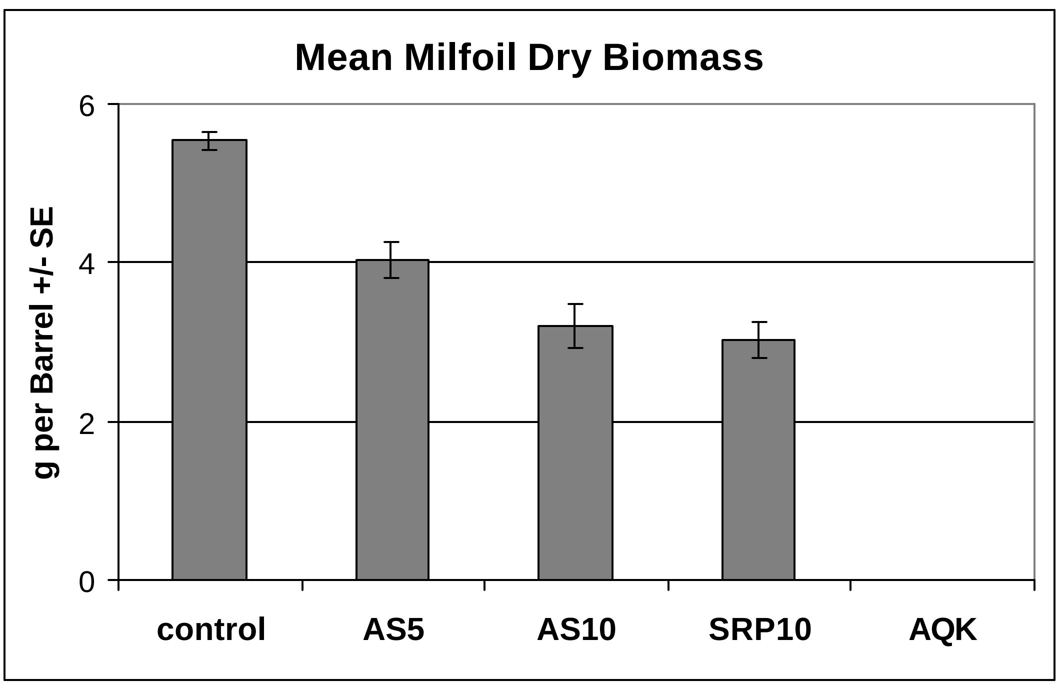

Figure 2. Mean plant biomass (g dry weight $barrel^{-1}$) of Eurasian watermilfoil for the treatments, 1.5 ppm Aquathol Kâ (AQK), 5 and 10 ppb rates for Sonarâ AS (AS5 and AS10, respectively) and 10 ppb Sonarâ SRP (SRP10). Means and standard errors (bars) of four replicates.

Acknowledgements

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Giant Salvinia: A New Aquatic Invasive Species Threat

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Giant salvinia has been labeled as the world's worst aquatic weed. It has been on the Federal Noxious Weed list for two decades. This preventative measure did not prevent the unfortunate escape of this aquatic invasive species into the wild. In 1998 it was found in a school wetland display near Houston, TX. Giant salvinia had been accidently introduced with other aquatic plants purchased for the project. Texas authorities found it being distributed in several other nurseries where it was removed. Nurseries in California and Arizona also had giant salvinia available. Native to South America, giant salvinia has growth characteristics similar to water hyacinth.

In August, 1999, giant salvinia was collected from the Lower Colorado River on the Imperial National Wildlife Refuge, Martinez Lake, Arizona. A Task Force was quickly formed and the source was found in the Palo Verde Irrigation District (PVID) drain near Blythe, CA. The multi-agency Task Force quickly formed a survey team to determine the extend of the invasion and plan a course of action. A Scientific Advisory Team estimated 1 million plant buds flowing into the Lower Colorado River each day from the source in the PVID drain. The Task Force drafted Environmental Assessments, Pesticide Use Proposals and conducted Public Information meetings before starting chemical controls on giant salvinia in the upper sections of the Colorado River in early 2000. Spraying started in December, 1999, with the approved herbicide Diquat in the PVID drain. Although spraying has been almost continuous, these efforts have been unable to eradicate giant salvinia in the drain. The 2 man, one boat, spraying operation has been a joint effort by the California Department of Food & Agriculture, PVID and Bureau of Reclamation with financial assistance from other Task Force members. The bank vegetation overhang prevented total herbicide coverage and giant salvinia soon recovered. Bank cleaning was started in the upper PVID December, 2000. Excavation units from BOR and PVID will work together to clean banks and spray giant salvinia right up to the dirt line to eradicate these sources as the cleaning work moves down the drain. A floating boom placed near the drain outflow will capture floating giant salvinia buds preventing them from entering the Colorado River.

Future actions of the Task Force will include educational efforts to prevent spread out of the present locations. Although giant salvinia has grown fairly well in waters on the Cibola National Wildlife near where the PVID enters the Colorado, in other sections it has not exhibited the growth rate expected for this invasive species. It was reported in some backwaters in 1999 but was completely absent in 2000 surveys. Experts are studying what factors may be inhibiting characteristic explosive growth. Plant buds have flowed into Mexico but no problems have been noticed. Educational materials are being produced in English and Spanish. Task Force efforts will concentrate on keeping the source as small as possible and preventing spread which would increase control efforts and costs significantly. Biological control may be possible in the next few years but until then, controls will rely on herbicides, man power, equipment and most importantly, money.

Herbicides in Recycled Water

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Introduction

In 1970, I foresaw the need to reduce nitrogen usage in the environment to reduce nitrate percolation into groundwater. In assessing what could be done, I decided that the most practical thing to do would be to recycle the irrigation runoff from container crop irrigation. Recycling water would also eliminate the need to have an NPDES (National Pollution Discharge Elimination System) permit. Such a permit is necessary if there is any discharge into a navigable water. Dry flood control channels are narrowly considered this also by some regional boards. Since runoff from overhead irrigation of container crops often amounts to 50% of that which is applied, recycling this runoff reduces N (nitrogen) usage by 50% because the N is recycled also.

The California Water Quality Control Board does not have set MCLs (maximum contaminant levels) for each pesticide or contaminant in runoff water. They leave it up to any of the 9 regional water quality control boards to set limits for any contaminant to 1) protect the environment, 2) protect a particular species, or 3) preserve beneficial use.

In 1970, I presented a proposal to grower groups to seek nominal funding for such a project and that Monrovia would do the research which would be shared by all. I had no "takers". I then requested cooperation from the University of California. They stated that they did not feel it was an important issue to warrant such research. After conducting research for 7 years, the University approached me and stated that they would be willing to cooperate in such a research project. I declined. It was too late! I had already completed most of my research.

When one recycles water, there are a myriad of factors which must be considered. One of the foremost is the problem of recycled herbicides – how much gets into the water, how can it be reduced and how will it influence ornamental plant growth. We grow 1400 different species and cultivars of ornamentals and some of them do not tolerate any herbicide.

The research with herbicides was basically divided into 2 main groups, the pre-emergence and post-emergence herbicides. The pre-emergence group was divided into 3 studies:

To determine the most efficacious water treatment – a lab study.

The collection of runoff from land and container applied herbicides, processing this water and recycling it.

The spiking of individual herbicides into simulated runoff, treating this water and applying the processed water to plants sensitive to those herbicides.

Methods and Materials

Pre-emergence Herbicides: Phase I, Water Treatment Efficacy Study

Runoff contains suspended solids, mainly clays. This colloidal fraction is not filterable through sand filters and must be flocculated before it can be filtered. A number of inorganic coagulants and polymers were tested for their efficacy in flocculation and aggregation. Alum and a cationic polymer were chosen. A pilot water treatment plant was built to process the runoff. Following flocculation and settling, the water was "polished" through a sand + anthracite coal filter. This is basically the same system as is used by public utilities to process drinking water.

Pre-emergence Herbicides: Phase II, Field Plot Runoff Recycling

This phase consisted of applying pre-emergence herbicides to land plots and to the containers crops on that land with specific herbicides and in some cases, multiples of different herbicides. The runoff from overhead irrigation was collected, sampled for analysis and recycled over container ornamentals known to be sensitive to these herbicides. Since many of the herbicides adsorb on the colloidal particles, removal of the colloidal fraction from the water should also remove much of the herbicides. The chromatographic analyses defined the efficacy of removal. The recycling over sensitive ornamentals provided information on the effect of "residuals" on the growth. The herbicides studied in these phases were:

Oxadiazon (Ronstar) @ 2.25 lb ai/A

Napropamide (Devrinol) @ 5.0 lb ai/A

Simazine (Princep) @ 0.7 lb ai/A

Alachlor (Lasso) @ 3.0 lb ai/A

Oryzalin (Surflan) @ 3.0 lb ai/A

DCPA (Dacthal) @ 10.0 lb ai/A

Nitralin (Planavin) @ 2.0 lb ai/A

Pre-emergence Herbicides: Phase III, Artificially Spiked Runoff Recycling

This phase consisted of spiking individual herbicides into water with a known amount of soil colloids to simulate the turbidity of the runoff, treating the water to remove the colloids and applying this water to container ornamentals sensitive to these herbicides. Spiking rates were based on a worst case scenario that one-half of the applied herbicide would erode with the first irrigation. Subsequent spiking was done at l/8 field rate.

Post-emergence Herbicides: Bioassay and Phytotoxicity Study

This study evaluated the effect of cacodylic acid (Phytar), paraquat and weed oil (no longer used) on the growth of plants. Since cacodylic acid is an arsenical, an arsenic background check of the fresh source water was necessary before beginning the study. Arsenical analyses were conducted on the runoff water, before and after water treatment. Since there was no known study of the sensitivity of ornamentals to arsenic, the processed runoff water was applied to vegetables and other crops known for sensitivity to arsenic, in addition to the application to ornamentals. The crops tested for phytotoxicity were sweet corn, lima beans, onions and strawberries. Plots were set up and the entire soil surface under the containers was treated.

The treatments were: 1) untreated check, 2) cacodylic acid @ 1 qt Phytar/100 gpa, 3) paraquat @ 1 qt/100 gpa and 4) weed oil at 20% oil + 80% water initially; and 100% oil subsequently. Treatments were repeated every 60 days.

Results

Chromatographic analyses of the runoff from the land plots indicates that we removed 64 to 97% of the lower solubility pre-emergence herbicides and 0 to 35% of the higher solubility herbicides, such as napropamide. Correspondingly, phytotoxicity was greatest with processed water from the higher solubility herbicides (Table 1). Analysis of the artificially spiked simulated runoff indicated that 35 to 97% of the pre-emergence herbicides was removed by conventional water treatment (flocculation and filtration) (Table 2).

The mean plant response to recycled runoff from the post-emergence treated plots varied from 96 to 102% of the growth in the untreated check. Corn coleoptile growth from the runoff of the cacodylic acid plots indicated that not only was there an absence of phytotoxicity , but a slight stimulation (Table 3). There were no differences in appearance of any of the vegetable crops. Yields increased for sweet corn and green onions and decreased for dry onions and the fresh weight of oats (Table 4). Arsenical levels in the strawberries were very low.

Bioassays of *Poa annua* in actual treated field runoff, indicates suppression of germination and growth. However, charcoal filtration of the processed runoff, stimulated germination and growth, well beyond that of the checks in fresh water indicating that there are growth enhancers in the runoff (Table 5). *Poa annua* was our major grass weed prior to recycling and is no longer a problem. This was an unexpected benefit of recycling. The suppression exists at very low ppb levels.

Glyphosate spiked water tests indicate there could be some phytotoxicity at approximately 100 ppbai (Table 6). Oxyflourfen threshold determination trials indicate possible phytotoxicity at levels as low as 2.5 ppbai with sensitive plants such as grapes receiving overhead irrigation (Table 7).

Conclusions

These studies show that it is possible to remove a substantial amount of pre-emergence herbicides by conventional water treatment involving flocculation, settling and filtration. It also indicates that if a pre-emergence herbicide has high solubility (5 mg/l or more), that adsorption sites on the colloidal fraction are quickly saturated and that there is enough residual dissolved herbicide in the filtrate to affect the growth of sensitive ornamentals. The arsenical bioassays with corn and other crops show that minute traces of arsenic in very low ppb amounts stimulates growth of these crops. Also, very low ppb levels of pre-emergence herbicides may stimulate the slightly sensitive plants or it may act as a growth regulator on very sensitive plants, resulting in an enhanced appearance.

These experiments were conducted under worst case scenarios, and under actual practices, levels are considerably less. In many cases, the concentrations are more than 1000 fold less. These concentrations are in the very low 2 digit and one digit ppb range and sometimes are undetectable.

If a grower embarks on recycling runoff, problems can be reduced by following certain practices:

- Use of low solubility herbicides which have strong adsorption characteristics
- Staggering of applications so that the entire field is not treated at the same time
- Treating the runoff with flocculants before filtration, or allow 2 to 5 days settling in a quiescent pond before recycling
- Blending the runoff with at least 50% fresh make-up water
- Using glyphosate only for spot treatments
- Applications of oxyflourfen only on dormant stock showing no bud break activity

Table l. Yield of ornamentals irrigated with runoff water from treated land and containers

Container Treatment %	Herbicide	Distribution lb ai/A	Land Treatment
34	Nitralin	2.0	Surflan @ 3.0 lb ai/A
18	Oxadiazon	2.25	
12	Oryzalin	3.0	
12	Napropamide	5.0	
12	Simazine	0.7	
10	DCPA	10.0	
2	Alachlor	3.0	

Plant	Yield as % of Check
Mahonia aquifolium	57
Nerium 'Seely Pink'	77
Pinus thunbergi	77

Pinus pinea	99
Convolvulus cneorum	92
Cortaderia selloana	114
Arbutus unedo compacta	93
Avena sativa	115
Lolium multiflorum	59

Table 2. Herbicide removal from spiked water using conventional water treatment

Herbicide	Added before clarification, mg/l	Detected after clarification, mg/l	% Removal based on addition	analysis
Oxadiazon	10.0	0.50	95	82
Oryzalin	12.0	1.22	90	82
Simazine	2.8	0.22	93	93
DCPA	40.0	1.16	97	97
Napropamide	20.0	11.10	45	35

Table 3. Corn coleoptile arsenic bioassay of runoff

Treatment	Mean coleoptile length, cm
Check	14.31
Cacodylic acid, l gal Phytar/100 gpa	14.94

Table 4. Agronomic and vegetable crop yields irrigated with runoff from cacodylic acid treated beds

Crop	Yield (% difference from check)
Corn (cobs)	+22
Corn (stalks)	+11
Onions (green)	+3
Onions (dry)	-8
Oats (fresh)	-3

Table 5. Poa annua bioassay of recycled water

Bioassay test	Non-processed Runoff	Processed Runoff	Blended Runoff	Fresh Fortified	Charcoal filtered Processed runoff
Top length, cm	1.72	1.84	2.22	2.64	3.40
% Germination	29	36	37	83	96
# Seedlings emerged	54	59	56	86	126
% Seedlings w/roots	18	8	31	80	92

Table 6. Glyphosate phytotoxicity trials in recycled water

Test 1. Misting: 8 sec/5 min/6 hrs/day for 28 days **Test plant: Tomato**

Glyphosate, ppbai	Shoot fresh wt., g	Phyto Symptoms
0	147	None
50	120[1]	None
200	114[1]	Slight
400	98[1]	Moderate

[1] Significant at 0.05

Test 2. Misting: 8 sec/5 min/6 hrs/day for 35 days

Glyphosate, ppbai	Shoot fresh wt, g	Phyto Symptoms
0	151	None
25	134	None
50	141	None
100	131	None

Table 7. Oxyflourfen threshold determination in recycled water

Elapsed time (days) of exposure to onset of phytotoxicity symptoms
Misting: 20 sec/12 min/10 hrs/day for 21 days

Oxyflourfen, ppbai	*Vitis* 'Thompson Seedless'	*Hydrangea* 'Red N Pretty'™
10	1	2
5	4	6
2.5	10	14
0	none	none

Weed Control in Ornamentals

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Weeds are commonly found in any ornamental site. These plants may not be a problem (weeds) since they may not be competitive or aesthetically displeasing. These small plants may be low-growing and scattered, and thus may not be considered weeds. On the other hand the plants may be large, are competing with the desired plants for nutrients and water, and are obviously a bad site, thus are weeds. Weeds can be a problem in all sites where ornamentals are grown, either as a landscape location or as a growing crop.

There are many locations where ornamentals are grown in California, namely urban or commercial landscapes, public buildings and infrastructure, parks and recreation sites, and production sites. Production of ornamentals can further be divided into container and field woody ornamentals, greenhouse-grown flowers, and field-grown flowers and bulbs. Often there are specific weed species associated with the different growing sites. In landscape sites weed are often the same species found at the location, whereas in container-grown nurseries, weeds are commonly found associated with the nursery culture; specifically, common groundsel, creeping woodsorrel, bittercress, spurge and willowherb.

There have been some major changes that have occurred in the ornamental industries over the late few years. These include the increase in use of synthetic (geotextile) and naturally produced mulches in the landscape, reduced dependence on preemergence herbicides in landscape and nursery production areas, " as needed" applications of post emergence herbicides, and the 2005 phase-out of methyl bromide as a preplant fumigant with the need for alternatives for hundreds of crops.

Mulches have many uses in the landscape. When a wood-derived mulch is used without a synthetic fabric underneath, often annual grasses and bermudagrass or other perennial weeds become more prevalant. The use of a synthetic fabric will reduce the number of yellow nutsedge compared to a preemergence herbicide or mulch alone. Though black plastic (polyethylene) is effective for weed control, it is not water and air permeable. The newer polypropylene fabrics are sometimes slightly less effective for weed control than black plastic but they remain effective for a longer period of time than black plastic and allow water and air to penetrate to the soil. All of these synthetic mulches would have a wood-derived mulch of the top of them to make them more aesthetically pleasing. In container grown ornamentals, yard waste, almond shells and pecan shells have given control of most of the common weeds found in this industry, though they may not be as effective as herbicides for the broad spectrum of weeds. Also, weeds may germinate and establish in the mulch from seeds coming in from outside the container.

Preemergence herbicides can be used with wood-derived mulches. These herbicides are deactivated by adsorption onto organic matter and clay. The colloidal size of clay and organic matter is 0.000001 to 0.001 mm diameter. If a 1 cm cube of the smallest diameter particle were evaluated for surface diameter to absorb herbicides, it would be equivalent to 6000m^2 or about ½ acre. Thus when compared to 1 ½ to 2 inches of chip mulch present, there would be more contribution from obstruction from the mulch for the herbicide to reach the soil than adsorption and herbicide loss. In two studies, Kuhn's in Pennsylvania and Elmore in California, found that oryzalin was slightly more effective for weed control when used before compared to after a chip mulch was applied, whereas oxadiazon was effective if use before mulch application but weed control was reduced when the herbicide was applied after the mulch application. The obstruction was greater from the mulch on the oxadiazon. This result is due to the mode of action of this herbicide, which requires a critical continuous layer of herbicide to be present to be effective.

There are many preemergence herbicides available for use in container grown ornamentals. The most frequently used herbicides are isoxaben, oryzalin, oxadiazon, pendimethalin or prodiamine used alone or a combination of oxyfluorfen plus oryzalin or oxyfluorfen and pendimethalin. All of these herbicides need to be matched with the weed species present and the species and plant age of the ornamental plant material being grown.

Field-grown flowers are a very diverse group of ornamentals. They are being grown for the cut flower, fresh or dry foliage, fruits and bulbs. The plants may be annual or perennial, direct seeded, transplanted or planted from bulbs, or young propagative materials (cormels, rhizome, tubers, etc). Preemergence herbicides are not available, nor will they be for each species, thus there is need for a preplant treatment that could be used for many species. There are herbicides available that can be used on some species including Gypsophilia, Limonium, Dutch iris, Narcissus, gladioli and many woody species. Most of the other species require clean seedbeds, cultivation and hand weeding as the major methods of keeping weeds in check.

Yard waste has been evaluated as a weed control method compared to several herbicides in Dutch iris. Results indicate that weed control is possible, sometimes with a slight delay in flower maturity, but at other times with no effect. Herbicides that were safe in Dutch iris trials included: diuron, linuron, isoxaben (removed from the label), dimethenamid (not registered in California), DCPA, quinclorac (not registered in California) and thiazopyr (not registered for ornamentals in California). In China aster and snapdragon, as transplants however, though yard waste has controlled weeds, there has been some killing of snapdragon when the mulch contacts the base of the transplants.

Many herbicides have been evaluated for weed control and plant tolerance in several field-grown flower crops (Table 1). In *Clarkia* spp. (Godetia) isoxaben was selective on transplants, however many herbicides reduced early vigor though flower yield was not reduced. Other herbicides killed the transplants. Similar results have been shown with the crop *Delphinium* spp. transplants. Low rates of pendimethalin or isoxaben gave some weed control but were only moderately safe on the plants. Other herbicides killed the plants. Snapdragon was sensitive to all the preemergence herbicides evaluated (Table 1). No new herbicides were found to be safe on *Limonium sinuatum* or *L. tartaricum* other than the herbicides currently available.

The post emergence herbicides clethodim, fluazifop and sethoxydim were found to be safe on all broadleaf ornamentals tested when they were in the vegetative stage as transplants. Grasses including annual bluegrass were controlled with clethodim but not with others. Clopyralid was evaluated for broadleaf control of aster and legume family weeds. Clopyralid was phytotoxic to China aster and snapdragon transplants but L. sinuatum was partially tolerant.

New, potential preplant fumigants evaluated to replace methyl bromide included iodomethane and propargyl bromide. Both of these fumigants are broad- spectrum pesticides and have been effective for the control of annual weeds and residual bulbs of calla lily and gladioli. Registered fumigants 1,3 dichloropropene (1,3-D) and chloropicrin were also evaluated in combination with metam sodium for broad-spectrum pest control. At the rates and methods of applications of 1,3-D and chloropicrin there is little weed control achieved. Metam sodium will be needed to obtain weed control. Chloropicrin has been shown to give effective weed control at 300 pounds per acre if applied into the bed top using drip irrigation. Additional research will be conducted to evaluate more fumigants and other preplant treatments for flower crops. Although other products such as composted chicken manure, blood meal and corn gluten meal have been combined with solarization; additional weed control was not apparent over solarization alone.

Weed control can be achieved in landscape plantings and most container-grown ornamentals. However, in field and greenhouse flowers a preplant treatment for a broad spectrum of pests will be difficult to develop for the market place. It probably will be even more difficult to maintain these products for the growers.

Multiple Applications of Proxy (ethephon) for Seed Head Suppression on an Annual Bluegrass (*Poa annua*) Putting Green

Mark M. Mahad, Mark M. Mahadv and Associates. Inc.

Introduction

A field research trial conducted on an annual bluegrass putting green at the Spanish Bay Golf Links located in Pebble Beach, California during 1999 showed a 96% reduction in Poa annua seed heads when compared to untreated check plots 14 days after a single treatment of Proxy (ethephon) applied at a rate of 5.0 ounces of product per thousand square feet (oz/M). Seed head suppression in Proxy treated plots remained at 96% 28 days after treatment (DAT). By 39 DAT the level of annual bluegrass seed head suppression had fallen to 30%. Embark (4.0 oz/A) exhibited 42% seed head suppression and Primo 1 EC (0.12 oz/M) exhibited 12% seed head suppression 28 DAT.

No injury or reduction in surface quality was observed following a single Proxy application at the 5.0 or 10.0 ounce rate. Surface appearance improved based on the virtual elimination of annual bluegrass seed heads.

The objectives of this new Proxy field study were as follows:

1. to determine the effect of three Proxy treatments applied at six week intervals for seed head suppression on an annual bluegrass putting green, and

2. to evaluate the potential for Proxy to injure an annual bluegrass putting green when subject to this multiple application program.

Materials & Methods

The field study was conducted on the chipping green at the Links at Spanish Bay Golf Club located in Pebble Beach, California. This area is characterized as a true coastal Mediterranean climate with cool, foggy summer conditions. High daytime temperatures generally range from 60 to 70° F with nighttime low temperatures of 48 to 55° F.

This USGA sand specification chipping green consisted of 100% annual bluegrass and was mowed seven days per week at a cutting height of 140/1000". The green received regular foliar fertilizer treatments, was aerified with 1/." hollow tines once during the 18 week trial and was irrigated to avoid moisture stress. An initial rating on the day of the first application, March 21, 2000, showed a mean average of 37.5% Poa seed head cover across four replications.

Treatments as presented in Table 1 were deployed on March 6, April 20 and May 29, 2000. The soil temperature registered 51.8° F at a depth of three inches and the air temperature was 57.2° F at 9:29 a.m. during the first treatment deployment. Individual treatment plots measured 5' x 10' with 24" aisleways. Treatments were replicated four times in a randomized complete block design. A calibrated C02 propelled spray system pressurized to 26 psi and equipped with 11004LP Tee-Jet nozzles applied treatments at a spray volume of 65 gallons per acre. A pacing watch was used to ensure appropriate walking speed and accurate applications.

Treatment evaluations consisting of percent annual bluegrass seed head cover and annual bluegrass injury were conducted at approximate rating dates of 7, 14, 28 and 42 days after every treatment. Annual bluegrass injury was rated on a 0 to 10 scale with 0 representing no injury, 3 minimally acceptable injury and 10 dead grass. Percent seed head control was calculated based on a comparison between the untreated check and changes in percent seed head cover. A simple green speed evaluation using the stimpmeter was conducted during six rating dates. Data were summarized and statistically analyzed. Differences between means were determined via LSD.

Results & Discussion

Annual Blue-grass Injury

- No treatment exhibited observable injury to annual bluegrass during any of the 14 rating events throughout the course of the 18 week trial. A visual review of soil cores following the trial showed no observable difference in root depth or density among treatments.

Proxy Performance Following the First of Three Applications (Table 1)

- Proxy at the 5.0 and 10.0 ounce rates showed limited seed head suppression, 4% and 11 % control, respectively, 7 days after the first application. However, by 15 DAT seed head control had increased dynamically to 70% for the 5.0 ounce rate and 85% control for the 10.0 ounce rate.

- The 10.0 ounce Proxy rate showed better seed head suppression than the 5.0 ounce rate on six of six ratings dates following the first application. During three of six rating events, 15, 28 and 44 DAT, the differences were statistically significant. Over the course of six rating dates encompassing 44 days after the first application, the 10.0 ounce Proxy rate showed an average improvement in control of 13.3% per rating event when compared to the 5.0 ounce rate. Control fell off dramatically for both rates between 28 and 35 DAT.

- The 10.0 ounce Proxy rate was consistently more visually dynamic than the 5.0 ounce rate relative to annual bluegrass seed head suppression.

Table 1. Percent Seed Head Cover and Control on an Annual Bluegrass Putting Green Following the First of Three Proxy Treatments Applied at Six Week Intervals. The Links at Spanish Bay, Pebble Beach, CA. Mahady & Associates, Inc. 2000.

Treatments	Rate	Application Schedule	Cover (Control) 3/13/00 7 DAT	Cover (Control) 3/21/00 15 DAT	Cover (Control) 3/28/00 22 DAT	Cover (Control) 4/4/00 28 DAT	Cover (Control) 4/11/00 35 DAT	Cover (Control) 4/20/00 44 DAT
1 Check			33.8 a[1]	42.0 a	59.5 a	58.8 a	72.5 a	47.5 a
			(0%)	(0%)	(0%)	(0%)	(0%)	(0%)
2 Proxy	5.0 oz/M	3/6/00	32.5 a	12.8 b	6.3 b	11.3 b	35.0 b	21.3 b
		(#1 of 3)	(4%)	(70%)	(89%)	(81%)	(52%)	(55%)
3 Proxy	10. 0 oz/M	3/6/00	30.0 a	6.5 c	2.3 b	3.3 c	16.0 c	15.5 b
		(#1 of 3)	(11 %)	(85%)	(96%)	(94%)	(78%)	(67%)

[1]Means followed by the same letter do not differ significantly (P=0.05, Duncan's MRT)

Proxy Performance Following the Second of Three Applications (Table 2)

- Following the second Proxy treatment, response as interpreted as a rapid reduction in the presence of annual bluegrass seed heads, was much more rapid than that observed following the first application. Seven days after the second Proxy treatment, seed head control had increased dynamically to 88% for the 5.0 ounce rate and 93% control for the 10.0 ounce rate. There was no 15 day lag time for an acceptable level of control as was observed following the first application.

- The 10.0 ounce Proxy rate showed better seed head suppression than the 5.0 ounce rate on five of five ratings dates following the second application. However, on only one of five rating events, the 39 DAT rating, was the difference statistically significant.

- Over the course of five rating dates encompassing 39 days after the second application, the 10.0 ounce Proxy rate showed an average improvement in seed head control of 9.5% per rating event when compared to the 5.0 ounce rate.

- Percent seed head control fell off dramatically for both rates between 28 and 39 DAT.

- The 10.0 ounce Proxy rate was consistently more visually dynamic than the 5.0 ounce rate relative to annual bluegrass seed head suppression.

Table 2. Percent Seed Head Cover and Control on an Annual Bluegrass Putting Green Following the Second of Three Proxy Treatments Applied at Six Week Intervals. The Links at Spanish Bay, Pebble Beach, CA. Mahady & Associates, Inc. 2000.

Treatments		Rate	Application Schedule	Cover (Control) 4/20/00 DOA2	Cover (Control) 4/27/00 7DAT2	Cover (Control) 5/4/00 14DAT2	Cover (Control) 5/18/00 28DAT2	Cover (Control) 5/29/00 39DAT2
1	Check			47.5 a (0%)	55.3 a (0%)	56.3 a (0%)	63.8 a (0%)	61.3 a (0%)
2	Proxy	5.0 oz/M	4/20/00 (#2 of 3)	21.3 b (55%)	6.8 b (88%)	4.3 b (92%)	9.0 b (86%)	25.0 b (59%)
3	Proxy	10. 0 oz/M	4/20/00 (#2 of 3)	15.5 b (67%)	4.0 b (93%)	1.0 b (98%)	2.8 c (96%)	15.0 c (76%)

Proxy Performance Following the Third of Three Applications (Table 3)

- Seven days after the third Proxy treatment, visual estimations showed 75% seed head control at the 5.0 ounce rate and 82% for the 10.0 ounce rate.
- The 10.0 ounce Proxy rate showed better seed head suppression than the 5.0 ounce rate on five of five ratings dates following the third application. However, on only one of five rating events, the 14 DAT rating, was the difference statistically significant.
- Over the course of five rating dates encompassing 42 days after the second application, the 10.0 ounce Proxy rate showed an average improvement in seed head control of 4.6% per rating event when compared to the 5.0 ounce rate.
- Percent seed head control fell off dramatically for both rates between 28 and 42 DAT.
- The 10.0 ounce Proxy rate was consistently more visually dynamic than the 5.0 ounce rate relative to annual bluegrass seed head suppression

Table 3. Percent Seed Head Cover and Control on an Annual Bluegrass Putting Green Following the Third of Three Proxy Treat~s Applied at Six Week Intervals. The Links at Spanish Bay, Pebble Beach, CA. Mahady & Associates, Inc. 2000.

Treatments		Rate	Application Schedule	Cover (Control) 5/29/00 DOA3	Cover (Control) 6/8/00 7DAT3	Cover (Control) 6/15/00 14DAT3	Cover (Control) 6/29/00 28DAT3	Cover (Control) 7/13/00 42DAT23
1	Check			61.3 a (0%)	73.8 a (0%)	72.5 a (0%)	56.3 a (0%)	57.5 a (0%)
2	Proxy	5.0 oz/M	5/29/00 (#3 of 3)	25.0 b (59%)	18.8 b (75%)	12.8 b (82%)	13.5 b (76%)	36.8 b (36%)
3	Proxy	10. 0 oz/M	5/29/00 (#3 of 3)	15.0 c (76%)	13.3 b (82%)	6.3 c (91%)	10.5 b (81%)	33.8 b (41%)

Summary & Practical Perspectives

Three sequential treatments of Proxy applied to an annual bluegrass putting green at a rate of 5.0 ounces of product per thousand square feet at six week intervals resulted in a mean average of 72.3% seed head control during 13 rating events evaluated over an 18 week period. The 10.0 ounce Proxy rate showed a mean average of 82.9% seed head control over the same period. The 10.0 ounce Proxy rate was consistently more visually dynamic than the 5.0 ounce rate relative to annual bluegrass seed head suppression.

With the exception of the 7 DAT rating following the first application, Proxy consistently showed the most effective seed head suppression between 7 and 28 DAT with a dramatic reduction in efficacy between 28 and 42 DAT.

No treatment exhibited observable injury to annual bluegrass during any rating event throughout the course of the eighteen-week trial. A simple visual review of soil cores in every treatment following the trial showed no observable difference in root depth or density among treatments.

Green speed evaluations were conducted with a stimpmeter on six rating dates during the 18 week trial. No significant differences or trends among or between treatments were observed.

From these data generated on an annual bluegrass green in the moderate coastal climate of the Monterey Peninsula, it would appear that at these rates and application intervals Proxy is a very safe and effective new tool for the control of seed heads on annual bluegrass putting greens.

If a putting green label is to be pursued, it is highly recommended that a multiple application rate/injury trial reviewing higher 2x and 3x rates be conducted. A rate structure of 5, 10, 15, 20 and 25 ounces per thousand square feet is recommended. Such work would help establish a 2x and 3x safety margin for overlapped applications, which would provide critical information specific to the development of a Proxy surface management program for annual bluegrass putting greens.

Acknowledgements

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Turf Weed Management in the Landscape

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Turf is an important component of the landscape because it adds continuity and beauty to each site. Someone once defined turf as "mowed weeds". This may have once been true, but that was before the advent of the current turf cultivars with their more aggressive growth and disease resistance. It was also before modern plant nutrition, irrigation, thatch management techniques, and modern herbicides were developed. Currently, there are varieties and techniques that allow production of healthy, competitive turf swards. Competitive turf swards are the first line of defense against weed invasion.

Why are weeds a problem in turf? They fill voids where stresses from heavy use, improper management, disease, or insect attack have left openings for weeds to develop. The old adage that nature abhors a vacuum is certainly true in turf where the "vacuum" is quickly filled with weeds. Even with the best varieties and management practices, openings for weed invasion may occur. This is where preemergent (PRE) and postemergent (POST) herbicides can help to temporarily eliminate weeds and aid in the reestablishment of a healthy, competitive sward.

Turf Weeds

Turf weeds have become specialized. Turf weeds are those that have are adapted to the growing conditions specific to turf. A management condition of turf that limits many of our most common weeds from becoming a problem is mowing. Most upright broadleaf weeds are eliminated in turf through this practice. Upright pigweeds and mustards are rarely problem weeds in turf. However, weeds that can withstand regular mowing because they are grasses or grass-like with prostrate growth habits are common problems. Both annual and perennial weeds can be problems in turf. Often a specific microclimate (shade, wet soil, wear stress, dry soil, compaction, etc.) will favor certain weed species over the desired turf.

Weed Management

Cultural practices used in turf significantly influence weed persistence. Mowing fertilization, irrigation and use patterns all influence turf health and ultimately weed invasion. A basic tenant in the control of annuals like crabgrass is to prevent reinfestation by seeds. Controlling seed production for several years will help reduce the viable seed supply (soil seed bank). Crabgrass, prostrate spurge, or annual bluegrass can not be controlled in one growing season because of the great number of viable seeds that accumulate in the soil from previous infestations. A good weed management program in turf is one that consists of both sound cultural practices and the use of herbicides appropriate for the species present. Satisfactory control requires several years of conscientious adherence to a good control program. A few tips on how keep turf more competitive with weeds:

- Strive for uniformity in irrigation, fertilization, and management so that extremes which produce excesses or stresses for moisture or nutrients, or abuse do not reduce the competitive ability of the turf.

- Seed or sod new turf areas with adapted turf cultivars and certified sources of seed and sod which are weed free. Plant when turf will rapidly establish and be most competitive.

- Mow lawns at the proper height. A 2-inch height of cut for cool-season grasses will benefit weed control. The taller grass competes better for light and shades the soil keeping it cool. Crabgrass seeds and other summer annual turf weeds do not germinate well under cool conditions.

- Water heavily, but less frequently, and avoid frequent light irrigation. This discourages the development of shallow-rooted, weedy species like annual bluegrass.

- Time fertilizer applications appropriately for the turf species. For cool-season species, maintain proper nutrition, but avoid excessive summer fertilization as annual weeds may benefit more from fertilizer application under high temperatures.

- Avoid overuse and wear areas by planning walk-ways and avoiding prolonged use of a particular area where soil compaction can result. This can lead to the development of specific weed problems such as knotweed.

Herbicides

Herbicides are most effectively used in an integrated weed management program, when careful attention is paid to the selection of adapted turf cultivars and every effort is made to manage them so that they remain as competitive as possible. Herbicides can be applied before weeds emerge as PRE applications or after weed emergence as POST applications. Herbicides are an effective tool where high quality turf is desired. However, they must be applied with care and must be compatible with the other components of the landscape:

- Care must be exercised to avoid drift of foliar broadleaf turf herbicides onto susceptible landscape species.

- Care must be exercised to avoid use of soil active herbicides around the roots of susceptible ornamental species.

- Conversely care must be exercised in the management of weeds in other parts of the landscape not to use herbicides which could damage adjacent turf species.

When using any herbicide for the first time, apply it at the recommended rate on a limited area to make sure it is successful under local conditions. Excessive rates, improper timing, or application errors of selective herbicides can injure or kill desirable turf or adjacent ornamentals. Insufficient application, on the other hand, usually results in failure or incomplete weed control.

Summary

Turf weeds encountered in the landscape vary in their frequency and intensity around the state. There are a few like crabgrass that are a problem in all areas. Control strategies, however, are common to all regions. The first line of defense is a strong, competitive turf sward. If turf areas are properly established and aggressively maintained, weeds will be much less of a problem. PRE and POST herbicides are tools to support sound management programs and aid in the production of desirable turf landscapes.

Liberty Link Rice in California

Matt Ehlhardt, Aventis CropScience

Liberty Link Rice is genetically engineered for resistance to the broad-spectrum, contact herbicide glufosinate-ammonia (GA) which is sold under the trade name of Liberty. The mode of action of GA is by acting as a competitive inhibitor of the enzyme glutamate synthetase. This enzyme is active in the nitrogen metabolic pathway where ammonia formed during photorespiration combines with ATP and glutamate to produce more glutamate and glutamine. By inhibiting the action of glutamine synthetase free ammonia is formed, building to toxic levels in the plant. In addition further photorespiration and photosynthesis is reduced. To induce resistance, the pat gene is introduced into rice via genetic transformation. The pat gene encodes for the PAT enzyme (*phosphinothricin transferase*). The PAT enzyme deactivates GA by catalyzing the transfer of a acetyl moiety from acetyl coenzyme A to the amino group of GA.

Research using Liberty Link Rice in California began in 1997. Objectives were designed to determine the efficacy on major California rice weeds, proper application timing, and cultural practices that would lead to effective control. Rates evaluated included 0.27, 0.36, and 0.45 lbs. of active ingredient per acre. Earlier, research in non-transformed rice (variety M-202) or fields which were fertilized and flooded to encourage weed growth under normal cultural practices but not seeded, were used to find a susceptible growth range of various weeds. Using this information initial application timings in transformed rice were chosen at 15, 25 and 35 days after seeding (DAS). This placed weed stage of growth at 1 - 4 leaf grass (*E. oryzoides*), 1 - 3 leaf sedge (*C. difformis, S. mucronatus*) with redstem (*A. cocinnea*) not yet emerged at 15 days; 2 - 6 leaf grass, 3 - 5 leaf sedge (2 - 5" growth) and just emerging to 2" redstem at 25 days; and 5 leaf – 2 tiller grass, 6-7" sedge and 2 - 5" redstem at 35 days. In early trials all fields were drained for application to ensure optimum coverage of the contact herbicide. Drained fields or where water was lowered for application were reflooded to normal depths (3 - 4") beginning 24 hours after application.

Watergrass, *Echinochloa oryzoides*, was controlled by all rates of Liberty herbicide from 1 leaf through the two tiller stage of growth. Applications at the early, 15 DAS, timing provided complete control but newly emerged watergrass after that timing required a second application in order to have 95% or greater control at the end of the season. When treated at 25 DAS one application of 0.36 – 0.45 lbs. gave 88 – 95% control. Similar grass control was obtained when treated at the 35 DAS timing, however, by waiting until this later stage yields were reduced from the duration of weed competition. Control of the two sedges, smallflower umbrellaplant, *Cyperus difformis* and ricefield bullrush, *Scripus mucronatus*, was obtained when treated at 25 DAS. At this point the sedges ranged from 2 – 5" in height with Liberty at 0.36 – 0.45 lbs. providing 95% control. By treating earlier control ranged from 30 – 42% with the same rates. By delaying application until 35 DAS when the sedges were 4 – 8" in height the same rates gave 85 – 87% control. In order to obtain 95% or greater control of sedges at 25 DAS the field water was drained. By maintaining a 1" flood at this time sedge control dropped to 33% with 0.45 lbs., compared to 99% control when the same rates were applied to a drained field where more foliage was exposed. Redstem, *Ammannia coccinea*, does not emerge in most fields until 15 – 20 days after the flood is established. At 25 DAS (with the flood going onto the field 1 to 3 days prior to seeding) 90% redstem control was achieved with a 0.36 lbs. when the plant was 0.25 – 2” in height. Similar control was achieved at 35 DAS on 2 – 5” redstem. When treated at 25 DAS the fields needed to be drained in order to get sufficient coverage. Small seedlings submerged by puddles were not controlled at this time, requiring a second application for season long control.

Agronomic Crop Seeds---A Source For Weed Problems?

Robert Stewart, Manager of Field Services
California Crop Improvement Association

The purpose of the California Crop Improvement Association (CCIA) is to provide a seed certification service, a voluntary quality assurance program for the maintenance and increase of agronomic and vegetable crop seed. Each variety entered into this program has been evaluated for unique characteristics such as pest resistance, adaptability, uniformity, quality, and yield. Seed production is closely monitored to prevent out-crossing, other crops, diseases, and equally important weed contamination.

Certification is a program that started in California in the 1920's, run by the California Farm Bureau (CFB) and then cooperatively by the CFB and the University of California. In fact, in those days and up until the mid-40's, it was called the "CalApproved Seed Program". When the program, as we know it today, was started in 1944, it was finally called "seed certification" and directed by the California Crop Improvement Association. The CCIA is a non-profit corporation officially recognized as the seed certifying agency under the California Seed Law. The services provided are supported by each of the seed industries through a schedule of fees.

In the early years of certification, the major crops certified were field crops of clover, small grains, beans, rice and alfalfa. The first varieties and standards were established through cooperative efforts of each seed industry involved and technical expertise of the University system. The standards were developed to provide seed stock to the agricultural industry that maintained high genetic purity of the varieties being released by the University Land Grant Colleges.

Certification is a system of record keeping, standards and inspections. A paperwork trail of identification, segregation, growing, harvesting, conditioning, bagging and tagging follows each and every seed lot. The crops are annuals and perennials and must be applied for each year to maintain a record and history of production. The growers are keenly aware that good weed control in seed production starts with a clean field. If not possible for all weeds, but clean and free from those weeds that are noxious to the crop or cannot be easily controlled in the field or cleaned out at the conditioner. This important first step of crop history in seed production can alleviate a lot of purity problems later.

The general and crops standards of certification, state that fields must be free of "prohibited noxious weeds" and any amount shall cause rejection of the field. Any "restricted noxious weeds" and common noxious weeds difficult to separate must be controlled. Prohibited and restricted noxious weeds are referred to in the California State Department of Food and Agriculture Noxious weed list of the California Seed Law, sections 52257 and 52332, 3854 and 3855. Common noxious weeds are those weeds the industry of each crop deems detrimental to seed production or finds can contaminate the final product to the consumer. Examples of these are cocklebur in cotton, nightshade in beans and wild oats in grain.

In an average year, CCIA field inspectors look at over 175,000 acres of 30+ different crops. Today there are five major crops, which comprise over 75% of all the certified acreage. The average acreage for these crops are alfalfa; 45,000 acres, cotton; 50,000 acres, rice: 22,000 acres, sunflowers; 15,000 acres and wheat; 24,000 acres. These major crops comprise the largest volume inspected but only a small portion of all the different types of crops certified. The value of each seed industry is unique to itself. Many of the smallest acreages are crops, demand the highest seed prices, such as asparagus, artichokes, and watermelons.

I would like to share with you a few of the procedures that through combined efforts of CCIA and the grower, a quality seed crop may be produced. Our field staff have for many years inspected fields for weeds that are detrimental to the sale of quality seed. The various seed industries have mandated that all seed be free from noxious weeds and allow only small amounts of common seed to be present.

Alfalfa, one of the largest crops by acreage, has been grown and certified in California since 1945. Today we have many major seed and breeding companies developing and releasing new varieties each year. In 1999 we certified over 140 different alfalfa varieties. The genetic quality of a variety is only one aspect of the certification process.

The original alfalfa seed certification program was started in the Hemet area in Riverside County. In the 1950's, Kern county was the leading area for alfalfa seed production in California. Alfalfa production in California, at one time, produced over 65 percent of all the alfalfa in the United States. The majority of the currant alfalfa seed production is in the Central Valley of California, mainly the Fresno and Kings county areas. Over the last ten years, alfalfa seed is also being produced in large acreages in the Imperial Valley. The majority of this seed was exported from California to areas of the United States and abroad. The alfalfa seed industry made sure a high standard was established in order to insure quality seed coming out of the certification program. California produces seed that is of the highest quality and pure enough to be shipped all over the world.

Weeds and weed control in alfalfa has been an important part of maintaining this quality. In alfalfa, the main noxious weeds that must be controlled are dodder, johnsongrass, alkali mallow and white horsenettle. These weeds have many different growth habits when contaminating alfalfa and control must be done in various ways. Dodder is the number one seed problem in alfalfa for certification. Dodder can be controlled with various pre-emerge herbicides, but the effectiveness of the application depends greatly on the condition of the field and the timing of the application. If the herbicide is not effective at the time of dodder emergence, then other steps for control must be taken. Field inspections normally start in late June or early July and this is the optimum time for verification of genetic purity, the full bloom period. This a little early for verification that dodder has been controlled. Second inspections by ground and air will confirm the establishment of a dodder control program, whether by roguing, spraying, or burning. The control of dodder by spraying and burning was the method of choice just a few years ago, but with the new laws and regulations on burning, the alfalfa seed grower must find new ways to control dodder once it has been established in a seed field. Another problem for the grower is the introduction of crops into the alfalfa growing areas that promote the growth of dodder with very little control, such as tomatoes, chickpeas and safflower. The alfalfa seed grower is constantly trying to find new methods of weed control to counteract all these new problems.

Grain is another crop that can be readily contaminated by noxious weeds. Some of the main weeds that must be controlled in the field and also are not allowed in the seed are wild oats, field bindweed, perennial peppercress and johnsongrass. Other weeds can be permitted in the field in light to moderate quantities, but must be conditioned out of the seed lot prior to final certification. The control of these weeds in small grains is normally with herbicides, but some must be rogued out for total eradication. Many of these weeds can be avoided with a good rotational cropping system, the proper application of herbicide or roguing.

Cotton field inspections start in the fall of each year, the optimum time for evaluating each field for weed problems. There are many different weeds that can be a nuisance, such as annual morning glory, nightshade and various grasses. But to produce a good quality cotton crop, most of these are not a seed problem. Other noxious weeds that can be found in cotton and must be controlled are; perennial peppercress and white horsenettle, but these have not been a major seed problem thus far. Cocklebur, which is considered a noxious weed in cotton seed, is not allowed in a seed field, and all plants must be rogued and taken out of the field prior to final inspection and approval. With the advent of new genetically modified cotton varieties with herbicide resistance, weed control in cotton has taken a leap forward in controlling many of the common and noxious weeds.

One crop in our certification program that has potential for heavy weed problems is rice, but if properly taken care of with herbicide and cultural practices the growers can produce a very clean seed crop. There is only one weed that is prohibited in seed rice and that is Red Rice, *Oryza sativa L*. Red rice, which is commonly found in the southern rice growing states, is not known to occur in the rice growing areas of California. In twenty years of inspections, CCIA has not found any red rice in certified rice seed. This is a good example of an industry that has realized the importance of a good seed program and has avoided bringing in a problem, which has plagued many other rice growing areas. In the past few years, we have seen grasses now becoming resistant and very difficult to control with the standard herbicides. These grasses are localized within areas of the rice-growing region of northern California. If isolation or separation is not maintained or control of this weed seed is not found, the grower will be faced with one more problem in the production of quality rice seed.

Sunflowers are one of the major crops in certification, that the weed of concern is not just a contamination of the seed, but also a contamination of the genetic purity of the crop. Wild species of *Helianthus* can be found in most of the sunflower growing regions of California. Northern California has distinct areas that have limited infestations of the wild type. Isolation of sunflowers for certification, can be up to 2.5 miles from contaminating flowering plants of other varieties, strains, volunteers and wild annual species. During field inspections, contaminating sources of wild pollen must be controlled, as an isolation, as well as for the wilds in the field.

Many of the other certified crops have specific weeds that can be a direct contamination of the seed lot. Other weeds, such as johnsongrass, can also contaminate a seed lot by cross pollinating with sudangrass, and can result in the loss the genetic purity of a variety. Most of the major noxious weed seeds can be found in the CDFA Seed law as prohibitive or restrictive weeds, but individual common weeds can be considered noxious with each individual seed crop. Here are a few crops and the noxious weeds that are commonly found during inspections for certification that can be a reason to reject a certified seed field.

Asparagus	Field bindweed
Artichokes	Artichoke thistle
Barley	Wild oats
	Field bindweed
	Quackgrass
Beans (Dry)	Nightshade
	Goundcherry
Bermudagrass	Common bermudagrass
	Spangletop
Cowpeas	Nightshade
	Groundcherry
Oats	Wild oats
	Field bindweed
	Quackgrass
	Johnsongrass
White Clover	Plantago spp
	Curly dock
	Dodder
	Bermudagrass
	Sweet clover
	Yellow starthistle
Red/Rose/Berseem Clovers	Johnsongrass
	Sweet clover
	Yellow starthistle
	Brassica spp
Safflower	Dodder
	Johnsongrass
	Perennial peppercress
Sudangrass	Johnsongrass
Watermelons	Citron

After the seed has been harvested and conditioned, it is the responsibility of the applicant or grower to submit a seed sample for inspection in the CCIA Lab. This sample is analyzed for purity, both genetic and physical. The lab maintains minimum standards on each crop for purity, inert matter, other crop, other varieties, diseases and weeds. Similar to field standards, but since this is the final product, which will be purchased by the seed buyer, no prohibitive or restrictive noxious weeds are allowed in the sample, nor are common weeds that the industry deems noxious. Common weeds that are incidental to the crop and have limited effects on the seed quality are usually confined to minimum amounts in the seed. While most of the seed lots sent to our lab are certifiable, there are a few seeds lots conditioned and sampled and found to be out of compliance and must be reconditioned before they can be certified. Here is an example of the 1995 through 1999 alfalfa seed samples received by the CCIA lab and rejected for the various weeds shown.

ALFALFA	1995	1996	1997	1998	1999
Acres	35,840	39,346	36,019	52,187	65,856
Samples	661	807	777	960	1590
Rejected for:					
Dodder	39	87	88	147	332
Alkali mallow	7	4	9	8	13
Johnsongrass	3	1	2	4	4
Yellow Starthistle	0	0	0	0	8
Sour clover	6	2	0	38	12

CCIA field and lab inspection results show that the majority of all seed lots do comply with the standards and minimum requirements designated by our certification program. However, it is the devotion and hard work of the seed growers that make the California seed program renowned worldwide and allows our state to maintain the great reputation for producing quality seed. The following table is the certified seed production for 1999.

Crop	Acres		Pounds
Alfalfa	65,856		40,396,952
Beans	9,687		2,018,086
Bermudagrass	5,047		579,126
Clover	5,555		2,299,801
Cotton	39,168		21,888,610
Cowpeas	2,449		4,207,010
Rice	21,063		68,216,587
Safflower	4,631		4,593,431
Sudangrass	10,898		23,297,878
Sunflower	23,286		3,214,899
Wheat	19,197		63,105,809
Others	5,945		23,916,854
Total	212,782		257,735,043

Alternative Cultivation Techniques for Corn Production

Chuck Dudley
Joe Heidrick Farms

I would like to share with you today our experiences with no-till corn. Last year was not the first time that we attempted to plant no-till corn. The first time was in the late 1970's. We went into a wheat field after it was burned and planted corn without doing any ground preparation. Our equipment by today's standards was much lighter but essentially of the same concept. We did not pursue non-tillage at that time due to several factors, most notably the lack of a broad-spectrum herbicide.

In the year 2000 we planted 2 fields of corn. One field was in the Cache Creek settling basin, and one field was in the Yolo Bypass. Both fields were flooded during the winter and the settling basin flooded again in April. The settling basin field was planted to corn in 1999 and the bypass field was planted to tomatoes. Both fields were in 60" beds and neither field had any post harvest ground work. We started planting no-till corn on April 4th 2000 and finished approximately a month later. Our plantings were stopped first by wet ground, then by rain, and then by flooding. Both fields had a spread of planting dates.

We were able to plant, fertilize, irrigate, control weeds, and harvest the crops without any preplant groundwork or any cultivation. We utilized existing technology which is far more common in the Midwestern corn belt than it is in California. We planted a Round-Up ready corn variety using a John Deere Max-Emerge corn planter with Yetter no-till attachments. The John Deere planter is a very heavy framed durable unit with enough weight and strength to keep the seed population at the target levels. The combination of the planter and the yetter implements insured our being able to plant seed at our targeted rate. The planter that we used was an off-the-rack Midwestern special. Waffle coulters that we used for starter fertilizer placement were too small for California conditions. The shallow placement of fertilizer resulted in a zinc deficiency in the second corn field. The first field we planted escaped this deficiency. I think for the most part due to a substantial rain that occurred after the corn was planted. This rain kept the soil moist at the surface allowing the corn better access to this shallow placement of fertilizer.

We selected a Round-Up ready corn seed variety, which had good production history in our local area. We sprayed both fields with Round-Up Ultra at 1 quart per acre. Both fields had some corn emergence at the time of the first application and both fields were treated a second time at varying heights. It would appear that the best time to clean up the weeds in the corn field is at about the 20" stage of corn growth. We were a little concerned that when the corn was this tall that we might not have a good spray pattern by spraying over the top, but we checked our spray pattern with water sensitive paper and we found that at this height our spray pattern coverage was very good. As I mentioned before, our planting and emergence between the fields and within the fields was spread out over approximately 3 weeks time. This variation of emergence led to the last Round-Up spray being made at a less than ideal time. If I were to hazard a guess, in the future more mistakes will be made by spraying too early than will be made by spraying too late.

The yield on the corn in the second field was approximately 5 tons per acre. The cost saving on groundwork in today's corn economy equals approximately a ton to the acre of corn.

I believe that no-till has a place in our farm program. No-till practices in California almost certainly will evolve and will be tailored to individual farms and circumstances. What I see on the positive side is this: the elimination of many trips across the land and the cost attending those trips, and the elimination of soil compaction by making those passes. It is and will be a difficult cultural transition away from groundwork and cultivation. There is an old saying, "If there is a farmer with an idle tractor, he will find a use for it." Today's economics will not support that. There is no doubt in my mind, and I think millions of acres in the Midwest prove that corn can be raised without cultivation. The potential for cost savings is enormous.

Early plantings conserving time and moisture are realities in non-tilling systems. Our experience in the year 2000 dealing with late rain, and in one field late flooding, leads me to think that the non-tilling system saved us at least 2 weeks and probably increased our yield because we were able to plant earlier.

Our experience led us to believe that we saved an irrigation. This feeling is most subjective on one hand, but on the other, it is very rational when I consider that we did not have to wait for the ground to dry out before we planted it. Moisture was protected by the previous crop residue mulch. Soil tilth improved the first year of non-tillage and I think it will continue to improve.

The selection of varieties of Round-Up ready corn in California is quite limited. As of last year, one could not purchase what I consider to be the best variety in the seed company's line that was Round-Up ready. The best yielding varieties need to be available as Round-Up ready. It surprises me that Seed-Tech, a small local seed company, has a better Round-Up ready variety than the national seed companies. A lot of effort has been put into Round-Up ready varieties in the Midwest. But outside of the corn belt, growers using Round-Up ready planting systems are not finding themselves at a prime spot on the udder.

There are millions of acres of genetically modified corn in the United States. I have not had any marketing problems with Round-Up ready corn to date, but I do get a feeling after last summer's problems with Star Link, that there will be some buffers required between human consumption white corn and genetically modified yellow corn.

I think the integrated system of seed and machine technology has a great potential to lower production cost and improve the land.

The Importance of Adjuvant Use with Alfalfa Herbicides

Mick Canevari, University of California Cooperative Extension San Joaquin County

Introduction

Postemergence foliar applied herbicides are used extensively in seedling and established alfalfa to control broadleaf and grass type weeds. Many of these herbicides require an adjuvant be added to the spray mixture to improve their performance. Today, the market place is inundated with more than 400 agricultural adjuvants made from organic substances to synthetic compounds and ranging in price from a few cents to hundreds of dollars per gallon. There is a lack of product knowledge and conflicting information available for adjuvants. More field tests are needed to help define the best adjuvant for the herbicide as to reduce herbicide rate and lower cost to the grower.

Adjuvants are necessary because they:

- Increase spray deposition
- Reduce spray run off
- Enhance absorption & uptake
- Correct mixing problems
- Minimize evaporation

Postemergence Herbicides

Four postemergence herbicides were evaluated in alfalfa in 1998-99:

Pursuit herbicide was registered in alfalfa in 1997. It is a newly developed family of chemistry that translocates into the weed through the leaf and inhibits the development of amino acids. This class of herbicide has shown significant response with the use of adjuvants in the spray mixture. Reports from other researchers have also demonstrated improved weed control with the use of different adjuvants over the standard non-ionic surfactants (Figure 1). Pursuit effectiveness for weed control depends on the amount of active ingredient that can move into the plant as quickly as possible with the adjuvant that best complements this action. Figure 2 illustrates the effect of various adjuvants had with Pursuit to control Wild Radish and the cost per acre of each treatment.

2,4-DB or Butyrac® (Figure 3) has long been a popular herbicide choice widely used in various alfalfa growing regions to control broadleaf weeds. This Phenoxy based herbicide acts as a plant growth hormone to kill weeds. In broadleaf weeds 2,4-DB is broken down to 2,4-D, a commonly known and widely used herbicide in cereal grain crops.

When an adequate amount of phenoxy herbicide accumulates into the plant it causes a rapid regeneration of cells without division, resulting in abnormal growth, plant twisting and eventual collapse. Weed researchers have also noted the benefit of using non-ionic surfactants to improve weed control with the amine formulation of 2,4-DB. Figure 3 illustrates effect of adjuvants on Wild Radish control.

Prism herbicide is the most recent addition to gain California alfalfa registration in September 1998. Prism controls a wide range of grass weeds, including perennials and annual bluegrass at lower rates than herbicides of similar chemistry. Its systemic mode of action also requires it to move through the leaf tissue and be carried by the plant phloem to sites of action. Prism being a weak acid herbicide greatly benefits from the addition of an adjuvant for penetration and to modify the pH of the spray solution (Figure 4).

Poast is the same chemistry family as Prism with the same mode of action. It has been used for many years in both seedling and established alfalfa for control of annual and perennial grasses. It has no effect on broadleaf plants and as in the case of other translocating herbicides, needs to penetrate the leaf surface quickly with maximum uptake for the best control. Poast was one of the first postemergence type herbicides to show improved performance when mixed with a crop oil concentrate adjuvant and pH modifier. The use of oil adjuvants and a pH adjustment helped increase weed kill by 40% (Figure 5).

Adjuvants

Four adjuvant types were used in these tests. It was difficult to select which adjuvants of the hundreds available to choose from that would fairly represent each adjuvant class. Ultimately the decision was based on convenience and commercial availability of the product.

Methylated or Esterfied Seed Oils MSO/ESO is one of the newest additions of adjuvants used in California. Derived from plants of either soybean, cotton, sunflower, canola or corn, these oils often result in better weed control with certain herbicides compared to paraffin oils or surfactants. They have become popular with the newer herbicides in the Sulfonylurea and Imidazolinone (Pursuit) chemistry. MSO's have proven superior in warm temperatures, lower humidity and windy conditions that favor rapid evaporation of the spray solution. MSO use rates range between one pint and one quart per acre in most cases.

Non-ionic surfactants (surface-active agents) or NIS have long been used as the standard spreader and wetter adjuvant. They reduce the surface tension of a spray solution in order to allow a more intimate contact between spray droplet and leaf surface. They help the herbicide spread and penetrate through the leaf cuticle more efficiently. They are recommended for most foliar applied herbicides. Their use rate is measured on a volume basis between ¼% to ½% VV.

Crop oil concentrate or COC adjuvants generally contain 80% non-phyto toxic paraffin based oil and 20% surfactant. COC's are compatible with oil soluble herbicides and the addition of the surfactant complements the spray solution to spread better, lower water surface tension and speed penetration into the leaf. The oil also reduces evaporation and crystallization of the spray solution under hot temperatures. The use rate of most COC products is one quart per acre.

Organosilicone surfactants or silicones are the newest of adjuvants and rapidly gaining popularity with certain pesticides. Silicone surfactants reduce the surface tension of water based sprays far beyond that of NIS and thus been given the nickname “Super wetters and spreaders.” In tests they have shown to be superior in coverage, particularly when in contact with highly pubescent or rough leaf surfaces difficult to reach with oil adjuvant alone. They have also shown faster penetration times through the cuticle and into stomata openings than oils. One hundred percent silicone surfactants are still open to debate for use with certain herbicides such as Roundup. The super wetting properties can be a disadvantage if the spray solution becomes too thin (higher rates) and runs off the plant before maximum absorption and chemical uptake is reached. Under hot temperature, silicones are subject to faster dissipation than oil based adjuvants reducing herbicides maximum uptake. The spray solution must fall between a pH of 6 to 8 for the silicone surfactants to remain stable and perform best. The use rates are measured on a volume basis and range between 1/8% to ¼% VV.

Fertilizers used as adjuvants are increasing in interest. Ammonium sulfate, or Urea-nitrate (UN-32) added to the spray solution can increase herbicide effectiveness. Researchers are still uncertain as to the precise interaction of the fertilizer and herbicide but suggest it reduces crystallization of herbicides, helps herbicides penetrate the leaf cuticle, and modifies the cell environment for herbicides such as Poast, Prism or Pursuit to work more effectively.

Summary

Adjuvant types showed a significant difference on weed control with Pursuit, Poast and Prism herbicides. 2,4-DB did not show a difference among adjuvants for weed control but a difference was noted for crop injury in seedling alfalfa. (Figure 6)

Pursuit performed best when mixed with the oil adjuvants either the MSO or COC types. Improved activity was seen with the combined organosilicone and MSO product. The NIS surfactant only equaled the oil adjuvants when a fertilizer was added into the solution; this treatment was also the most cost effective. The Organosilicone treatment alone was inconsistent in performance showing dramatic differences in weed control for the two years.

Prism and Poast herbicides performed best in both years with the Oil adjuvants. There was little difference between the MSO and the COC although the trend favored the COC. The NIS showed a 10%decline in control of Yellow foxtail compared to the Oils. Adding a fertilizer solution to the NIS did increase weed control. The Organosilicone had a negative effect and reduced control by 35%.

Conclusion

Adjuvants play an important role in weed control with poast emergence foliar applied herbicides. They modify negative environmental effects unfavorable for optimum herbicide performance. They generally improve overall weed control and are particularly important in aiding the more difficult to control weed species. By improving efficacy a reduced rate of herbicide can often be utilized to help reduce cost. However; adjuvants alone will not substitute the importance of proper timing and spray coverage of weeds.

Adding Ammonium based fertilizer solutions appears to be a positive component to the spray solution were it was tested. The minimal cost for these commercial grade fertilizers with widespread availability strongly supports their use whenever possible.

The chart below highlights the adjuvant types best suited for the herbicides tested.

Adjuvant	Pursuit	2,4-DB	Prism	Poast
MSO	X		X	X
NIS		X		
COC	X		X	X
Silicone				
NIS + fertilizer	X		X	X

Figure 1.

Adjuvant Comparison of Pursuit Herbicide In North Dakota

Pursuit .047 +	Pigweed	Cocklebur	Foxtail
	------ % Control		------
NIS + UAN	80	61	59
NIS + Micronutrients	64	50	47
Petroleum oil + UAN	85	85	80
MSO/ESO + UAN	95	93	95
MSO + NIS + UAN	93	92	95
MSO + Organosilicone	95	85	95
MSO + Drift retardant	99	92	98
Adjuvant blend	99	95	99

Richard Zollinger NDSU 1997

Figure 2.

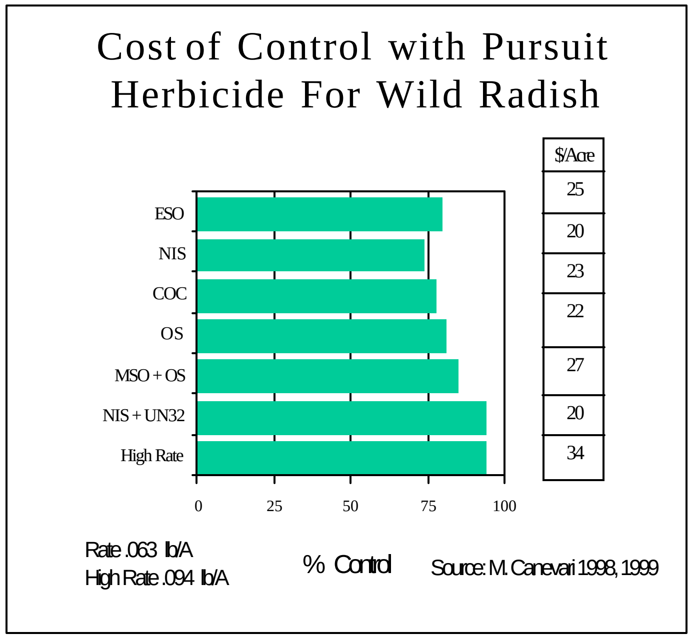
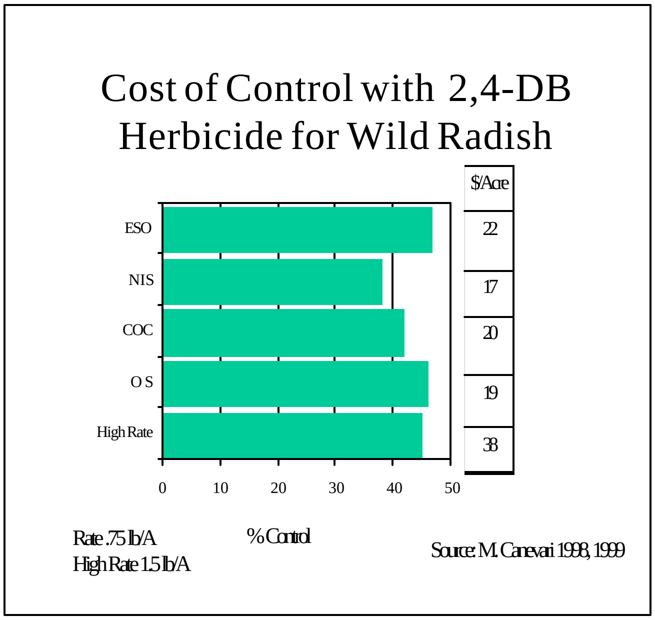


Figure 3.



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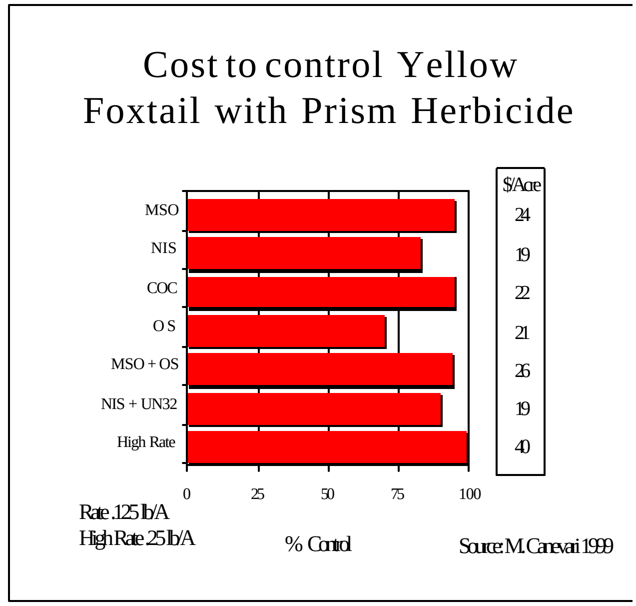

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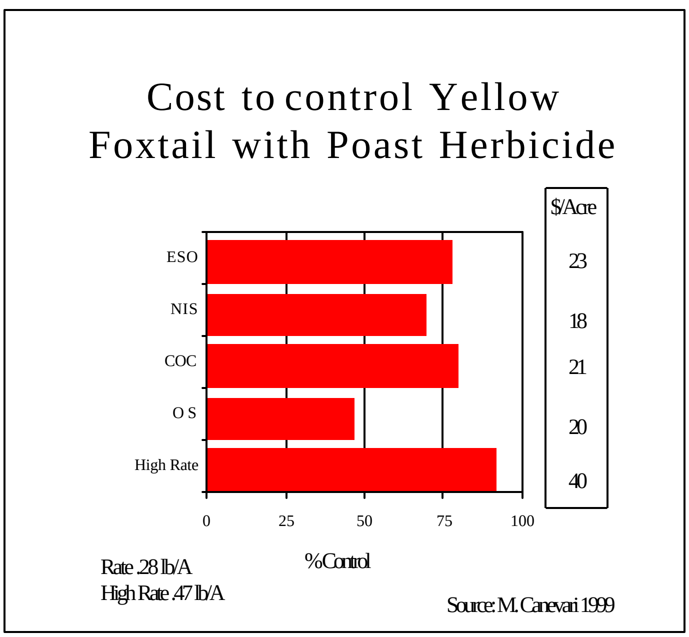
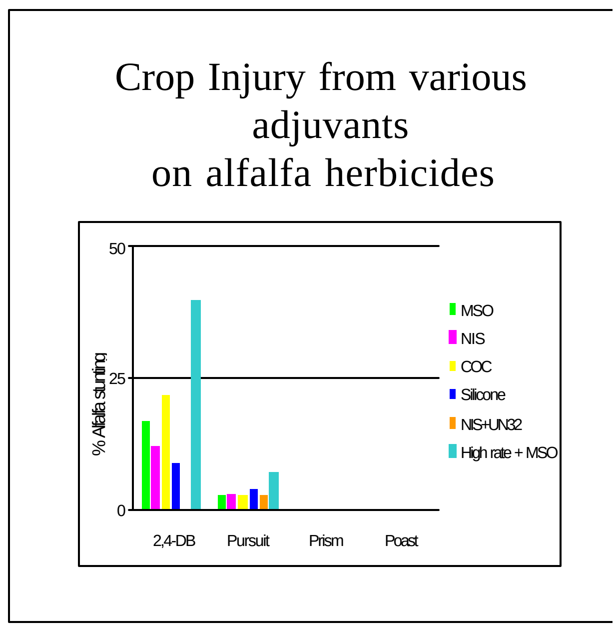


Figure 6.



Recent Advances in Cotton Weed Control

Ron Vargas and Steve Wright, Farm Advisors, Madera & Tulare Counties
University of California Cooperative Extension

Introduction

Since the introduction of herbicide tolerant cotton in 1997 (500 experimental acres) acreage has continued to increase. The first Roundup Ready varieties tested in California were not Acala types, but rather upland cotton varieties less adapted to our San Joaquin Valley growing conditions. Adoptions was slow, but acreage began to increase when the Acala Cotton Board changed direction and began allowing, what are now referred to as California Upland varieties to be plant in the San Joaquin Valley. After a year of experimental testing of 12,000 plus acres of Roundup Ready cotton in 1998, with growers experiencing very positive results, acreage increased to 85,000 in 1999. Besides limited small test acreage of BXN cotton in 1997-98 a small portion of the 1999 acreage included the California Upland variety Stoneville BXN 47.

In the 2000 production year, 295,000 acres of herbicide tolerant cotton was grown. The biggest increase in acreage occurred due to the release of an approved Acala Maxxa Roundup Ready variety (Riata) which amounted to 185,000 acres. Another 42,359 acres of Roundup Ready and stacked gene (Roundup + BT) cotton varieties were planted. The remainder of the acreage, 68,340, consisted of a SJV Experimental Acala, BXN Maxxa or Nova, (33,167A) and the California Upland variety Stoneville BXN 47 (35,172A).

Overall, grower experience as well as University studies, have been positive. Growers have been able to effectively control problem weeds while some have reduced or eliminated hand weeding and cultivation resulting in a considerable cost savings.

Herbicide tolerant cotton varieties are now an available option for California cotton growers. Along with the use of conventional herbicide programs such as preplant dinitroaniline herbicides (Treflan and Prowl), selective over-the-top grass herbicides (Poast, Fusilade and Prism), Staple, a selective over-the-top broadleaf herbicide, and layby herbicides such as Caparol and Goal, herbicide tolerant cottons allow growers to effectively and economically control their weed problems. Alternative production systems such as conservation tillage and ultra-narrow row cotton using herbicide tolerant cottons are also being studied to determine their economic and agronomic feasibility.

The decision to use transgenic herbicide tolerant cottons should be based on a number of factors including:

1. Weed species present (annuals vs. perennials).
2. Density and extent of weed population.
3. Is weed pressure enough to impact yield?
4. Can hand weeding be eliminated?
5. Cost of alternative herbicides.

6. Cost of technology fee and seeding rate.
7. Are there well-suited transgenic varieties with favorable agronomic characteristics?

Results

BXN (Buctril tolerant) Cotton

Results of University studies have indicated good to excellent control of most summer annual broadleaf weeds when Buctril is applied over-the-top of two to four-leaf cotton to weeds no larger than the four-to-six-leaf stage.

So far, the research has shown good performance in controlling many weeds but has also identified some problem areas requiring more research and alternative management practices. Buctril provided 95-100 percent control of Chinese thornapple, black and hairy nightshade, lambsquarter and velvetleaf with one application of the herbicide at .5 - 1.0 pound active ingredient per acre. There appeared to be no advantage in control of these weed species when Buctril was applied as a tank mix with either Staple or MSMA.

Buctril is selective on broadleaf weed species only, so tank mixes with selective grass herbicides such as Prism, Poast and Fusilade are necessary to achieve grass control. The research indicated no antagonism or loss of control with either annual (barnyardgrass) or perennial (johnsongrass) grasses when grass herbicides are tank mixed with Buctril. Reduced pigweed control has been seen in some locations when Buctril was tank-mixed with any of the grass herbicides.

Control of annual morningglory with Buctril has been slightly more difficult. Careful attention to application timing makes all the difference. When Buctril was applied to morningglory with four to six leaves and 4- to 12-inch stolons, control ranged from 20-60 percent a 7DAT. Best control was achieved when Buctril was applied to morningglory with two or fewer leaves and enhanced when the herbicide was tank mixed with MSMA. Best control - 90 percent at harvest was seen with an initial Buctril-MSMA tank-mix application at the two-leaf stage, followed by an application of Buctril at 1.0 lb ai/A in early July.

Studies to date have shown no evidence of cotton injury by Buctril at any stage of growth, even during hot temperatures. Buctril can be applied over-the-top and/or post-directed up to 75 days from harvest without effect to cotton growth and development.

Roundup Ready Studies

Research continues to indicate excellent control of summer annual broadleaves and grasses when applied to young seedlings. Larger weeds, including lambsquarter and Chinese thornapple, are not adequately controlled if 12-24 inches tall. Control of nightshade and morningglory is good to excellent. Season-long control or morningglory is achieved but two and sometimes three applications of Roundup are needed. Field bindweed can be effectively controlled with one or two timely applications of Roundup.

Cotton tolerance studies continue to indicate the importance of cotton's stage of growth when Roundup is applied to Roundup Ready cotton. Over-the-top applications above the four-leaf stage results in deformed and lost bolls and, ultimately, yield reductions.

Studies indicated that Roundup can be safely applied to cotton beyond the 4th leaf stage with a hooded sprayer. In-season plant mapping data showed no significant difference when Roundup was applied post-directed in a hooded sprayer to cotton in the 8 or 13th node stage when compared to Roundup applied over-the-top at the two- and four-leaf stage.

Weed resistance is always a concern with any herbicide program, but with transgenic herbicide tolerant cotton, weed resistance is an added concern. Because Roundup and Buctril do such an excellent job of controlling weeds, there is a temptation to rely on only one or the other of these herbicides to solve weed problems. If weed control programs are developed which solely rely on one herbicide, weed resistance may become a problem. Growers need to implement resistance management strategies including crop rotation, herbicide rotation and control of weed escapes by tillage in order to prevent resistance from developing.

Other Studies

Nutsedge Studies

Evaluations of an experimental herbicide CCA 362622 for the control of both yellow and purple nutsedge provided mixed results. Cotton tolerance seemed to be acceptable but control varied from 30 to 78 percent in studies conducted at different locations. This herbicide did provide 95 to 98 percent control of annual morningglory.

Staple Surfactant Studies

Evaluations of Staple applied with various surfactants for the control of both nightshade and pigweed indicated no significant difference in control with any surfactant when compared to Staple applied alone. Control for both species in studies conducted in a number of different locations ranged from 70 to 100 percent. There were no differences or increases in cotton phytotoxicity due to various surfactants.

Post Directed Herbicide Studies

A number of herbicides including Shark, V-83482, Harvade, and Liberty were evaluated for control of various broadleaf weeds when applied post directed to cotton 20 to 36 inches tall. These herbicides were also evaluated in tank mix combination with Roundup, Staple and MSMA.

Shark, V-83482, and Harvade alone or in combination with Roundup, Staple or MSMA gave excellent control of annual morningglory at 21 DAT. Roundup and Touchdown only provided 60 to 70 percent control at 6 DAT, but at 21 DAT were providing 90-98 percent control. All treatments were exhibiting cotton injury up to 21 DAT except for the Harvade, Roundup and Touchdown treatments. Shark, Shark in combination with Roundup or Buctril and Liberty all provided acceptable control of barnyardgrass and pigweed.

Table 1. Weed Control in Riata (Roundup Ready) Cotton 2000, Ron Vargas, Farm Advisor, University of California Cooperative Extension

Treatment	Cotton No. Leaves	Rate/Acre		Barnyardgrass Control		Pigweed Control	
		ai	Product	14 DAT	28 DAT	14 DAT	28 DAT
1. RO	2	1 lb	1 qt	100	97	100	100
2. RO + Agridex	2	1 lb + 0.5%	1 qt	96	94	100	100
3. RO + LI-700	2	1 lb + 0.5%	1 qt	91	89	100	100
4. RO + Hook	2	1 lb + 0.5%	1 qt	98	93	100	100
5. RO + R-11	2	1 lb + 0.5%	1 qt	100	97	100	100
6. RU	2	1 lb	1 qt	91	92	93	100
7. RU	4	1 lb	1 qt		94	100	100
8. RU B. RU	2 4	1 lb 1 lb	1 qt 1 qt	55	97	100	100
9. RU	2	2 lb	2 qt	100	97	100	100
10. TD	2	1 lb	1 qt	100	96	100	100
11. TD	4	1 lb	1 qt		85		97
12. TD B. TD	2 4	1 lb 1 lb	1 qt 1 qt	100	99	100	100
13. UTC				0	0	0	0

RO = Roundup Original
RU = Roundup Ultra
TD = Touchdown

Table 2. Field Bindweed Control in Riata (Roundup Ready) Cotton 2000, Ron Vargas, Farm Advisory, University of California Cooperative Extension

Treatment	Rate/Acre	Field Bindweed Control				Seed Cotton Yield lbs/A
		1st Application		2nd App	3rd App	
	ai	6 DAT	15 DAT	9 DAT	11 DAT	
1. RU B. RU C. RU	1 lb 1 lb 1 lb	27	32	88	99.4	4835
2. RU B. RU C. RU	1 lb 1 lb 1 lb	30	36	87	98	
3. RU B. RU C. RU + Caparol 4	1 lb 1 lb 1 lb + 0.8 lb	27	62	89	97	4970
4. RU B. RU C. RU + Prowl	1 lb 1 lb 1 lb +1 lb	29	33	88	89	
5. RU B. RU C. RU + Dual 8E	1 lb 1 lb 1 lb +.95lb	27	52	90	95	4898
6. RU B. RU C. RU	1 lb 1 lb 1 lb	31	54	88	94	
7. RU B. RU C. RU + Goal	1 lb 1 lb 1 lb + .2 lb	29	47	86	99	4873
8. RU B. RU C. RU + Aim 40DF	1 lb 1 lb 1 lb + .0018 lb	29	50	88	95	
9. RU B. RU C. RU + Aim	1 lb 1 lb 1 lb + .0036 lb	26	51	88	99	4827
10. RO + Ag98 B. RO + Ag98 C. RO + Caparol + Ag98	1 lb + .5% 1 lb + .5% 1 lb + 0.8 lb + .5%	25	35	85	94	
11. RO + Staple + Ag98 B. RO + Staple + Ag98 C. RO + Ag98	1 lb + 1 oz + .5% 1 lb + 1 oz + .5% 1 lb + .5%	24	51	89	100	4760
12. RO + Staple + Ag98 B. RO + Staple + Ag98 C. RO + Staple + Ag98	1 lb + 1 oz + .5% 1 lb + 1 oz + .5% 1 lb + 1 oz + .5%	21	55	90	99.7	
13. UTC		5	0	0	0	3813

RU - Roundup Ultra RO – Rounup Original

Table 3. Postemergence Weed Control in Riata (Roundup Ready) Cotton 2000, Steve Wright, Farm Advisor, University of California Cooperative Extension

Nutsedge % Control					
Treatment	**Rate ae/A**	**App. Code**	**7 DAT**	**15 DAT**	**21 DAT**
1. Touchdown	.75 lb	B	18	62	93
2. Touchdown	.75 lb	C	0	60	97
3. Touchdown 3. Touchdown	.75 lb .75 lb	B C	20	88	100
4. Touchdown 4. Touchdown	.75 lb .56 lb	B C	20	83	100
5. Roundup Ultra	.75 lb	B	20	53	95
6. Roundup Ultra	.75 lb	C	0	53	100
7. Roundup Ultra 7. Roundup Ultra	.75 lb .75 lb	B C	20	80	100
8. Roundup Ultra 8. Roundup Ultra	.75 lb .56 lb	B C	23	94	100
9. Prowl 9. Cotoran 9. Touchdown 9. Touchdown	.825 lb AI 1.0 lb AI .75 lb .75 lb	A A B C	22	73	100
10. Prowl 10. Cotoran 10. Roundup Ultra 10. Roundup Ultra	.825 lb AI 1.0 lb AI .75 lb .75 lb	A A B C	33	87	100
11. Untreated	---	---	0	0	0

Table 4. Annual Morninglory Control in Roundup Ready Cotton 2000, Steve Wright, Farm Advisor, University of California Cooperative Extension

Annual Morning-glory % Control				
Treatments	**Rate ai/A**	**6 DAT**	**14 DAT**	**21 DAT**
1. Shark	0.008 lb	88	80	93
2. Shark	0.015 lb	95	90	97
3. Shark + Roundup Ultra	0.015 lb + 0.56 lb	97	97	99
4. Shark + Staple	0.015 lb + 0.0625 lb	93	93	100
5. Shark + MSMA	0.015 lb + 2.0 lb	93	93	98
6. V-53482	0.063 lb	93	88	96
7. V-53482 + Roundup Ultra	0.063 lb + 1.0 lb	93	90	99
8. Harvade + MSMA	0.3 lb + 2.0 lb	87	87	93
9. Harvade + MSMA	0.55 lb + 2.0 lb	87	87	99
10. Harvade + Roundup Ultra	0.3 lb + 1.0 lb	87	87	98
11. Harvade + Roundup Ultra	0.55 lb + 1.0 lb	87	90	96
12. Roundup Ultra	1.0 lb	70	72	98
13. Touchdown	1.0 lb	60	68	90
14. Untreated	-----	0	0	0
LSD .05	-----	**0.08**	**0.13**	**0.07**
% CV	-----	**4.8**	**8.5**	**4.3**

Table 5. Nova Cotton in Weed Control Study 2000, Ron Vargas, Farm Advisor, University of California Cooperative Extension

Treatment	Rate		Timing	Barnyardgrass Control		Pigweed Control	
	lb ai	Product		14 DAT	28 DAT	14 DAT	28 DAT
1. Buctril	0.5 lb	1 pt	DAY 1	0	0	80	82
2. Prism	0.125	17 oz	DAY 1	100	100	0	0
3. Buctril + Prism	0.5 lb + .125	1 pt + 17 oz	DAY 1	100	95	92	64
4. Poast	0.188	16 oz	DAY 1	99	100	0	0
5. Buctril + Poast	0.5 lb + 0.188	1 pt + 16 oz	DAY 1	100	95	93	68
6. Fusilade	0.188	12 oz	DAY 1	100	100	0	0
7. Buctril + Fusilade	0.5 lb + 0.188	1 pt + 12oz	DAY 1	89	88	94	66
8. Buctril Prism	0.5 lb 0.125	1 pt 17 oz	DAY 1 DAY 7	98	100	93	70
9. Buctril Poast	0.5 lb 0.188	1 pt 16 oz	DAY 1 DAY 7	98	100	82	70
10. Buctril Fusilade	0.5 lb 0.188	1 pt 12 oz	DAY 1 DAY 7	86	95	69	69
11. Buctril	1 lb	1 qt	20 A Band @ 2TL	0	1	97	79
12. Buctril	0.5 lb	1 pt	Broadcast @ 2TL	0	0	97	71
14. UTC				0	0	0	0

Note: All treatments receive COC @ 1% v/v

Table 6. Johnsongrass Control in BXN Cotton 2000, Steve Wright, Farm Advisor, University of California Cooperative Extension

Johnsongrass % Control				
Treatments	Rate/A	**7 DAT**	**14 DAT**	**21 DAT**
1. Buctril	16 oz	0	0	0
2. Buctril + Prism	16 oz 17.02 oz	50	75	80
3. Buctril + Fusilade	16 oz + 12.03 oz	40	75	77
4. Buctril + Poast	16 oz + 16.04 oz	50	53	37
5. Buctril B. Prism	16 oz 17.02 oz	0	70	72
6. Buctril B. Fusilade	16 oz 12.03 oz	0	67	68
7. Buctril B. Poast	16 oz 16.04 oz	0	37	35
8. Prism	17.02 oz	40	78	75
9. Fusilade	12.03 oz	43	80	75
10. Poast	16.04 oz	17	60	48
11. Untreated	-----	0	0	0
LSD .05	**---**	**1.2**	**1.2**	**1.0**
% CV	**---**	**103**	**54**	**57**

1% v/v Agridex was tank mixed with all the treatments

Biological Control of Yellow Starthistle

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Yellow starthistle (*Centaurea solstitialis L.*) is an alien plant that probably originated from the eastern Mediterranean. It was first collected in California in 1869, and now infests 42% of the state's townships. It interferes with land use such as grazing and recreation, displaces native species, and is toxic to horses (Sheley, et al. 1999 and papers cited therein).

This weed is much less invasive in its land of origin. This is presumably because natural enemies, such as insects, plant diseases, animals or competing plants help to keep it under natural control. We are exploring for insects and pathogens that attack this plant. They are tested for host specificity to make sure they do not attack other plants. After evaluation and approval by state and federal agencies, these agents will be released to try to reestablish the natural control that occurs in the land of origin.

So far, six species of insect biological control agents have been introduced to control yellow starthistle (Turner et al. 1995; Rees et al. 1996; Jette, et al. 1999). All six attack the seedheads. The most promising agent is the hairy weevil (*Eustenopus villosus*), which is well established in California and occurs in high densities, attacking 25 to 80% of seedheads. Adults damage young flower buds by feeding on them, and lay eggs on later-developing flower buds. Their larvae develop inside a seedhead and consume all the seeds. However, this insect has only one generation per year and does not attack flowers that develop later in the summer. The other established agents, *Urophora sirunaseva*, *Bangasternus orientalis*, *Chaetorellia australis* and *Larinus curtus* are fairly widespread (see Table) but do not attain high numbers and appear to have little impact on yellow starthistle populations. *Chaetorellia australis* is better synchronized with bachelor button, which blooms earlier in the spring than yellow starthistle. *Bangasternus orientalis* appears to suffer from high egg predation and parasitism. The gall fly, *Urophora jaculata*, failed to establish because yellow starthistle in California is unsuitable for the fly (Clement 1994). The fly originated from a population of yellow starthistle in Italy that was much more susceptible to its attack. Recently, the parasitic mite *Pymotes tritici* has been found attacking seedhead insects in California and may be reducing their effectiveness.

The false peacock fly (*Chaetorellia succinea*), which was accidentally introduced in 1991, emerges in the spring about a month before the plant has developed flower buds large enough for egg-laying. However, the fly has several generations per year and increases numbers progressively through the growing season, complementing the seasonal activity of the hairy weevil. The false peacock fly is being tested for nontarget impact on safflower and native thistles and preliminary results have shown no significant adverse effects.

The rust pathogen, *Puccinia jaceae*, has been evaluated for host specificity by William Bruckart at the USDA-ARS laboratory in Fort Detrick, MD. A petition for its introduction has recently been submitted. Foreign exploration and evaluation of additional agents is currently increasing in Turkey, Russia, Greece and Italy.

Status of yellow starthistle biological control agents

Biological control agent	Common name	First release	Status
Urophora jaculata		1969	Never established in USA.
Urophora sirunaseva	YST[1] gall fly	1984	Widely established, present at most YST infestations in CA & OR; a few sites in WA, ID.
Bangasternus orientalis	YST bud weevil	1985	Widespread in CA, OR, WA & ID.
Chaetorellia australis	YST peacock fly	1988	Prefers bachelor button; established at a few sites in CA; widespread in OR, WA, ID.
Eustenopus villosus	YST hairy weevil	1990	Well established in CA; widespread in OR, WA; a few sites in ID, UT.
Larinus curtus	YST flower weevil	1992	Established at a few sites in CA, WA, ID; widespread in OR.
Unapproved accidental introduction:			
Chaetorellia succinea	YST false peacock fly	1991	Widely established in CA & OR, and spreading into WA, ID & NV. Currently being evaluated for nontarget impacts.

[1] YST = yellow starthistle

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Control of Glyphosate Tolerant Ryegrass

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Purpose

Recently glyphosate tolerant annual ryegrass (Lolium spp.) has been observed in isolated Northern California orchards. Extensive research is being conducted at the University of California-Davis regarding ryegrass tolerance/resistance, however at this time no information has been published. In Australia ryegrass resistance occurred which has been well documented by researchers. Combinations of chemistries and tillage have been used to control resistant ryegrass in Australia. Ryegrass seed was collected from an orchard in Northern California on June 21,2000. Ryegrass in this orchard had exhibited tolerance to Roundup Ultra at one quart per acre.

Materials and Methods

Seeds of this tolerant annual ryegrass were placed in four inch pots containing Yolo Fine Sandy Loam and covered to a depth of a quarter inch (July 28, '00). The pots were placed in a greenhouse that maintained a temperature range of 52 to 84 degrees Fahrenheit. The pots were irrigated daily by a timed drip system. Approximately a quarter inch of moisture was applied every 24 hours. Sixteen days after seeding, emergence occurred (8/13/00). On September 8, 2000 the pre-emergent treatments were seeded. They were covered in a quarter inch of soil and left unirrigated until herbicide application.

Prior to herbicide application the post-emergent treatments were sorted by size and placed in treatment order. The herbicides were applied between 10 a.m. and 4 p.m. on September 17, 2000 using an O'brian Linear Sprayer. The post-emergent treatments were applied at a rate of ten gallons of distilled water to the acre at 20 psi.

Results

#	Treatment	8 dat	15 dat	22 dat			29 dat			64 dat		
				large	med	small	large	med	small	large	med	small
1	Roundup Ultra	30	40	10	85	95	10	50	95	10	10	50
2	Roundup Ultra	25	50	15	85	90	10	55	90	10	50	70
3	Roundup Ultra	50	60	65	85	90	55	70	95	20	30	90
4	Roundup Ultra	40	65	55	85	95	55	70	95	35	50	95
5	Prism	40	75	75	85	95	85	90	95	50	65	100
	COC											
6	Poast	30	65	80	80	95	80	80	95	60	80	95
	COC											
7	Fusilade	35	30	5	5	95	5	5	95	10	65	85
	COC											
8	Roundup Ultra	40	70	90	90	95	90	90	95	40	50	70
	Prism											
	COC											

9	Roundup Ultra	40	60	15	65	85	25	70	90	0	50	95
	Prism											
	COC											
10	Roundup Ultra	25	75	70	85	95	80	85	95	55	65	90
	Poast											
	COC											
11	Roundup Ultra	25	75	90	90	95	90	90	95	80	75	100
	Poast											
	COC											
12	Roundup Ultra	30	65	70	85	x	75	85	X	20	70	X
	Fusilade											
	COC											
13	Roundup Ultra	20	60	90	90	x	90	90	X	50	50	X
	Fusilade											
	COC											
14	Check	0	0	0	0	x	0	0	X	0	20	X

Observations

Weed tolerance to herbicides is costly. It has been documented that mixtures of chemistry and tillage can help to eliminate populations of resistant ryegrass. In this trial there was a direct relationship between plant size at application, and level of control. Herbicide application made at the four to five inch stage of growth was three times as effective than application made at ten to twelve inches of growth. Applications made at the four to five inch stage of growth had significantly better control than application made at seven to ten inch stage of growth. These results were observed for all treatments fifteen to twenty two days after application.

Roundup Ultra at three pints per acre tank mixed with Prism at one pint per acre, or Roundup Ultra at three pints per acre tank mixed with Poast at two pints per acre provided the highest level of control.

It has become widely accepted that glyphosate tolerant ryegrass has emerged in Northern California. However, simple practices can eliminate the problem in a very economical way. This trial has demonstrated that early application and mixtures of chemistry will effectively control tolerant/resistant annual ryegrass. To Control tolerant/resistant annual ryegrass "hit them hard" with a tank mixture of Roundup ultra with Post or Prism, and "hit them early" before plants grow beyond four to five inches in height.

Summary of Control of Herbicide Resistant Watergrass with RegimentÔ Herbicide in Northern California Rice
October 2, 2000

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Introduction

Watergrass and barnyardgrass are serious weeds in California rice culture. There are three forms of watergrass and barnyardgrass indigenous to California, which infest rice. The early form of watergrass, *Echinochloa oryzoides*, blooms about 40 days after flooding. Its spikes are heavily awned and the heads are drooping or pendant. A second form of watergrass is *Echinochloa crus-galli var. oryzicola (E. phyllopogon)*. This form has upright foliage, erect panicles and awnless spikelets. It begins flowering at the same time as rice, about 90 days after flooding. This species resembles rice in the vegetative stage of growth and is an example of a weed mimic. Barnyardgrass, *Echinochloa crus-galli var. crus-gali* is common throughout the rice growing areas of California. Barnyardgrass is small seeded and quite variable in appearance. It is especially prevalent in fields where intermittent (pinpoint and leathers) flood-culture is utilized.

Over the last 3 to 5 years, many growers and PCAs in the Sacramento Valley have experienced difficulty controlling watergrass species in various fields. Late watergrass (rice mimic) has been identified as the major problem. However, control failures have also been identified on barnyardgrass and early watergrass. The major geographical area of concern is in Glenn County near the town of Princeton. The problem, however, is not limited to the Princeton area, and control failures have been documented throughout the Sacramento Valley.

Watergrass control problems were observed with maximum labeled rates of thiobencarb (Bolero® and Abolish®), molinate (Ordram®) and fenoxaprop-ethyl (Whip®). Failures occurred with singular and sequential applications of these herbicides. In 1998, Dr. Albert Fischer, UC-Davis, began extensive greenhouse and laboratory studies to confirm or refute the supposition that resistance to thiobencarb, molinate and fenoxaprop-ethyl had developed in the three forms of the *Echinochloa species* found in California. His findings are based on bioassays of watergrass and barnyardgrass grown from seed samples that had been collected from fields suspected of containing resistant biotypes. Results confirm that certain resistant populations of *Echinochloa species* are resistant to all three herbicides and that resistance is likely due to enhanced degradation via modified metabolic processes.

Discussion

Regiment™ 80 SP (bispyribac-sodium) is a post-emergence herbicide that has excellent efficacy against certain grasses, sedges and broadleaf weeds with selectivity for rice. It inhibits the plant enzyme acetolateate synthase (ALS), thus blocking branched-chain amino acid biosynthesis.

Regiment has a wide application window for control of barnyardgrass and watergrass. The herbicide can be applied to watergrass and barnyardgrass from the 1 leaf to 2-3 tiller stages for growth. Use rates range from 10 to 18 gram ai/Acre. Optimum use rates and application timing for control of non-resistant watergrass and barnyardgrass are 10 to 12 grams ai/A when the grass is in the 3 to 5 leaf stage. Higher use rates, up to 18 grams ai/A, are required for control of herbicide resistant *Echinochloa species*. The best timing for these biotypes is the 1 to 2 tiller growth stages. A non-ionic silicone based surfactant is required for optimum efficacy.

Valent USA first tested Regiment (V-10029) in California in 1995. In 1996, a small plot test was established in a field where the grower had experienced total herbicidal failure. Results of the test were promising and in 1997 full scale testing was initiated in the problem watergrass areas.

By the end of 2000, a total of 16 trials had been completed on herbicide resistant watergrass (Table 1). Thirteen of those trials were conducted on late watergrass and 3 on early watergrass. All trials were established in fields confirmed by Dr. Fischer to contain herbicide resistant grass. In all cases, the trial locations had histories of multiple herbicide failures.

Table 2 is a summary of efficacy data resulting from early and late applications of Regiment for control of late watergrass *(E. phyllopogon)* in rice. The application was made at the 4 to 5 leaf stage and the late application was made at the 1 to 2 tillers stage of *Echinochloa* development.

Table 2. Control of Herbicide Resistant Late Watergrass with RegimentÔ.

RATE TIMING	10 GM AI/A	12 GM AI/A	15 GM AI/A	18 GM AI/A	24 GM AI/A
EARLY 4 TO 5 LEAF	72.3 (4)	77.3 (4)	84.3 (3)	88.9 (5)	86.5 (1)
LATE 1 TO 2 TILLER	75.0 (4)	80.4 (6)	89.1 (12)	91.5 (7)	95 (2)

All Regiment treatments had a silicone-based surfactant @ .125 to .25% v/v.

() Number of trials.

The data clearly indicate that Regiment at 15 grams ai/A and higher provides economic control of resistant late watergrass. The late timing, 1-2 tiller, provides better control than the early timing. The difference in control between early and late application timing is more than likely a result of coverage, susceptibility or subsequent watergrass emergence. Better control at the late application timing was consistently observed in all trials.

Table 3 is a summary of data comparing Regiment applied at 15 grams ai/A to the standard treatments for control of late watergrass. Of the three standards in the trials, SuperWham® provided the best control when compared to Ordram and Whip. SuperWham was the most consistent performer of the three standards but did not control the late watergrass at the same level as Regiment. Ordram and Whip did not provide economic control of late watergrass.

Table 3. Control of Herbicide Resistant Late Watergrass with Regiment vs. the Standard herbicides.

RATE TIMING	6 QT/A SUPERWHAM	1.2PT PR/A WHIP	4 LBS AI/A ORDRAM	15 GM AI/A REGIMENT
EARLY 4 TO 5 LEAF	81.4 (5)	---	56.7 (1)	84.3 (3)
LATE 1 TO 2 TILLER	82.2 (7)	62.2 (4)	---	89.7 (12)

All Regiment treatments had a silicone-based surfactant @ .125 to .25% v/v.

() Number of trials.

Table 4 is a summary of efficacy data for control of early watergrass *(E. oryzides)* comparing Regiment to the standards, SuperWham, Ordram and Whip. Regiment application was made at either the 4 to 5-leaf stage or the 1 to 2-tiller growth stage of rice.

Table 4. Control of Herbicide Resistant Early Watergrass with Regiment.

RATE TIMING	12 GM AI/A REGIMENT	15 GM AI/A REGIMENT	18 G MAI/A REGIMENT	4 LBS AI/A ORDRAM	1.2PT PR/A WHIP	6 QT/A SUPERWHAM
EARLY 4 TO 5 LEAF	90.0 (1)	---	88.0 (1)	65.0 (1)	---	---
LATE 1 TO 2 TILLER	98.0 (1)	95.5 (3)	86.2 (3)	---	49.1 (3)	75.8 (3)

All Regiment™ treatments had a silicone-based surfactant @ .125 to .25% v/v.

() Number of trials (data points).

The data clearly indicate that Regiment at 12 grams ai/A and higher provides economic control of early watergrass. The late timing, 1-2 tiller, provides slightly better control than the early timing. None of the standards, Ordram, Whip or SuperWham gave adequate control of resistant early watergrass.

Summary

In all trials, Regiment has consistently provided excellent control of all three resistant *Echinochloa* biotypes found in Northern California rice. Early watergrass appears to be more sensitive to Regiment than the late species. However, both species can easily be controlled with Regiment. Best application timing appears to be at early tillering for both species. Application timing does not appear to be as critical for the control of early watergrass as it does to the late species. Use rates of 15 to 18 grams ai/A have consistently outperformed the standard herbicides, Bolero/Abolish, Ordram, Whip and SuperWham for control of these grass species.

The Effect of Glyphosate Application Timing On Weed Control Efficacy and Crop Yield and Quality in Glyphosate Tolerant Lettuce

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Introduction

The development of glyphosate tolerant lettuce provides a potentially powerful and economical alternative weed management strategy for lettuce growers. A field study was established in the Salinas valley to determine the lettuce growth stage at which to apply glyphosate postemergence for optimal weed control efficacy, lettuce yield, and quality.

Materials And Methods

Glyphosate tolerant lettuce, 'RR Raider 323', was seeded in 40-in raised beds on May 10, 2000 in the Salinas valley. Pronamide and bensulide treatments were applied preemergence at rates of 1.2 and 5.0 lb ai A^{-1}, respectively, in a spray volume of 40 GPA. These herbicides were sprinkler incorporated immediately after application. Glyphosate treatments were applied post-emergence timed to occur at six lettuce growth stages: at two (2-leaf), four (4-leaf), six (6-leaf) and eight (8-leaf) true leaves; at two leaves plus a sequential application 14 days later (2-leaf+14d); and at four leaves plus a sequential application 14 days later (4-leaf+14d). All glyphosate applications were made at the rate of 1.0 lb A^{-1} in a spray volume of 40 GPA, with the exception of the 8-leaf stage, when the glyphosate was applied in 20 GPA. All treatments were replicated four times within a randomized complete block design. Weed densities were assessed June 2 and June 14. Lettuce thinning was timed for each treatment on June 5, and hand weeding times were recorded for each treatment on June 20. Phytotoxicity was assessed on May 27, June 5, June 10, June 17, July 1 and July 10. Lettuce was graded and fresh weight determined at harvest on July 11 and 14. Local cultural practices were followed for soil fertility, irrigation scheduling, row cultivation, and for scheduling of thinning, weed removal, and harvest. Results were analyzed using ANOVA and Fisher's protected LSD (α=0.05) was used for mean separation.

Results and Discussion

Weed control efficacy. Based on weed densities assessed June 2, the 2-leaf glyphosate treatment provided control superior to that of preemergence compounds pronamide or bensulide (Table 1). Weed densities in the 2-leaf treatment did not differ from the hand weeded check and were lower than those of the untreated check. Bensulide provided excellent control of redroot pigweed, and pronamide resulted in significant reductions in little mallow and hairy nightshade densities.

Based on weed densities assessed June 14, glyphosate applied at the 4-leaf, 2-leaf+14d, 4-leaf+14d, and 6-leaf stages provided the best overall control, equal to or superior to that of pronamide and bensulide. Redroot pigweed densities in the 4-leaf, 2-leaf+14d, 4-leaf+14d, and 6-leaf stages along with bensulide were lower than the untreated check. The pronamide and 2-leaf glyphosate treatments did not reduce redroot pigweed densities below that of the untreated check. Little mallow densities were lower than the untreated check for pronamide and all glyphosate treatments except the 2-leaf application. Hairy nightshade densities in the pronamide treatment, and all glyphosate treatments except the 8-leaf application, were lower than the untreated check. It should be noted that the 8-leaf application was made only two days prior to the June 14 rating, such that efficacy could not be reasonably evaluated.

Labor. Total labor requirement for the 4-leaf, 2-leaf+14d, 4-leaf+14d and 6-leaf stage glyphosate treatments were approximately equal to the hand weeded check (Table 2).

For all treatments applied before the time of thinning, i.e., before June 5, required thinning time was lower than that of the untreated check. A single glyphosate application at the 2-leaf or 4-leaf stage was as effective as sequential applications. Delayed 6-leaf and 8-leaf applications resulted in at least one additional man-hour per acre for the thinning operation.

All treatments significantly reduced weeding time relative to the untreated check. All glyphosate treatments resulted in lower labor inputs than pronamide.

Lettuce yield and quality. Based on ratings taken on six occasions within the crop cycle (data not shown), there was no evidence that any of the treatments resulted in phytotoxicity. Glyphosate applications did not result overall fresh weight reductions relative to the hand-weeded check (Table 3). Fresh weight means in the 2-leaf+14d treatments were significantly higher than those of the untreated check, pronamide and bensulide treatments. The 4-leaf, 2-leaf+14d, 4-leaf+14d and 6-leaf glyphosate treatments produced significantly more cartons/acre than pronamide or the untreated check.

Conclusions

Glyphosate-tolerant lettuce is a viable weed management system for lettuce. Weed management costs were reduced compared to costs associated with existing commercial herbicides. Glyphosate was more effective in reducing the impact of weed competition, and therefore, lettuce yield and quality were greater for glyphosate treatments than for existing preemergence herbicides.

Table 1. Average weed densities at time of thinning, June 2 and at time of hand weeding June 14

Treatment	Rate	Growth Stage	Redroot pigweed		Little mallow		Hairy nightshade	
			2-Jun	14-Jun	2-Jun	14-Jun	2-Jun	14-Jun
	lb A^{-1}		m^{2-1}					
Untreated	-	-	355	59	43	18	139	31
Hand weeded	-	-	3	0	4	0	3	0
Glyphosate	1.0	2-leaf (24-May)	51	38	12	12	14	7
Glyphosate	1.0	4-leaf (31-May)	241	2	34	8	111	0
Glyphosate	1.0 + 1.0	2-leaf (24-May) + 14 d	110	2	4	4	6	0
Glyphosate	1.0 + 1.0	4-leaf (31-May) + 14 d	346	0	32	9	79	0
Glyphosate	1.0	6-leaf (5-Jun)	346	2	37	4	125	5
Glyphosate	1.0	8-leaf (12-Jun)	175	30	35	9	90	25
Pronamide	1.2	Preemergence (10-May)	250	70	22	9	28	14
Bensulide	5.0	Preemergence (10-May)	4	5	35	16	71	26
		LSD (P=.05)	232	47	18	8	74	16

Table 2. Required thinning, weed removal and total labor time hr A^{-1} in glyphosate-tolerant lettuce

Treatment	Rate	Growth Stage	Thinning labor (5-Jun)	Hoeing labor (20-Jun)	Total
	lb A^{-1}			hr A^{-1}	
Untreated	-	-	9.3	90.3	99.6
Hand weeded	-	-	7.9	16.0	23.9
Glyphosate	1.0	2-leaf (24-May)	7.2	33.8	41.0
Glyphosate	1.0	4-leaf (31-May)	7.2	19.9	27.0
Glyphosate	1.0 + 1.0	2-leaf (24-May) + 14 d	7.3	16.2	23.6
Glyphosate	1.0 + 1.0	4-leaf (31-May) + 14 d	7.4	17.4	24.8
Glyphosate	1.0	6-leaf (5-Jun)	8.9	25.4	34.3
Glyphosate	1.0	8-leaf (12-Jun)	9.0	37.0	46.0
Pronamide	1.2	Preemergence (10-May)	7.9	64.6	72.5
Bensulide	5.0	Preemergence (10-May)	7.7	53.6	61.4
		LSD (P=.05)	1.0	16.2	16.1

Table 3. Lettuce yield by cartons of 24, 30 and 36 cartons acre^{-1} and by fresh weight lb A^{-1}

Treatment	Rate	Growth Stage	24	30	36	Total	Fresh weight
	lb A^{-1}			Cartons A^{-1}			lb A^{-1}
Untreated	-	-	26	157	87	270	12626
Hand weeded	-	-	266	394	125	785	36290
Glyphosate	1.0	2-leaf (24-May)	213	202	145	560	24372
Glyphosate	1.0	4-leaf (31-May)	396	275	96	767	34875
Glyphosate	1.0 + 1.0	2-leaf (24-May) + 14 d	261	429	119	809	38229
Glyphosate	1.0 + 1.0	4-leaf (31-May) + 14 d	266	432	119	817	35998
Glyphosate	1.0	6-leaf (5-Jun)	240	387	154	781	35069
Glyphosate	1.0	8-leaf (12-Jun)	131	387	157	675	30609
Pronamide	1.2	Preemergence (10-May)	44	247	113	404	17750
Bensulide	5.0	Preemergence (10-May)	196	185	102	483	22519
		LSD (P=.05)	266	152	91	288	13893

Fair Game

Poems by
David E. Haskell
California Department of Pesticide Regulation

Fair Game

Now the pesticide salesman,
he has a "tough row to hoe".
And negotiating a peace with man's best friend,
is the hardest sale he'll ever know.

I.

Well, it was my first week on the job,
so how could I have known.
That 100 lbs. of black German shepherd,
was sleeping in the roses by the road.

When my pickup woke him from his favorite dog dream.
His chain had finally broke.
And he rose up for that first taste of freedom,
that wouldn't end in a sudden choke.

He lunged for the driver's side pickup door.
And his teeth burst through the dust cloud.
He flashed a set of canine incisors,
That would have made Godzilla proud.

I jerked my arm in and hit the steering wheel.
I almost put the truck in a ditch.
Now I knew why this was a walk-in account.
Who would risk making a ranch sales pitch.

II.

A salesman building a new territory,
has to try some of those gravel roads.
And a grower at the end of one of them,
turned my day into a Tarzan episode.

When I introduced myself, he looked surprised.
"What are you doing here?"
"I haven't business with your company,
for at least fifteen years".
When the short conversation abruptly stopped,
I realized I had parked a little far out.
And this old ranch dog started to follow me back.

He was looking for trouble, no doubt!

He gave me his best hardened stare,
Hoping to flush me into a run.
Now he was a sporting dog.
He just wanted to have a little fun.

When I finally decided to make my move.
He thought he could beat me back to the truck.
Then his dysplasia suddenly acted up.
Finally, a piece of good luck.

III.

How I hate these home deliveries,
But the customer is always right!
He wants to spray tomorrow morning.
So he wants his chemicals tonight.

His instructions were plain and simple,
"Honk the horn when you first pull in".
"I'll make sure the dog is in the house"
"He is my wife's and he doesn't like men".

When I arrived I shut the pickup door hard.
But I didn't hear a single bark.
So I guessed that the coast must be clear,
and I ventured out into the dark.

I grabbed that deadly cargo from the back of the truck,
four gallons of ethion.
This is going to be easier than I thought.
Five minutes, and I will be gone.

I started out for the front porch light.
Then I heard a backdoor slam.
When I heard the dog's nails clicking on the driveway.
Trouble was coming, I didn't need a telegram.

Well, my mind froze in confusion and fear,
but my fingers held on real tight.
If I dropped those pesticide bottles here.
I'd turn his driveway into a hazmat site.

The dog kept barking, but he didn't bite.
And he skidded to a sudden stop.
When the grower arrived for a late rescue.
Boy, I was ready to drop.

I have often sat and wondered,
Why that dog didn't try to bite.
I know they are an intelligent breed.
Maybe he saw the skull on the box that night

South County Shop of Horrors

They say he missed his morning coffee,
everyday at the shop this week.
So he must be doing something.
Why don't you try his shop down by the creek.

How I hate making the winter farm calls.
It can be a dangerous time.
But the bloom spray coming in February.
I've got to make that chemical sale mine.

Because he claims he can build anything,
the neighbors call him Mr. Make-it.
But the truth of the matter is.
Most of his projects turn out like ____!!

His wife finally gives me a solid clue.
He's at the shop on the Dairy Ranch.
He is overhauling the air-blast sprayer.
So I decide to give it a chance.

The sprayer is parked out on the tarmac,
the scrod pulled like a canning jar lid.
But it's been sitting there since Thanksgiving.
So who is he trying to kid?

Dumb stupid luck has finally found me,
his pickup is parked outside.
I pull at the rusty sliding barn door.
This could be an attempted suicide.

The abandoned manger is now the storage room.
Already, I have made a bad mistake.
Choking on the ferric carbon dioxide fumes.
Now don't panic, for heaven's sake.

The fan belts are arranged like hangman nooses.
Carefully, I brushed them aside.
And I stepped over the yellow metal carcass,
that once was Peoria's Pride.

I headed for the flickering shafts of light,
from a smudge pot's blazing fire.
And Marilyn winked at me from an old calendar,
wearing nothing but an eight ply tire.
I had to pass a man waving a hand-held grinder.
So I whispered a silent prayer.
And then he showered me with a tail of metal sparks.
He didn't even know I was there.

I heard the hiss of a gas cutting torch.
Rubin's was dissecting the ranch carryall.
To create a pile of new metal bones,
for some idea the boss is trying to recall.

He pointed with his torch towards the milking room.
The boss is striping parts off the old John Deere.
To build a tree shaker like the one he saw,
at the farm equipment show last year.

I followed a trail of red hydraulic fluid,
left by a severed limb.
Another causality of the creative thoughts,
of this strange breed of homo sapien.

I see a man sprawled out on the floor,
his body buried under the Deere's transmission.
Muttering swear words, I know he's alive.
I have finally found the right person.

What kind of a man could lay for hours,
on that cold concrete.
I asked myself while making conversation,
to the greasy boots he wore on his feet.

After getting nothing, but one-word answers,
I realize he's not going to budge.
If this is how the man spends his leisure time.
Then who am I to judge.

He says give him a call early next month.
But I know that's going to be too late.

Already, my competitors are circling.
So I will try again and accept my fate.

How I hate to make these winter farm calls.
You never know what you might stumble on to.
Idle hands are truly the devil's workshop.
And they might just be the end of you.

Jumping John

Jumpin John was a bareback rider.
He performed his horseback stunts with pride.
He managed DPR's assessment group,
and tried to keep us all in stride.

He held a different rein for each of us,
some were long and some were short.
To keep our heads up and watching,
to survive in this dangerous sport.

He guided us with a soft whip.
We were all professionals in his eyes.
With different gaits and different goals,
and answers for the reasons why.

He jumped us through the assessment hoops,
with controversy licking our sides.
Above the activists cries and the pilots jeers,
we rescued Molinate and Methyl Bromide.

His circus stunt was a formidable one,
to keep us prancing in the matinee ring.
Around and around in circles he rode,
until Adm. decided on something.

But they kept us out of the Center Ring.
They thought our science was just horseplay.
And the crowd never rose to clap their hands,
to cheer our feats at the CAL/EPA.

Integrated Conventional and Biological Control of Yellow Starthistle at Fort Hunter Liggett, Monterey County, California

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Yellow starthistle (*Centaurea solstilialis*) is an invasive, annual weed native to the Mediterranean. Problematic in most western states, yellow starthistle has invaded 10 to 15 million acres within California. This large-scale yellow starthistle study occurs at Fort Hunter Liggaett (FHL), a military training facility located in southern Monterey County, California. Yellow starthistle has steadily spread into 20,000 of FHL's 165,000 acres. Targeting starthistle's massive seedbank, we plan to significantly reduce the amount of yellow starthistle, improve the value of the existing ecosystem, and prevent the invasion of other noxious weed species within large acreages of land. An integrated management plan has been developed for three habitat types: 1) grassland with military use; 2) grassland with oaks; and 3) grassland with rare plants. Prescription burning, pre- and post-emergent herbicides, and biological control are some of the yellow starthistle management methods we are applying to these large acreages of land. For each site and its corresponding control site, data was collected for overall veaetation and yellow starthistle cover, density, biomass, seedbank, and biocontrol. After one year of treatment, aerial application of Transline (clopyralid) resulted in 94% to 100% reduction of starthistle vegetative cover, density, and biomass in the two treated sites. Transtine treatments at both sites resulted in increased species richness. At the third site, yellow starthistle cover was lower in the pre-treated site (36%) compared to the adjacent untreated area (73%). Species richness was reduced in the more heavily infested untreated area. Biocontrol and seedbank results have Yet to be analyzed. After one year of treatment. we can conclude that Transline can dramatically reduce the extent of starthistle infestation while having little impact on total species richness in treated areas.

A Comparison of Control Methods for Perennial Pepperweed Within Infestations of Varying Densities and the Resulting Impacts on Resident Plants Populations

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Perennial pepperweed (*Lepidium latifolium* L.) is a herbaceous perennial weed that has been rapidly invading California. It can establish dense, monospecific stands in a variety of habitats. Previous research has demonstrated that spring mowing can enhance the effectiveness of systemic herbicides in controlling perennial pepperweed by altering the architecture of the plants and allowing a greater amount of the herbicide to be deposited onto the basal portion of the canopy (Renz & DiTomaso 2000 CWSC 52:28). The goals of this research are to further quantify the effectiveness of this mowing strategy on perennial pepperweed infestations of various densities and to determine how specific treatments affect resident plant populations one year after treatments.

Results indicate mowing enhanced the effectiveness of herbicides in controlling perennial pepperweed in dense infestations, but in low density infestations mowing did not improve the effectiveness of systemic herbicides. Incorporating mowing into the management program reduced native plant and annual dicot cover, while perennial plant cover increased. Herbicide treatments, while species specific, generally reduced perennial pepperweed cover and increased bareground, perennial plant, and native plant cover. These results indicate that the form of the infestation (density, canopy architecture) may alter the effectiveness of specific control methods on perennial pepperweed. Management programs should be developed considering the proper control methods for the form of the infestation and the resulting impacts the control methods selected have on desirable plants reestablishing.

Potential for Using *Allium* Spp. Amendments, With and Without Soil Heating, for Weed Control Via Biofumigation

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Summary

Previous studies using soil amendments with onion (*Allium cepa*) and garlic (*Allium sativum*) extracts or residues have demonstrated a range of deleterious, inhibitory, or stimulatory effects on certain fungal and nematode plant pathogens. The research described in this paper showed small to moderate reductions in viability of barnyardgrass (*Echinochloa crus-galli*), London rocket (*Sisymbrium irio*), and annual sowthistle (*Sonchus oleraceus*) seed when exposed to onion and garlic residues incorporated in soil in microcosms at concentrations of 1 or 3% at ambient temperature (23° C). This deleterious effect on seed viability was considerably magnified when the amended soil was exposed to sublethal heat (39° C). In the search for useful alternatives to soil fumigation, there appears to be good potential for weed control using *Allium* amendments, particularly when coupled with soil heating. Further work is currently underway.

Introduction

With the soil fumigant methyl bromide scheduled to be phased out of production in the United States by 2005, there is an urgent need for alternative methods of soil disinfestation. The possibility exists that, without methyl bromide, growers may use combinations of less effective, but perhaps more environmentally hazardous chemicals. Consequently, effective, non-traditional soil treatments for use in high value horticultural crops are being sought.

Biofumigation is the process of incorporating organic amendments, primarily animal and plant residues, in soil to produce biotoxic volatile compounds (7). It is well documented that higher plants are capable of producing a wide variety of secondary products which are biologically active and can be exploited as fungicides, herbicides, and insecticides. These compounds are usually produced inside plant tissues and released as plant residues are incorporated into the soil and subjected to microbial degradation (9). There has been shown to be a direct correlation between concentration of some of these compounds in the soil and increased temperature (1). Crucifers have demonstrated biocidal activity both as green manures and when combined with solarization (1,2,5). However, as green manures, suppressive activity has often been incomplete or unpredictable. When combined with heat, effects have been more reliable in eradicating or weakening pest populations of some nematodes and pathogenic fungi (1,2,5).

Previous studies on green manures and volatile compounds of *Allium* species, primarily onion and garlic, have shown various degrees of pest management potential (4,8,10).

Soil solarization is a non-chemical means of soil disinfestation in which plastic film functioning as a mulch is stretched over moist soil during the hottest part of the year. Solar radiation is trapped under the mulch, creating an environment in which soil is heated to temperatures lethal or sublethal to a variety of soilborne pathogens and pests. Despite its proven effectiveness in suitable climates, solarization has only cautiously been accepted to date as a means of disease and weed control (7). Reasons for this include lack of treatment guidelines and skilled applicators, continued availability of established fumigation methods, and lack of technical support. Solarization combined with the incorporation of plant residues in the soil produces a more consistently suppressive and sometimes eradicative effect on soilborne fungi, bacteria, nematodes, weeds and pests than either treatment used alone (1,2,5).

The experiments described in this paper comprised a preliminary study designed to examine herbicidal effects of incorporating dried residues of onion or garlic at two concentrations similar to those found in residues following crop harvest into soil microcosms containing buried weed seeds. Microcosms were then incubated at ambient temperature or with sub-lethal heating (so seeds would not be killed by heating alone) for varying periods of time, and weed seed survival and viability were determined.

Materials And Methods

Soil, weed seeds, and *Allium* amendments. Hanford fine sandy soil was collected and sieved through a 3 mm mesh sieve to remove roots and other surface debris. Weed seeds were collected from plants growing wild in the Fresno area. The three species tested were *Sonchus oleraceus* (annual sowthistle), *Sisymbrium irio* (London rocket), and *Echinochloa crus-galli* (barnyardgrass). *Allium* species used as soil amendments were garlic (*A. sativum* 'California Early') and onion (*A. cepa* ‘Mission') harvested from commercial fields on the west side of the central San Joaquin Valley.

Preparation of weed seeds for treatment. Ten seeds of each species were placed in 3.5 cm diameter nylon organdy bags. Bags of seeds were dipped in deionized water and placed between moist paper towels to imbibe water for 24 hours prior to immersion in water bath.

Preparation of microcosms for treatment. Soil was moistened to approximately field capacity (14-15%) before amendments were added. *Allium* amendments consisted primarily of air and oven dried residues of roots and bulbs which were ground in a Thomas-Wiley mill using a 1 mm mesh. Samples consisted of 200 g of soil amended with either 1 or 3%, by weight, of the residues. Amended samples were thoroughly mixed then placed in a 355 ml, clear plastic cup. Three bags of weed seeds, one of each species, were placed halfway down in the center of the cup. Each cup was covered with 1 mil polyethylene film and secured with a rubber band.

Treatment. Heated microcosms were placed in a 385 l capacity, stainless steel water bath maintained at 39° C using a Techne FTE10A immersion circulator. Unheated samples were kept in an ambient temperature (22-23° C) water bath. Temperatures of soil samples and water baths were monitored with HOBO data loggers. Microcosms with each amendment percentage

(1 or 3%) were conducted as separate trials. For each trial, 36 samples-12 each of garlic-amended, onion-amended or non-amended-were placed in the 39 C water bath and 36 in the ambient temperature bath. At intervals of 2, 4, and 7 days, four microcosms of each amended or non-amended treatment were removed from baths. Following removal, weed bags were extracted from soil, opened and checked for survival. In addition, 4 groups of 10 seeds of each of the three species were placed in the incubator according to the germination protocol to serve as the time '0', non-treated control.

Germination. Seeds from each bag were placed in 100 x 15 mm petri dishes on 70 mm Whatman #1 filter paper moistened with 1.4 ml deionized water. Petri dishes were placed in crispers and incubated in a Revco incubator on a cycle of 8 hours at 20° C and 16 hours at 30° C, and exposed to a fluorescent plant growth light during the 30 C cycle. Water was added to petri dishes as needed during the incubation period. Germination counts were done at regular intervals for a period of 30 days. Seeds were counted as germinated if the radicle had emerged and the plumule emerged to a length of 3 mm. Non-germinated seeds were gently squeeze- tested to determine viability (3).

Results And Discussion

Following incorporation of 1% onion and garlic residues at ambient temperature, viability was essentially unchanged for annual sowthistle and London rocket over the 7 day treatment period. Barnyardgrass experienced some increase in viability, though this did not change over 7 days. When subjected to sublethal heating, seeds of annual sowthistle, London rocket, and barnyardgrass were completely killed after 7 days of exposure to either onion or garlic. Viability of non-amended samples of all three species was essentially unchanged regardless of temperature regimen.

Incorporation of 3% onion and garlic at ambient temperature had little effect on viability of annual sowthistle. Viability of London rocket was little changed with onion, but dropped after 4 days of garlic exposure. Viability of barnyardgrass was reduced following exposure to onion or garlic amendment. Incubation with sublethal heating completely killed annual sowthistle seeds after 2 days with garlic and 4 days with onion. After 4 days, London rocket seeds were completely killed using either onion or garlic plus soil heating. Barnyardgrass seeds were completely killed at 4 days with garlic and 7 days with onion when combined with soil heating.

Viability of non-amended samples was essentially unaffected by the addition of heat, in many cases germinating at more than 100% of the time '0', non-amended control seeds.

Incorporation of dried, ground residues of onion and garlic in soil, combined with 4 to 7 days of soil heating at 39 C, resulted in a drastic reduction of viability of annual sowthistle, London rocket, and barnyardgrass seeds. Survival of weed seeds in the non-heated treatments was somewhat erratic, possibly due to unexplained interactions among seeds, soil, and soil microflora.

Conclusions

Previous studies with onion (*Allium cepa*) and garlic (*Allium sativum*) juices or extracts have demonstrated a range of deleterious, inhibitory, or stimulative effects on certain fungi and nematode plant pathogens. Our preliminaryresearch showed small to moderate reductions in viability of barnyardgrass (*Echinochloa crus-galli*), London rocket (*Sisymbrium irio*), and annual sowthistle (*Sonchus oleraceus*) seed when exposed to onion and garlic residues incorporated in soil at 1% or 3% (w/w) concentrations at 23° C. The deleterious effects on seed viability was considerably magnified when the amended soil was exposed to sublethal heating (39 C). In the search for useful alternatives to soil fumigation, there appears to be good potential for weed control using *Allium* amendments, particularly when coupled with soil heating. Further experimentation to clarify the effects of these treatments is currently underway.

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Touchdown 5 Sl (Sulfosate): Control Of Yellow Nutsedge, *Cyperus esculentus* L., In Citrus

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Introduction

Yellow nutsedge, *Cyperus esculentus* L., is a troublesome perennial that infests many irrigated annual and perennial crops. The mature plant grows to 1-3 feet tall, with a triangular-shaped stem. The flowering head has slender stalks that radiates like spokes from the tip of the stem to form an umbrella-like top. The plant is extremely prolific, with new plants coming from abundantly produced tubers and bulbs[1]. Touchdown 5SL (Sulfosate) was evaluated for burn down and long-term control of yellow nutsedge in citrus.

Materials And Methods

First Year—1999

This trial was conducted in a young citrus orchard (cv. Late Lane) that had a dense population of yellow nutsedge across the row middles. Sulfosate was applied at 1.25 and 2.0 lb ai/A. For comparison, Gramoxone Extra 2.5 SL (Paraquat dichloride) was applied alone at 0.94 lb ai./A. Quest (NIS by Helena) was added to each treatment at 0.25% v/v. Treatments were applied through a CO_2 backpack sprayer and a hand-held flat boom, housing four nozzles 20 inches apart. Treatment were mixed to volume and applied at 15 GPA and 35 psi. Each plot was 14-ft wide (2 boom swaths) and 24 feet long, set up in an randomized complete block design, each treatment replicated four (4) times.

Evaluations were made at 7, 14, 21, 28, and 35 days after application (DAA), by assigning the nutsedge in each plot a visual percent control rating (0= no effect, 100 = complete kill). After the 35 DAA rating, plots were reapplied with the same treatment and evaluated for another 30 days. All treated plots were over sprayed with Sulfosate at 1.25 lb ai/A.

A total of three (3) applications were made to each treated plot during the first year

Second Year—2000

Sulfosate treatments were repeated the second year. Four additional treatments were initiated the second year that included: Sulfosate at 1.25 and 2.0 lb ai/A and Roundup Ultra (Glyphosate) applied at 1.0 and 2.0 lb ai/A. No surfactants were used the second year. Application equipment and plot size remained the same. Two total applications were made for each treatment in 2000.

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1 U.C. Cooperative Extension. Growers Weed Identification Handbook. U.C. Cooperative Extension, Division of Agriculture and Natural Resources. 1991. p. 73.

Results

First Year—1999

Paraquat dichloride applied at 3 pts gave 73% burn down at 3 DAA, while no response was observed in Sulfosate treatments at 3 DAA. Sulfosate treatments started showing burn down response at 7 DAA, and by 14 DAA, the 1.25 and 2.0 lb ai/A rates provided 13 and 30% control, respectively, while Paraquat dichloride continued to show 73% burn down. At 21 DAA, Paraquat dichloride control declined to 47% burn down, while Sulfosate applied at 1.25 and 2.0 lb ai/A showed 28 and 65% control, respectively. By 35 DAA, Paraquat dichloride provided only 23% control. Sulfosate applied at 1.25 and 2.0 lbs. ai/A provided 35 and 68% control, respectively (Figure 1). Treatments were reapplied at 35 DAA.

Figure 1. Percent Burndown of Yellow Nutsedge in Citrus

Treatment	3 DAA	7 DAA	14 DAA	21 DAA	28 DAA	35 DAA
Sulfosate – 1.25 lbs ai/A	0 b	0 b	12.5 c	27.5 c	32.5 bc	35.0 a
Sulfosate – 2.0 lbs ai/A	0 b	7.5 b	30.0 b	57.5 a	65.0 a	67.5 b
Paraquat dichloride–0.94 lb ai/A	73.3 a	76.7 a	73.3 a	46.7 b	40.0 b	23.3 c

Paraquat dichloride applied at 0.94 lb. ai/A provided 70% burn down at 6 DAA2. The Sulfosate treatments showed 45 (1.25 lbs. ai/A) and 73% control (2.0 lbs. ai/A). At 16 DAA2, Sulfosate applied at 1.25 and 2.0 lbs. ai/A provided 65 and 94% control, respectively, while Paraquat dichloride gave 53% control. At 30 DAA2, Paraquat dichloride plots showed only 30% control. Sulfosate applied at 1.25 and 2.0 lbs. ai/A gave 85 and 95% control (Figure 2). The final application was made at 30 DAA2 by applying Sulfosate at 1.25 lbs ai/A across all treated plots (including Paraquat, but not the untreated).

Figure 2. Percent Burndown of Yellow Nutsedge in Citrus

Treatment	6 DAA 2	16 DAA 2	23 DAA 2	30 DAA 2
Sulfosate – 1.25 lbs ai/A	45.0 b	65.0 b	82.5 a	85.0 a
Sulfosate – 2.0 lbs ai/A	72.5 a	93.8 a	94.0 a	94.5 a
Paraquat dichloride–0.94 lb ai/A	70.0 a	52.5 b	35.0 b	30.0 b

Second Year—2000

The following Spring (280 DAA3), nutsedge populations were assessed by estimating the number of plants per square foot that had emerged. The untreated and Paraquat dichloride (with Sulfosate applied at the end of the year) treatments showed 48 and 31 nutsedge plants per plot emerged per square foot, respectively. Sulfosate applied with a total of three applications the prior year had 7 to 8 nutsedge plants emerged per square foot the following year (Figure 3).

Figure 3. Number of Yellow Nutsedge Plants per square foot

Treatment	280 DAA 3
Sulfosate – 1.25 lbs ai/A	7.3 c
Sulfosate – 2.0 lbs ai/A	7.8 c
Paraquat dichloride–0.94 lb ai/A	31.3 b
Untreated	47.5 a

Note: all treated plots received Sulfosate at 1.25 lb ai/A at the third application.

Post-Emergent Nutsedge Control

Sulfosate treatments that were continued from the previous year at 1.25 and 2.0 lbs. ai/A gave 85 and 95% nutsedge control, respectively at 21 DAA 4. Sulfosate treatments were retreated at 92 DAA4. By 14 DAA 5, Sulfosate applied at 2 and 3.2 lb ai/A gave 98 to 100% burn down of nutsedge. At 32 DAA 5, both Sulfosate treatments had 100% control of nutsedge. (data not shown).

Reduced Nutsedge Stand

By 45 DAA 4, the untreated averaged 23 nutsedge plants per square foot, while Sulfosate treatments applied 4 times (3 times in the previous year) had less than 0.3 nutsedge per square foot. Even at 92 DAA 4, the untreated showed 35 nutsedge plants per square foot emerged, while Sulfosate treatments had 2 nutsedge plants or less. At 32 DAA5, the untreated had 13 newly emerged nutsedge plants per square foot, while Sulfosate treatments applied twice this year and three times the previous year had less than 1 nutsedge plant per square foot (Figure 4).

Figure 4. Number of Yellow Nutsedge Plants per square foot

Treatment	45 DAA 4	92 DAA 4	32 DAA 5
Sulfosate – 1.25 lbs ai/A	0.2 b	0.3 b	0.3 b
Sulfosate – 2.0 lbs ai/A	0.2 b	2.0 b	0.9 b
Untreated	22.5 a	35.0 a	12.5 a

Sulfosate compared with Glyphosate on Nutsedge Burn down

At 21 DAA2 (first application made the prior year), Sulfosate applied at 1.25 and 2.0 lbs ai/A provided 60 and 79% control, respectively, while Glyphosate (Roundup Ultra) applied at 1.0 and 2.0 lbs. ai/A averaged 43 and 75% control. At 92 DAA2, treatments were reapplied on newly emerged nutsedge. Sulfosate applied at 1.25 and 2.0 lbs. ai/A both gave 99 to 100% control at 14 DAA3. Glyphosate applied at 1.0 and 2.0 lbs. ai/A showed 93 and 100% control, respectively at 14 DAA3. By 32 DAA3, all treatments gave 100% burn down of nutsedge (Figure 5).

Figure 5. Percent Burndown of Yellow Nutsedge in Citrus

Treatment	21 DAA 2	14 DAA 3	32 DAA 3
Sulfosate - 1.25 lbs ai/A	60.0 b	99.5 a	99.5 a
Sulfosate - 2.0 lbs ai/A	78.8 a	100.0 a	100.0 a
Glyphosate - 1.0 lbs ai/A	42.5 c	92.8 b	100.0 a
Glyphosate - 2.0 lbs ai/A	75.0 a	99.5 a	100.0 a

Sulfosate and Glyphosate also reduced nutsedge populations when compared to the untreated. Sulfosate applied at 1.25 and 2.0 lbs. ai/A showed 2.6 to 3.8 nutsedge plants per square foot at 45 DAA, versus 23 for the untreated. For comparison, Glyphosate applied at 1.0 and 2.0 lbs. ai/A had 3.4 to 6.3 plants per square foot. Sulfosate and Glyphosate treatments had between 2 and 5.6 plants per square foot at 92 DAA2, while the untreated had 35 plants per square foot. At 32 DAA 3, all Sulfosate and Glyphosate treatments had between 0.4 and 1.0 nutsedge per square foot vs. 13 for the untreated (Figure 6).

Figure 6. Number of Yellow Nutsedge Plants per square foot

Treatment	45 DAA 2	92 DAA 3	32 DAA 3
Sulfosate - 1.25 lbs ai/A	2.6 b	1.9 b	0.5 b
Sulfosate - 2.0 lbs ai/A	3.8 b	3.8 b	0.5 b
Glyphosate - 1.0 lbs ai/A	6.3 b	4.3 b	1.1 b
Glyphosate - 2.0 lbs ai/A	3.4 b	5.6 b	0.4 b
Untreated	22.5 a	35.0 a	12.5 a

Conclusions

First Year—1999

Although Paraquat dichloride showed better burn down at 7 DAA, Sulfosate applied at 2.0 lbs. ai/A was the superior treatment against yellow nutsedge at 35 DAA after one application (Figure 1). Sulfosate applied at 1.25 lbs. ai/A, though inferior to the 2.0 lbs. ai/A rate, showed better nutsedge control when compared with Paraquat dichloride at 0.94 lb. ai/A at 35 DAA. After two applications, Sulfosate applied at 1.25 lbs ai/A showed no significant difference in nutsedge control (85 vs. 95% control) when compared with the 2.0 lbs. ai/A rate.

Second Year—2000

Three applications of Sulfosate at either 1.25 and 2.0 lbs. ai/A in the previous year effectively reduced nutsedge populations by 85% the next spring (280 DAA3) when compared to the untreated or 75% when compared to Paraquat dichloride (2 apps.) and one application of Sulfosate (Figure 3). The continuation of Sulfosate applications at 1.25 and 2.0 lbs. ai/A were very effective in further reducing nutsedge populations. Even at 92 DAA 4, both Sulfosate treatments showed 95% and greater control of nutsedge (Figure 4). One more application of Sulfosate was needed to control nutsedge for the entire season.

Sulfosate applied at 2.0 lbs. ai/A showed burn down of yellow nutsedge comparable to Glyphosate applied at 2.0 lbs. ai/A at 21 DAA2, 14 DAA3, and 32 DAA3. Sulfosate applied at

1.25 lbs. ai/A gave greater burn down of nutsedge when compared with Glyphosate at 1.0 lb. ai/A at 21 DAA2 and 14 DAA3. By 32 DAA3, both products applied at the lower rate showed similar burn down.

Both Sulfosate and Glyphosate were equally effective at reducing nutsedge populations. At 45 DAA2, all Sulfosate and Glyphosate treatments showed 75 to 90% reduction of new nutsedge plants. By 92 DAA2, the level of control by both Sulfosate and Sulfosate was 85 to 95% control, with no significant difference in nutsedge populations between either Sulfosate or Glyphosate or between rates of either product. At 32 DAA3, all treatments showed 90 to 97% reduction of nutsedge.

Weed Control In Roundup Ready^{TM} Rice

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Introduction

Roundup Ready rice *(Oryza sativa)* is a biologically improved M202 containing a gene for tolerance to Roundup Ultra^{TM} herbicide (glyphosate). Roundup Ultra controls a broad-spectrum of rice weeds including those that are resistant to current broadleaf, sedge and grass herbicides.

Monsanto Company in cooperation with Northern California trade partners, the Rice Experiment Station and the University of California, Davis are currently developing the Roundup Ready rice weed control system. Line selection, efficacy and water management trials have been conducted since 1998.

Adoption of new cultural practices in rice production may be possible with Roundup Ready weed control systems. For example, flush management 30-40 days after roller or drill seeding may improve seedling vigor and ultimately yields. Conservation Tillage may also be made more practical using a Roundup Ready weed control system.

Results from the 2000 University of California, Davis efficacy trial are presented below.

Materials and Methods

Plot design was a randomized complete block with four replicates per treatment. Plots were 10 feet wide and 20 feet long. Seeding of Roundup Ready M202 rice was completed on June 2, 2000. Seeding rate was 150 pounds per acre.

Single foliar applications of Roundup Ultra at three rates (0.38, 0.75 or 1.12 lbs AE/A [pounds of acid equivalent per acre])* were made at 1-2 tillers 24 days after seeding (DAS), 2-4 tillers (28 DAS) or mid-tillering (34 DAS).

Sequential foliar applications of Roundup Ultra (0.38 followed by 0.75, 0.75 followed by 0.75 and 0.75 followed by 1.12 lbs AE/A) were made at the 3 leaf stage of rice (13 DAS) followed by mid-tillering (34 DAS) or 4-6 leaf stage of rice (17 DAS) followed by tillering (40 DAS). See further explanation of sequential treatments in Table 1.

Table 1. Timing of Sequential Treatments

Roundup Ultra Rates (AE/A)	3 lsr[1] 13 DAS	4-6 lsr 17 DAS	mid-tillering 34 DAS	tillering 40 DAS
0.38 followed by 0.75	X		X	
0.75 followed by 0.75	X		X	
0.75 followed by 1.12	X		X	
0.38 followed by 0.75		X		X
0.75 followed by 0.75		X		X
0.75 followed by 1.12		X		X

[1] Leaf Stage of Rice (lsr)

Rice paddy water depth was one to two inches at the time of all applications. Weed species present were watergrass *(Echinochloa crusgalli [L.] Beauv.)* and ricefield bulrush *(Scirpus mucronatus L.)*. Ricefield bulrush foliage began to emerge above the water line at the 4-6 leaf stage of rice (17 DAS). Evaluations were made 10, 30 and 60 days after treatment (DAT) using a 0 - 100% scale.

All applications were made with a CO_2 backpack sprayer using 8001 flat fan nozzles and a spray volume of 10 GPA at 20 PSI.

Results

Ricefield bulrush was submerged and not controlled 10 days after treatment (DAT) with the first application made in sequential treatments at the 3 leaf stage of rice (13 DAS) or at the 4-6 leaf stage of rice (17 DAS). Watergrass control (10 DAT) at the same stages of rice growth ranged from 74% to 100% indicating partial submergence. Full control of both species was achieved after each sequential treatment at 30 and 60 DAT.

Watergrass control with single treatments (0.75 or 1.12 lbs AE/A) applied at 2-4 tillers (28 DAS) or mid-tillering (34 DAS) was 100% (30 DAT) and ranged from 98%-100% (60 DAT). Using the same treatments, ricefield bulrush control ranged from 93%-100% (30 DAT) and 95%-100% (60 DAT).

Watergrass control with single treatments (0.38 lbs AE/A) applied at 2-4 tillers (28 DAS) or mid-tillering (34 DAS) ranged from 95%-99% (30 DAT) and from 85%-86% (60 DAT). Using the same treatments, ricefield bulrush control ranged from 90%-100% (30 DAT) and from 90%-100% (60 DAT).

Watergrass control with single treatments (0.375 lbs AE/A) applied at 1-2 tillers (24 DAS) was 85% (30 DAT) and 69% (60 DAT). Using the same treatment, ricefield bulrush control was 70% (30 DAT) and 71% (60 DAT).

Treatment detail is presented in Table 2.

Conclusions

All sequential treatments provided commercially acceptable season long weed control in Roundup Ready rice.

Single treatments (0.75 and 1.12 lbs AE/A) applied at 2-4 tillers or mid-tillering also provided commercially acceptable season long weed control in Roundup Ready rice.

In 2001, yield analysis will help further refine rates and application timing.

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* Equivalent to 1, 2 and 3 pints of Roundup Ultra per acre.

TABLE 2. ROUNDUP READY RICE WEED CONTROL (%)

Treatment	Roundup Ultra (lbs AE/A)	Application Timing	Watergrass (ECHOR) 10 DAT	Watergrass (ECHOR) 30 DAT	Watergrass (ECHOR) 60 DAT	Ricefield Bulrush (SCPMU) 10 DAT	Ricefield Bulrush (SCPMU) 30 DAT	Ricefield Bulrush (SCPMU) 60 DAT
1	0	Percent Cover	41	45	51	18	15	16
2	0.38	1-2 tillers (24 DAS)	85	85	69	58	70	71
3	0.75	1-2 tillers (24 DAS)	98	99	100	68	83	73
4	1.12	1-2 tillers (24 DAS)	99	100	100	76	65	63
5	0.38	2-4 tillers (28 DAS)	95	95	85	100	90	90
6	0.75	2-4 tillers (28 DAS)	100	100	98	98	93	95
7	1.12	2-4 tillers (28 DAS)	100	100	100	98	100	100
8	0.38	mid-tillering (34 DAS)	80	99	86	100	100	100
9	0.75	mid-tillering (34 DAS)	94	100	100	98	100	100
10	1.12	mid-tillering (34 DAS)	99	100	100	100	100	100
11	0.38 0.75	3 lsr (13 DAS) mid-tillering (34 DAS)	74	100	100	0	100	100
12	0.75 0.75	3 lsr (13 DAS) mid-tillering (34 DAS)	88	100	100	0	100	100
13	0.75 1.12	3 lsr (13 DAS) mid-tillering (34 DAS)	75	100	100	0	100	100
14	0.38 0.75	4-6 lsr (17 DAS) tillering (40 DAS)	85	100	100	0	100	100
15	0.75 0.75	4-6 lsr (17 DAS) tillering (40 DAS)	100	100	100	0	100	100
16	0.75 1.12	4-6 lsr (17 DAS) tillering (40 DAS)	96	100	100	6	100	100