Monday, January 20
Weed Management Workshop
Moderated by: Jim Downer, Farm Advisor-Environmental Horticulture, University of California Cooperative Extension, Ventura Co.

Weed Survival in Yardwaste Piles

Jim Downer, Ben Faber, Oleg Daugovish University of California Cooperative Extension, Ventura County

Since passage of the integrated waste management act of 1989, California has recycled its greenwaste (yardwastes). Green materials are gathered from residences or delivered to recycling centers by commercial landscape maintenance and tree trimming companies. Yardwaste is piled and then ground and either sieved or sold as coarse materials. Yardwaste has been used mostly as mulching material around landscape and orchard trees (Downer and Faber, 1999). Its use as a mulch has increased steadily during the 1990's so that it is now a valued resource for many landscape and orchard managers.

The effect of mulching on weed control is fairly well understood. Generally, when organic mulches are maintained at greater than 3.5 inches depth, over 90% of annual weeds are suppressed and do not emerge through the mulch material. However, we have observed perennial weeds encroaching from mulched areas. Yellow nutsedge (*Cyperus esculentus* L.) and bermudagrass (*Cynodon dactylon* (L.) Pers.) are frequently present in yardwaste.. Although the occurrence of weeds has been noted after mulching, there have been no reports of the spread of these weeds through the yardwaste recycling system.

Although yardwaste processors create large piles that undergo a heating and pest reduction process, this process is not uniform or consistent throughout yardwaste facilities. Stockpiling, inconsistent turning, aging and moisture content all favor the escape of living pest propagules from these facilities.

In an effort to better understand pathogen survival in the yardwaste recycling process, we conducted several experiments at Oxnard, California in 2001- 2003. The goal was to simulate a "worst case scenario" for yardwaste handling and weed contamination. We created static piles (ten cubic yards) of fresh (ground that day) yardwaste. No water was added after piling. Propagules of bermudagrass and yellow nutsedge were placed in nylon bags and buried at 100, 30, 15 cm depths inside the piles. Additional samples were fixed to the outside edge of the pile. Samples from each of these depths were retrieved at 0.5, 1, 2, 4, 7, 14, 21, 28 and 56 days after piling. The experiment had five replications (piles) and was conducted four times. The experiment has been run an additional two times using mature compost as the feedstock in an effort to create a "cold pile". The waste used for cold piles was up to 18 months old.

Viability of nutsedge tubers and bermudagrass stolons was assayed by growing them in a greenhouse for several weeks after retrieval from piles. The data were compiled as the percent of propagules that survived and resumed growth under greenhouse conditions. Both bermudagrass and nutsedge were killed inside of static piles after 7 to 14 days and survived somewhat longer on the outside of the piles. In cold piles nutsedge was viable for up to one month at various depths, however, bermudagrass did not persist past two weeks.

It is clear from our studies that under certain conditions, both yellow nutsedge and common bermudagrass can survive the yardwaste recycling system. It appears that nutsedge is more persistent than bermudagrass. Static yardwaste piles tend to become very dry and the bermudagrass stolons rapidly desiccate, however the yellow nutsedge tubers seem to withstand the drying process and retain their viability. Neither propagule can withstand the interior temperatures of a static pile (which reached over 165^{o}F) for more than a few days. Consumers should consider yardwaste a source of noxious weeds. To ensure that landscapes and orchards are not contaminated, consumers should only purchase yardwaste mulches from a vendor that uses a consistent pathogen/pest reduction process.

References

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Selected Weed Identification

Donald F. Rodrigues, Environmental Horticulture Program, Ventura College

The term "weed" does not always indicate that a plant is undesirable. In many situations, it depends on where the plant is, what your attitude is about the plant and how the plant affects your management practices.

Many of the typical so-called weedy plants have earned their reputation because they have no economic importance; they can become invasive; they can have prolific reproductive life cycles; they can interfere with natural resources; and they may intrude into our desirable cultivated plants. Some are even unattractive!

But not all defined weedy plants are totally obnoxious. Many have culinary or medicinal value, some are appreciated for their beautiful flower displays and many species provide valuable wildlife or beneficial insect habitats. In the end, you must decide which is the weed !

Weeds, like all plants, have distinct habitats, lifecycles, morphological and physiological characteristics. Some live in or near water, others prefer diverse soil conditions. They originate locally or were introduced from foreign lands. All have specific life cycles and botanical characteristics that aid in determining their specific identification. Numerous publications, plant keys and experts are available to assist in identifying specific plants.

Today, we describe 15 selected plants of our region. These were chosen for their unique characteristics and commonality in our community.

Dandelion (*Taraxacum spp)*, a member of the sunflower family, Asteraceae. A common perennial herb often associated with lawns. Yellow daisy like flowers with a circular ball windblown seed head. The branched taproot exudes a milky sap when broken. This native from Europe is very cosmopolitan, found throughout the United States. It thrives in moist soils, loves lawns and even survives mowing. The foliage is edible.

English Daisy *(Bellis perennis L.)*. A perennial spreading plant of the Asteraceae family. The basal leaves create a low matted appearance. White flower heads with yellow centers appear on long stalks in the spring and summer. Introduced from Europe as a garden plant, it is now a common escapee typically found in lawns.

Annual Bluegrass *(Poa annua L.).* This annual grass often becomes perennial along the coast. Typically found in turfgrass plantings and planter beds. Emerges in the winter as a small clump with bright green leaf blades and an inflorescence that is pyramidal in shape with spreading branches. A fast grower that thrives with moisture. A major problem in golf course greens.

Nutsedge *(Cypresus esculentus L.).* Yellow Nutsedge and *(C.rotundus L)* Purple Nutsedge.

Often mistaken for a grass or called nutgrass, this plant belongs to the Cyperaceae family of plants which includes 600 species of sedges. An aggressive perennial that grows 6-30" in height. Identified by its triangular shiney waxy appearing leaves. Prefers moist soils.

A native from Europe, the plant produces brown nutlets on the roots which are a means of spread if cultivated. Nutsedge also reproduces by seed.

Spotted Spurge *(Euphorbia maculate L.).* A member of the Euphorbiaceae family of plants, this prostrate annual forms a dense mat in the summer time. Stems exude a milky latex sap when broken. Small pinkish flowers are formed in the leaf axils. A prolific seeder. Easily identified by its rounded leaf with purple spots. Some consider it edible.

Puncture Vine *(Tribulus terrestris L.).* A summer annual forming prostrate mats that reach 10-12'. Small foliage resembles a fern. One half inch yellow flowers with 5 petals are formed in the leaf axils. Mostly known for its spiney sharp fruit (seed) burs that can puncture through shoes and bike tires. Sometimes called goat head. Originally introduced from Europe, it belongs to the Zygophyllaceae family of plants. Seed can remain dormant in the soil 4-5 years. Prefers dry, sandy soils.

Field Bindweed *(Convolvulis arvensis L.).* Often called morning glory vine. This plant is a member of the Convolvulaceae family of plants and was introduced from Europe. A perennial with an extensive deep root system and prostrate growth. However, it will climb anything near by. The leaves are alternate and somewhat arrow shaped. The trumpet shaped flowers are white to pinkish, 1-2" in diameter. Flowers from June to October. Most often found in cultivated fields and gardens. Seeds viable up to 50 years in the soil.

Curly Dock *(Rumex crispus L).* Native to Eurasia and a member of the Polygonaceae family of plants. A deep tap rooted perennial that grows 2-5' in height. The mostly basal curly leaves are 4-12" long with wavy margins. Small green flowers appear on spike like terminals in axillary clusters. Inflorescences and even entire plants turn reddish-brown at maturity in the fall. A common plant in wet areas..

Sowthistle *(Sonchus oleraceus L.).* Sowthistle was introduced from Euorope and is found throughout the western United States growing in vacant lots, roadsides, cultivated fields and gardens. The plant is a member of the sunflower family, Asteraceae. Basal leaves are stalked and deeply lobed. The flower heads are numerous and pale yellow, ¼ to ¾ inch wide. The mature seed head containing seeds resembles a white powder puff ball. The seeds are flat and ribbed lengthwise with a tuft of fine hairs which allows wind-borne dissemination. The overall plant at maturity reaches a height of 1-4 feet.

Fennel *(Foeniculum vulgare Miller).* Often called Anise or Sweet Anise, this perennial is native to Europe and belongs to the Apiaceae or carrot family of plants. It is often cultivated for its edible young leaves and the aromatic seeds are used to flavor foods. The plant matures in the fall with feathery fern like leaves on stalks 2-7' tall. Small yellow flowers are formed in clusters on the stalks. Seeds germinate in April-May. Found in vacant lots, roadsides and ditch banks. Fast growing and invasive.

Poison Hemlock *(Conium maculatum L.).* Also a member of the Apiaceae family of plants, all parts of this plant are poisonous. A biennial native to Europe, it can grow 6-8' in height. Erect stems are purple spotted. The shiney green lacy leaves resemble a fern. The foliage has a distinct parsnip odor. White flowers are produced on many umbrella shaped clusters. A very attractive plant! Tolerates poor soils and is generally found along streams and ditch banks.

Wild Mustard *(Brassica kaber (DC) Wheeler).* An edible plant in the Brassicaceae family. Generally a winter annual 1-3' tall. Erect stems with 2-8" long leaves that are 1-4" wide. The lower leaves are lobed with the upper leaves more toothed. Bright yellow flowers. Introduced from Europe, it is widespread and invasive especially along the foothills of the coast.

Datura *(Datura innoxia Miller).* A member of the nightshade, Solanaceae family of plants. Recognized by its large grayish-green foliage and large white to lavender trumpet flowers that can reach 6-10" across. The spring produced seed pod resembles a ball with spikes. The plant is hallucinogenic. Datura prefers dry soils and is generally found growing along roadsides.

Dodder *(Cuscuta spp)* A parasitic plant that lacks chlorophyll and is very apparent from its bright orange to yellow thread like stems. A member of the Convolvulaceae family of plants. Small seed germinate in the soil producing a thread like stalk that attaches to a plant. The root system disappears and the plant becomes parasitic on its host. Numerous white to pink small flowers from July to October. The seed are long lived.

Kikuyugrass *(Pennisetum clandestinum).* An east African introduction, this prostrate perennial is an aggressive and dense plant in the Poaceae family of plants. The major growing season is in the summer with dormancy during the winter. It is quite invasive growing by rhizomes and stolons. Stems can reach ½' in diameter and 6-10' in length. The reproductive flowers are at the base of the plant with filamenous anthers appearing above the foliage from March to October. It produces prolific seeds that can be spread by mowing. Considered by many to be a weed, it is commonly managed as a lawn due to the inability to control its growth.

References:

Weeds of the West, Whitson, Burrill, Dewey, Cudney, Nelson, Lee and Parker, 1991
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Understanding Weed Dormancy, Weed Control with Hot Foam and in Yardwaste Mulch

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Dormancy is defined as a temporary failure to germinate under favorable environmental conditions. It is often referred to as a dispersal in time. Physiological dormancy is controlled by the physiological processes in a propagule (hormonal balance, embryo development, etc). Physical dormancy occurs when environmental factors favorable for germination are excluded by certain morphological characteristics (hard seed coat, waxes, etc). Dormancy that combines both physiological and physical mechanisms is considered combinational (for example, impermeable seed coat and dormant embryo - a drought induced dormancy in some legumes).

Dormancy may be regulated by plant or by environmental conditions. Many plant species produce seed different in morphology, amount and dormancy level, a variation known as 'somatic polymorphism'. For example, the same common lambsquarter plant can produce a lot of black, large seed with high dormancy and few larger brown seed with low dormancy. This mechanism ensures that the majority of seed will remain in the soil seed bank and germinate over time, thus, escaping the immediate competition from the mother plant and having a chance to germinate when conditions are favorable in the future. Larger lambsquarter seed, in turn, may insure immediate re-establishment of the species on a site, and being fewer would likely experience less competition.

Environmental conditions that break dormancy include but are not limited to: scarification (destruction of hard seed coats), light exposure, increase in nitrogen level, increase in temperature and other propagule disturbances. Knowledge and understanding of species specific dormancy coupled with accurate record keeping allows for more precise long-term weed management through seed bank disturbances and timely weed control. However, in an attempt to rapidly and drastically deplete weed seed bank, soil fumigation is often undertaken. Neither methyl bromide nor alternative fumigants destroy propagules of such weeds as little mallow (*Malva parviflora*) or California burclover (*Medicago polymorpha*) (Fennimore 2002, personal communication). Alternative control of these troublesome weeds with hot foam and their survival in yardwaste mulch (targeted to be weed-free material) are described below.

An experiment conducted near Santa Paula, CA, evaluated seed survival of California burclover, little mallow and perennial ryegrass (*Lolium perenne*) after application of heated organic foam (mixture of coconut syrup and water) and the effect of foam on existing weed vegetation. Existing vegetation consisted of little mallow at >100 plants m^{-2} and bernudagrass (*Cynodon dactylon*) at > 100 plants m^{-2}. Heat and gas permeable bags with weed seed were placed at 0, 3, 6 and 9 cm depth in soil and hot foam was applied at 950 L h^{-1} with the "Waipuna"[1] system at about 1 m^2 min^{-1}. Weed seeds were recovered 1 day after treatment (DAT) and germinated in laboratory.

Aboveground biomass of little mallow and bermudagrass was destroyed 1 d after application, however, bermudagrass resumed growth at 14 DAT and achieved plant density similar to the initial at 31 DAT. At 0 cm (surface) seed germination of little mallow was reduced 57% and ryegrass 82%, but germination of California burclover was not affected. At all other soil depths weed seed of the three species were not affected by treatment. These results indicate effectiveness of hot foam for above-ground weed control. However, the treatment failed to

control rhizomes of a perennial weed and seed in soil, likely due to poor heat conductivity of soil.
The ‘Waipuna’ hot foam treatment shows potential effect on a weed seed on the surface, an area were the vast majority of weed seed is situated in no-till (no-disturbance) systems.

An experiment conducted at Oxnard, CA compared survival of seed of little mallow and California burclover in 7.6 m^3 static piles of freshly ground mulch and 18 mo old mulch. Heat resistant permeable bags with weed seed were placed at 0, 0.15, 0.3 and 1 m depths in the mulch piles and removed at 0.25, 1, 2, 4, 7, 14, 21, 28 and 56 d. Survival of propagules differed among the weed species. However, all weed seed were killed in freshly ground mulch after 2 d at 1 m and after 7 d at 0.3 m, while germination and viability were variable at 0.15 m and not affected at 0 m. Weed seed germination and viability at all depths and removal times were not affected in 18 mo old mulch. Temperatures greater than 60 C generated at depths greater than 0.3 m in freshly ground mulch were most likely responsible for destruction of weed propagules. This experiment indicates that the two troublesome weeds, commonly surviving chemical fumigation may be effectively destroyed in fresh mulch, however, they are likely to survive on the surface or at depth less than 0.3 m. It is essential, therefore, to mix the mulch and expose the initially surviving weeds to lethal temperatures normally existing at depths greater than 0.3 m.

[1] Waipuna Systems Ltd. P. O. Box 62-158, Mt Wellington, Auckland, New Zealand.

Understanding the Mode of Action of Selected Herbicides

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Herbicides are widely used in agriculture and landscape management. Most contemporary herbicides are organic molecules, i.e. contain carbon. These molecules vary in size, shape and elemental composition. The mode of action of a herbicide is fundamentally related to its specific molecular structure. The chemical structure of the herbicide molecule affects the distribution of electrons, hence negative charge, within the molecule. Certain structures, called aromatic or conjugated, possess unusual stability because electrons can be delocalized, and such molecules or their aromatic components may be less reactive than other molecules without aromatic moieties (McMurray 1988).

Herbicides act by interfering with plant growth. Plant growth implies cell division through biochemical processes, such as production of sugars via photosynthesis, synthesis of proteins from amino acids, and synthesis of nucleic acids. These biochemical processes are regulated by naturally occurring hormones, such as auxin. Herbicide molecules interact with the biochemical mechanisms within the plant. Many herbicides in use interfere with only one step of a biochemical pathway, while others have more general biochemical effects. To be bioactive, herbicide molecules must be able to react with biochemical mechanisms in the target plant. It follows that some herbicides could owe their activity to their similarity with naturally occurring plant compounds.

Three fundamental principles guide reactions in organic chemistry, as can be seen in a study of that subject (McMurray 1988). They are steric effects, inductive effects, and resonance. Steric effects refer to the shapes of the reacting molecules. Presence of side chains or rings may allow either a fit with another molecule, or may block approach, thus preventing reaction. Inductive effects refer to the amount and placement of negative charge within the molecule. Such negative charge may cause a herbicide molecule to be attracted to a receptor molecule within a plant. Resonance refers to the stability of reactants or products in a given reaction, and helps determine whether a reaction is energetically favorable. We now review these three fundamental principles as they apply to specific herbicides. For simplicity we consider each of these principles separately, although all three may be involved in a given chemical reaction.

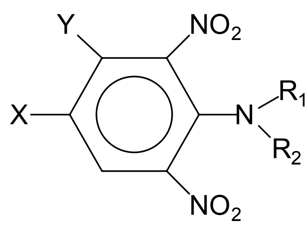
Because of steric considerations, herbicides with similar structures could be expected to have similar modes of action, since they would likely react with the same receptor. Herbicides within certain chemical classes often do have the same mode of action for this reason. An example may be seen in Figure 1, showing the similarity of structure among three dinitroaniline herbicides, all of which interefere with cell division by blocking tubulin synthesis (Cremlyn, 1991). Similarly, the pryidine herbicides clopyralid and picloram have a similar mode of action and similar physicochemical properties (Cremlyn, 1991) (see also “Clopyralid Problems in Mulch and Compost” in these proceedings).

Because of inductive considerations, a herbicide molecule may interact with a receptor molecule within the plant. Location of either full or partial negative charges can be similar to a naturally occurring molecule. This can be seen in Figure 2, where we compare the placement of a full negative and partial negative charges on indole-3-acetic acid, a naturally occurring auxin, with a placement of charges on 2,4-D (Cremlyn, 1991). That herbicide acts as an auxin mimic, stimulating the plant to produce RNA and causing growth abnormalities (Cremlyn, 1991). The cupping and twisting of 2,4-D-affected plants are familiar to people who have used 2,4-D or similar herbicides.

Resonance can confer stability to herbicides or their reaction products. Conversely, the lack of resonance contributors can affect the reactivity of a herbicide molecule. Glyphosate is chemically classified as an organophosphorus (OP) compound, yet it does not have the insecticidal activity or toxicity associated with the organophosphate insecticides. The reason is that although glyphosate has an OP structure at its center, the bond between P and CH_2 (Figure 3) does not readily cleave. In many OP insecticides an aromatic moiety is connected to the P atom, and because electron density can be taken and shared within the aromatic structure, the molecule cleaves easily—an essential feature of OP insecticide compounds (Cremlyn, 1991).

The three principles of steric effects, inductive effects, and resonance are responsible for the similarities among herbicides in their several chemical classes, and for the biochemical interactions of the herbicides themselves. Plant resistance can at times be overcome by switching to a herbicide with a different mode of action, and thus interacts with a different biochemical pathway. On the other hand, it may be possible to substitute a herbicide within the same chemical class to achieve cost savings or because of regulatory issues.

Figure 1. Three dinitroaniline herbicides are used to illustrate structural similarities in a herbicide chemical class.



	X	Y	R_1	R_2
Oryzalin	SO_2NH_2	H	CH_3H_7	CH_3H_7
Pendimethalin	CH_3	CH_3	H	$CH(C_2H_5)_2$
Trifluralin	F_3C	H	CH_3H_7	CH_3H_7

Figure 2. Distances are similar between partial and full negative charges in indole-3-acetic acid, a naturally occurring auxin shown at left, and 2,4-D shown at right.

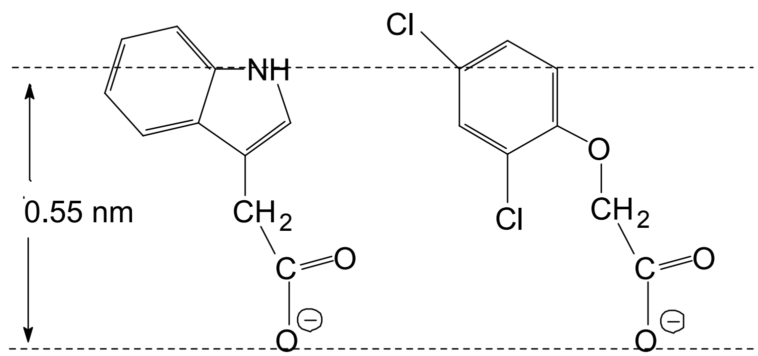
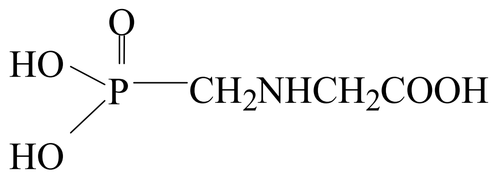


Figure 3. The structure of glyphosate.



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Session C: General Session
Presidential Address: Bruce Kidd, Dow Agro Sciences

Presidential Address: Toward a Renewed Vision and Mission

Bruce Kidd, Dow AgroSciences

It's a pleasure to welcome you all to the 55th annual conference of the California Weed Science Society in Santa Barbara, which is certainly one of the best meeting locations California has to offer. I hope all of you had a good holiday season and are ready to get back to work.

First thing, on behalf of the members I want to recognize and thank all the people who worked together to design and present the 2003 conference. It would not be possible to name everyone who pitched in, but in particular I want to recognize Program Chair Pam Geisel, who overcame a serious bicycling accident last Fall and still got the speakers and agenda together. I also want to recognize Local Arrangements chair Elaine Hale, who sweated out the details with the hotel so that we would have a place to meet, with technical support plus food and refreshments. And I certainly need to recognize our new Business Manager Judy Letterman, who handled the society's business, the newsletters, the registration process, and much more.

The Weed Conference is typically the first big meeting of the new year, and represents a gathering of the weed clan from all parts of the state and all parts of the discipline. The CWSS is proud to be a "big tent" organization that includes anyone and everyone concerned with weed and vegetation management. The CWSS is the oldest organization of its kind in the country, predating even the Weed Science Society of America. In it's 55 years of existence, the CWSS has provided a unique forum where regulatory, business, farming, recreational, governmental and environmental interests can meet to exchange information, confront issues in weed management, do business, and enjoy the educational benefits of a strong professional society.

The work of the CWSS goes far beyond the annual conference. For instance, we have just published the 3rd edition of *Principles of Weed Control*, a textbook authored by members of the society. *Principles of Weed Control* was created as a college level textbook and as a study guide for the California Pest Control Advisors' exam. The 3rd edition has been completely updated with new chapters added, and is available for purchase through Thompson Publications. Every year, the CWSS also publishes a conference proceedings from the papers given at our meeting. The Proceedings are available in print form, on CD-ROM, or online through our website at www.cwss.org. Our First Wizard of Technology, Jerry Schmierer, is currently leading a project to scan in the entire 55 years of CWSS Proceedings so they will be available to anyone via the website. As part of your registration, the CWSS is proud to have sponsored the gorgeous calendar for 2003, "*Weeds of California"* which all of you received in your registration packets. And finally, the CWSS is proud to be a sponsor of two extraordinary weed identification books currently being produced by another member, Dr Joe Ditomaso of UC-Davis. The first of these books, *Aquatic and Riparian Weeds of the West,* is due for publication in 2003 and can be ordered at a pre-publication discount at this time. The second book*, The Weeds of California,* is intended to replace the venerable *Growers Weed ID* manual that many of us have depended on for years. Joe's book is a mammoth undertaking that will define the art of weed identification for generations to come and bring worldwide attention to our society. As members of the California

Weed Science Society, every one of us shares in these accomplishments, and I congratulate all of you.

Looking to the future, the CWSS faces all of the challenges that we face personally as individuals, as workers, and as citizens. The pace of technological change is unrelenting. Many of us feel pressured to do more in less time than ever before. Every day, we hear of new cutbacks or layoffs, in business and in government alike. As we enter 2003, the state of California is up against a budget shortfall estimated as high as $35 billion dollars, which will force staff reductions and cripple key programs for management of invasive and noxious weeds. The agricultural chemical industry is beset with a flood of issues created or driven by consolidation within the industry, changing technologies, loss of patent protection on key chemistries, lack of new products in development, and constant environmental scrutiny driven by negative public perceptions. Growers are being challenged by commodity prices that are down on many crops, and public weed management applicators are having to deal with increased regulation, heavier work loads, reduced budgets, and fewer people to do the work. Of course, no one knows whether the stock market will go up or down or whether our nation may soon be at war again. But it’s not all bad; at least we’re here in Santa Barbara for a few days, eating lunch in the sun, with the beach right across the street, and it’s never gonna snow here!

As President of the CWSS, I’m here to tell you today that the CWSS does not intend to be buried by these problems, but instead plans to surf the wave of change and emerge as a stronger organization. Recognizing the need for evolution in our own organization, and to assure that our society remains relevant and responsive to the needs of the members, this year the Steering Committee embarked on a special project. On your tables at lunch tomorrow, you will see a proposal for a new Vision and Mission statement for the CWSS, and suggestions for structural changes that will produce a more robust support network for expanded activities by the CWSS. This is not a task that can be accomplished in a single meeting, nor can the improvements be implemented within a single year. At the Business Lunch on Tuesday, Steering Committee chair Carl Bell will briefly review the process taken by his committee this year, and summarize the basic objectives that were agreed on. We will then put the proposals to a vote by the members, and if approved, begin to implement the improvements in 2003. I won’t try to get into the proposals at this time, but I will share with you that the future of the CWSS is up to each and every one of us here today. As a volunteer society, we need volunteers, people who care about weed science, and who value being part of an organization like the CWSS. If you would like to work on a committee, or be part of the program, please check with me or any of the Board members sometime during the conference. We need your help, and the discipline of weed science needs your help. Retirements, cutbacks, and job changes have severely impacted the old guard. Things have changed and the future will be only what we make it.

Is it worth the effort? More than ever. As an example, I’d like to share a little bit of personal history with you about my own first exposure to the CWSS. I attended my first conference in January 1985. During my Master’s studies at the University of Arizona, I’d read numerous research papers including a number from that great generation of weed workers from the University of California extension service and University system. I’ll never forget what a thrill it was to attend my first weed conference and meet people like Harry Agamalian, Clyde Elmore, Harold Kempen, Bill Fischer and others. Although I was majoring in weed science, I’d never before been to a big conference with so many like-minded weed people. I was amazed at the quality of the program, and the spirit of the people. Right then and there I developed a love for the California Weed Science Society and what it represents. One of our most important functions is to hold onto the good things and improve the rest for future generations. I hope we all share a sense of responsibility for ensuring that future generations of weed workers have the opportunity to experience that same sense of community and discovery. I never dreamed I might someday be President of the CWSS, but it happened anyway and I just want to tell you all what fun it's been and how much I appreciate the opportunity to have participated in the work of this group. With all that said, let me say again it's a pleasure to welcome you all to the 55th annual conference of the California Weed Science Society, and I hope you have fun, and get all that you wanted and more over the next three days. And again, let me invite you to join in as an active participant in this diverse and dynamic society and make your contributions to a great cause that benefits us all.

Session D: Weed School
Moderated by: Joe DiTomaso, Weed Specialist, University of California, Davis
"Weed Impacts"

Economic Impacts of Weed Control in Agricultural and Non-Agricultural Systems

Karen Klonsky, Dept. of Agricultural and Resource Economics, University of California – Davis

A market economy can be viewed as the flow of goods and services between firms and households. Households supply land, labor and capital to firms through the factors market and receive payment in the form of rent, wages, interest and profits. Firms produce good and services and sell them in the goods market to households in exchange for revenue. Transactions in the goods and factors market determine the price of goods and factors based on the supply and demand from firms and households. Numerous influences continuously shift supply and demand changing prices faced by consumers and firms in the marketplace.

With respect to weed control in agricultural production, decisions at the farm level are made regarding how much of any one input to use and the most profitable combination of inputs based on the efficacy of the inputs and the prices of the inputs and the output being produced. In determining the amount of an individual input to use, the rational producer will to continue to add the input until the value of the production gained from the additional unit is equal to the cost of the additional unit. This criteria is consistent with the law of diminishing returns stating that when an input is added and all other inputs are held constant, the resulting production will first increase at an increasing rate, then increase at a decreasing rate and finally decrease.

As a result, the yield maximizing level of input is always higher than the profit maximizing level. This holds because the yield maximizing level occurs at the point where production changes from increasing at a decreasing rate to decreasing and the marginal value of an additional unit of output is zero. The profit maximizing level of input occurs at the point where the cost of an additional unit of input equals the marginal value of an additional unit of output. Since the cost of a unit of input is greater than zero, this equivalency holds when the output is still increasing and is therefore less than the yield maximum. What is most important to realize is that the optimum level of an input changes as absolute and relative prices change.

In practice, of course, agricultural producers choose among a range of possible inputs and use several inputs in combination. In choosing the most profitable combination of inputs, the most profitable combination of inputs for a given output level occurs when the rate of substitution between two inputs equals the rate of the cost of substitution. Again, this tradeoff will change as the relative prices of the inputs change. Therefore, the information needed for weed management decisions at the farm level includes the prices of inputs and outputs, the physical relationships between inputs and outputs, and a criteria for making a decision.

In the previous discussion the criteria used for decisionmaking was profit maximization. But in practice agricultural producers meet multiple objectives which may include risk reduction, cost minimization, meeting quality standards, or establishment of wildlife habitat to name a few. Also, no mention has been made of regulatory constraints that also impact decisions.

Weed Control Costs in Agriculture –Examples from the Sustainable Agriculture Farming Systems Project

The Sustainable Agriculture Farming Systems Project located at the University of California – Davis, is an interdisciplinary project comparing alternative farming systems including conventional, low input and organic rotations. The eleven - year experiment from 1989 to 2000 strove to develop the best farming practices for each of the farming systems. The conventional system used preplant and within season herbicides at rates consistent with practices of top farmers in Yolo County. The low input system used a low rate of preplant herbicide and no in season applications. The organic system followed organic regulations and did not use any herbicides. All of the tomato systems included tillage and hand hoeing for weed control. The organic and low input systems used winter cover crops that were in part weed control.

The processing tomato cost of production for the three systems excluding the cost of equipment ownership shows that the total cost for the conventional system averaged $724 per acre, $1,1016 for the low input system and $1,080 for organic (Figure 1). The higher costs for the low input and the organic systems relate to the use of transplants in these systems and direct seeding in the conventional, winter cover crops only in the low and organic systems, and a higher cost for hand weed control compared to conventional. The cost of weed control averaged $166 in the conventional system, $213 for low input and $234 for the organic system. The low input systems spent only $2 per acre on preplant herbicides and the organic system used no preplant herbicides compared to $26 for the conventional (Table 2). With respect to hand hoeing (referred to as custom in figure 2) the conventional system averaged $33 per acre compared to $75 for the low input and $85 for the organic system. Therefore, not only were the total weed costs different among systems but the input use within the weed control programs varied.

For corn the average cost of production was $289 per acre for the conventional system, $290 for the low input and $372 for the organic system (Figure 3). The cost of weed control averaged $41 for the conventional system compared to only $19 for the low input and $13 for the organic system. For corn the major differences in the costs were the use of cover crops in the low input and organic systems, manure in the organic system, and lower rates of herbicides and fertilizer in the low input system than the conventional system. The organic system used no synthetic fertilizers or herbicides. All three systems included tillage for weed control. The weed control costs for the conventional system were 60% for materials, 21% fuel, lube and repairs for equipment, and 19% labor (Figure 4). For the low input system the expenditure was spread evenly among the three input categories. For the organic system the costs were spread evenly between labor and equipment operating costs.

The weed control costs for corn were lower for the low input and organic systems than for the conventional systems while the opposite was true for processing tomatoes. For both crops the conventional system had higher fuel and herbicide use than the other systems. For corn weed control represented 14% of operating costs for the conventional system but only 6% and 4% for low input and organic, respectively. For tomatoes, weed control represented about 21% of total costs for each of the systems.

Figure 1.Tomato Operating Costs by Operation - SAFS
(average dollars per acre, 1989-2000)

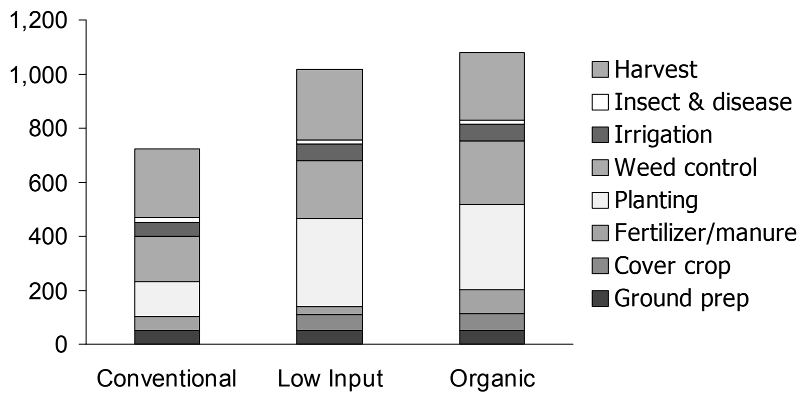


Figure 3. Corn Operating Costs by Operation - SAFS
(average dollars per acre, 1989-2000)

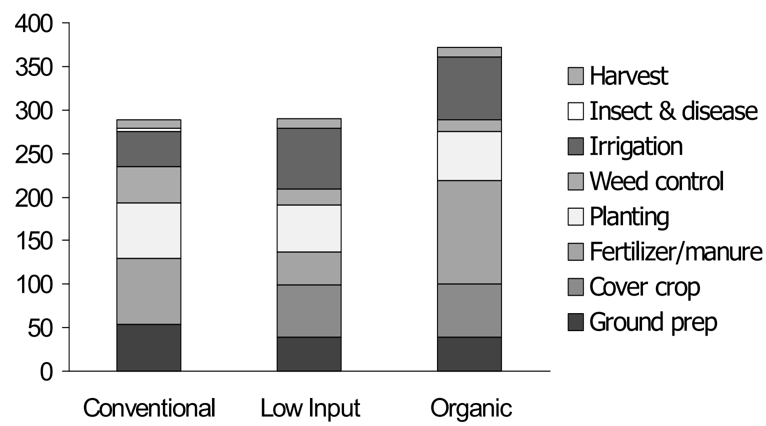
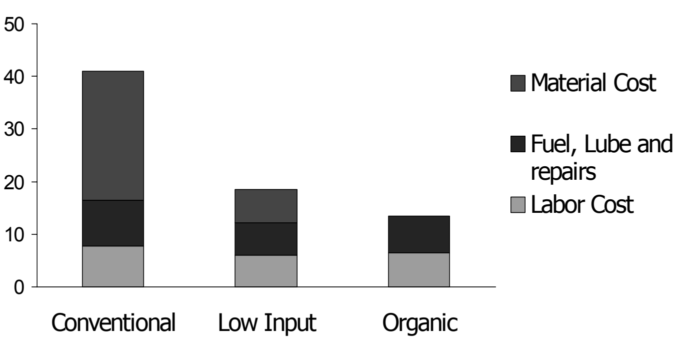


Figure 4. Weed Control Costs for Corn by Category– SAFS
(average dollars per acre, 1989-2000)



Weed Control Costs in Non – agricultural Systems – Example of Yellow Star Thistle Control in California

Weeds create costs to society that may not be fully reflected in the marketplace. These include aesthetics, rural viability, cultural diversity, habitat, flood control, fire control water quality, watersheds, food security, recreation, access to wilderness, and erosion. When market prices do not reflect externalities, government often employs taxes, subsidies and regulations to discourage negative externalities. It also steps in to control weeds when there is not the economic incentive to do so in the private sector.

Using yellow star thistle in California as an example, the groups negatively impacted include ranchers, landowners, homeowners, recreation enthusiasts, horse owners, farmers, wool growers, and honey producers. None of these groups have the resources to control star thistle statewide. While there are some examples of efforts by some of these groups to work together for weed control, the transaction costs are high. Private stakeholder organizations include the Nature Conservancy, the Audubon Society, Farmland Trust, and the CA Cattleman's Association. Public agencies involved include the Bureau of Land Management, US Forest Service, Bureau of Reclamation, US Fish and Wildlife Service, CA Department of Fish and Game, CalTrans, and park services at the national, state, county, and local levels. Many of these groups do work together, but again, the cost of coordination is high.

Control Scenarios include 1 do nothing, 2) intense, immediate suppression, 3) eradication in high priority areas and containment in others, and 4) statewide biological control program. Obviously, the cost of scenarios 2 and 3 will depend on the methods used for suppression and the definition of high priority areas. However, yellow star thistle is estimated to be spreading at a rate of 10% per year and 15 million acres in California are already infested. At that rate all 42 million acres of susceptible land will be infested in 10 years. The present value of the cost of intense suppression with Transline and biological control is estimated to be $2 billion over a 10 year period. The cost of high proporyt are eradication with containment elsewhere is estimated as $500 million, and the cost of a biological control program only at $8 million.

Policy Issues

The examples of cost of weed control in agricultural systems and in a non - agricultural system reveal relevant policy issues. With respect to both agricultural and non – agricultural systems the regulation of pesticides will always determine what is in the set of herbicide options available for control. Mil taxes on sales of pesticides impact the price and the demand for herbicides. Publicly funded incentive programs such as the Environmental Quality Incentives Program provide cost share arrangements to encourage the adoption of environmentally friendly practices for farmers and landowners. Pest management alliances funded by the Department of Pesticide Regulation provide information and research dollars related to alternatives to pesticides. The development of weed management teams to leverage spending and expertise for regional weed control can make public funding more efficient. There are opportunities for public private partnerships but funding must be made available to facilitate the initiation of these partnerships. Preemptive measures to keep exotic weeds from entering California is critical to reduce the economic impact of weeds in the future. Finally, the level of funding for weed management will always be made in the context of the total state budget and the benefits per dollar spent weighed against the potential benefits of other state programs.

Impacts of Invasive Species on Rangelands

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Introduction

I will discuss the impacts of invasive species as they affect rangeland managers and especially beef producers. The discussion will be limited to the California annual vegetation type excluding the northern coastal prairie where annual precipitation is greater than 50".

The forage plants in the annual rangeland discussed in the scope of this paper are mostly exotics which could be considered invasive species. They provide us with a rangeland that has higher herbaceous production than any natural vegetation type west of the Rockies (Menke, 1989). Its annual forage production is greater than much of the short grass prairie of the mid west. At Sierra Foothill Research and Extension Center (SFREC) annual herbaceous production has averaged 2900 pounds of dry matter over 19 years. This vegetation type produces forage that is nutritious with protein levels of 6-22% (Hart et al., 1932) and digestible organic matter of 50-80% (Morris, 1985). The forage produces good livestock gains: stocker calves at SFREC averaged 285 pounds gain in 190 days over four separate grazing seasons (Raguse et al., 1988).

The forage system is durable under moderate to heavy utilization by livestock. Management guidelines recommend leaving 500-800 pounds per acre of residual dry matter after grazing (Bartolome et al., 2002). This allows for about 75% utilization of forage plants by grazing animals, considerably more than the 45-55% usually recommended for perennial species.

Grazing annual plants does offer short-comings: there is a relatively short green growing season – 2-4.5 months at San Joaquin Experiment Range vs. 5-6 months for many perennial pastures. Forage productivity from annual species is also highly variable from year to year. At SFREC annual yield ranged from 1100-4700 pounds over 19 years. Range cattle managers mostly respond by using one of three production systems (or combinations of the three): stocker calves brought in as weanling calves in the fall and kept until forage matures in the spring; a cow-calf system with calves born in the fall and weaned and sold in the spring; and a cow-calf system of fall calving with the cows and calves moved to irrigated pastures or mountain meadows in the spring.

Troublesome Invasive Plants

Poisonous Plants

Poisonous plants are not a major problem on annual ranges. Yellow starthistle (*Centaurea solstitialis)* is poisonous to horses. Horses will not usually become poisoned unless other forage is short. Klamathweed *(Hypericum perforatum)* is no longer an issue because of the success of the biological control program. The biggest cause of poisonous plant livestock fatalities in California is a planted ornamental, oleander.

Injurious plants

Economic losses result from physical injury caused by annual grasses with long, rigid, barbed awns. Problem plants are mostly limited to the following: *Bromus diandrus* *Hordeum murinum* ssp. *leporinum, Hordeum* spp.*, Taeniatherum caput-medusae, and Aegilops triuncialis.* Losses are due to eye injuries and lump jaw because of harsh awns that work their way into the soft tissue of the eye and mouth.

Plants That Replace Desirable Forage Plants

The most serious impacts of invasive plants on annual rangeland are a result of those plants that out-compete the more desirable forage plants for moisture and space, thereby reducing forage yield and/or quality. Such plants also affect grazing distribution because livestock tend to ignore areas with a high concentration of unpalatable plants even though desirable forage species are present. As a result, carrying capacity may be substantially diminished.

I will discuss three weedy species that I feel are the worst threat to California annual range: yellow starthistle, medusahead, and barbed goatgrass.

Yellow starthistle (*Centaurea solstitialis)* now infests 15 million acres in California, including cropland, roadsides and recreation lands as well as rangelands. It provides nutritional, palatable forage for livestock in winter and spring, with protein content up to 14%, but digestible protein and total digestible nutrients are reduced in the fall in yellow starthistle infested fields (http://wric.ucdavis.edu/yst/impacts/impacts.html). Ranchers need dry forage of at least moderate quality and palatability to support their animals in late and fall until adequate green feed is present. Yellow starthistle does not provide that quality of forage in summer and fall.

In spite of its widespread nature, there are no studies documenting the impact of yellow starthistle on the state's rangeland. At SFREC we established permanent line transects in eight moderately infested pastures ranging in size from 20-200 acres. The pastures are grazed by cattle. Yellow starthistle makes up 20-31% of the plant composition. It is difficult to estimate the impact on carrying capacity because of yearly variations in weather, but at this time, four years after establishment of the transects, it appears that carrying capacity has been reduced by at least 10-15%.

In another pasture, 50% composition of yellow starthistle was estimated along line transects. Vegetative material was dried and weighed with the following results:

Yield of Vegetation Components

Component	lbs./ac.
YST	2994
Grasses	1315
Other Forage Species	1584

Impacts on carrying capacity will vary with the degree of infestation and perhaps with the desired season of use. Very heavy infestations can probably result in loss of over 50% of a pasture's original carrying capacity.

Medusahead *(Taeniatherum caput-medusae)* has been in the state since 1900 and is now widespread. It is palatable while green, and in early growth stages its nutrient content is comparable to that of other annual grasses. It loses palatability as it matures, and it is poorly digested when mature and dry. In addition, its harsh awns at maturity discourage grazing, resulting in dense, ungrazed patches. The dry matter is slow to break down, and germination of other species is reduced. Thus, the patches tend to grow in size, effectively reducing the amount of area available for grazing.

Barbed goatgrass *(Aegilops triuncialis)* was first seen in California in the early 1900's. It was confined to two counties for about 70 years, but recently it has been expanding rapidly. It is a successful invader irrespective of soil, terrain or canopy cover. Early research stated that barbed goatgrass was unused by livestock, and in thick stands it may reduce carrying capacity by 50-75% (Jacobsen, 1929). Recent work and personal experience suggest that cattle do graze the plant when it is young, however its vegetative component is relatively small at early stages of growth.

Control Methods

Yellow starthistle

Biocontrol agents are widespread, and they reduce seed production, but enough seeds remain to maintain and expand yellow starthistle populations.

Intensive grazing is a useful tool in yellow starthistle control. In one study, high intensity, repeated cattle grazing reduced flowering heads by 78-91% (Thomsen et al., 1993). This practice is difficult to use on a large scale because of the high number of grazing animals needed at specific times. For example, to treat 1000 acres at the intensities used in the above study would require 1900 cows. In addition, for effective control grazing should be continued beyond the time when yellow starthistle is most palatable, so livestock production is diminished.

Chemical control. The selective herbicide clopyralid offers very effective yellow starthtistle control at label rates (DiTomaso et al., 1999b). We achieved at least 99% control at the field scale by applying clopyralid at the low label rate. (Connor et al., 2002). Multiple years of chemical treatment are required, with follow-up spot spraying in succeeding years.

Prescribed burning is an effective control method if applied at the early flower stage (DiTomaso et al. 1999a). Again, multiple years of treatment are required.

A combination of prescribed burning and clopyralid application in alternate years also provides successful control. We found that substituting fire for clopyralid application during either of the first two years of a three year treatment program resulted in yellow starthistle control equal to that achieved from three years of clopyralid use (Connor et al., 2002). Follow-up spot spraying will need to continue for several years. Joe DiTomaso gained good control with a two year program of burning the first year and clopyralid spray the second year.

Medusahead

Prescribed fire can substantially reduce medusahead populations if the fire occurs as soon as desirable annual plants have matured and dried enough to carry a hot fire. At SFREC we reduced medusahead significantly from 25% composition to 6% or less in burns targeting yellow starthistle and consequently timed later than optimal for medusa head control. While burning will reduce medusahead, it will not eradicate it.

Intensive grazing is a usual tool for medusahead management. Timing controlled grazing reduced medusahead from 45% cover to 10% (George et al., 1989).

Barbed goatgrass

Glyphosate at one pound per acre followed by reseeding with a perennial grass-clover mix has been effective in controlling barbed goatgrass (Peters et al., 1996). At SFREC we have had success seeding with annual ryegrass plus nitrogen fertilization. Such treatments may be too expensive for wide scale use.

Prescribed fire appears to be the best barbed goatgrass control method available. It should be applied after desirable annuals mature and before goatgrass seed matures and drops. The fire must be hot enough to achieve a complete burn, and two successive years of burning are required (DiTomaso et al., 2001).

Constraints to Treatment

Costs vs. returns for chemical control

The following costs were incurred at SFREC annually during three years of chemical application for yellow starthistle control:

Clopyralid 4 oz./ac.	$12.00
Aerial application	14.50
Total cost per acre	$26.50
Follow up spot spray	$2.50

At least two to three years of clopyralid application are required. These costs are for helicopter application on about 300 acres per year. They may be reduced if flatter terrain and a nearby airstrip will allow use of fixed wing aircraft or if larger acreages are treated. Conversely, smaller treatment areas may result in much higher application costs. Follow-up spray costs are calculated based on our experience of searching about 10 acres for every acre that is actually sprayed. That is, if 100 acres are checked and 10 acres actually sprayed, the cost covers the labor, equipment and chemical to check 100 acres and spray 10 acres, divided by the 100 acres checked. Spot spraying will be necessary for several years following initial treatment.

An important point to make is that these costs must be applied to land from which the total annual rent received is typically only $10-$12 per acre.

Challenges to prescribed burning

Cost. At SFREC, over three years of prescribed burning for yellow starthistle control, the costs were not substantially less than that for applying herbicide. Out-of-pocket costs for labor, fuel, minor equipment repairs, permits, and seed and fertilizer for firebreaks was $23.00 per acre burned. We burned 200-400 acres per year, and we enjoyed the assistance at no cost of California Department of Forestry and Fire Protection (CDF) crews for fire ignition and control. This assistance is available to private land owners, but there are many more requests annually than there is available assistance.

Financial liability for escapes is the responsibility of the land owner unless he or she can get into one of the limited number of CDF programs available.

Other constraints include air quality requirements, variable weather during desired burn periods and the difficulties of burning within the time period required for weed control while also fitting agency requirements into periods of proper wind, humidity and temperature parameters.

Summary

Impacts of invasive weeds on annual rangelands are mostly due to those plants that out compete and therefore replace more desirable forage species. There are valuable tools that are used for control or management of these weedy plants. The rangeland manager faces constraints that explain why the tools are not more widely used on large acreages. The manager may want to focus weed control on the most productive or most easily managed areas. And we must emphasize the importance of catching weed invasions in there early stages, when there is less area that must be treated.

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Impacts of Aquatic Weeds in Water Use and Natural Systems

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Aquatic plants include microscopic algae, filamentous algae, and rooted plants that grow entirely underwater or as emergent plants in shallow water, or float on the water's surface. Carpenter and Lodge (1986) and Madsen (1997) summarized the roles they play in freshwater ecosystems. Aquatic plants aid in stabilizing sediments and in binding nutrients. They supply dissolved organic matter into the water and entrap organic material. Plant beds affect water chemistry by removing nitrate and other ions (Moss 1988). Aquatic invertebrates, which are the essential food of many fishes and semi-aquatic animals, are often more diverse or abundant in beds of aquatic plants as opposed to non-vegetated areas. Aquatic plants are often significant food sources for invertebrates, waterfowl, and some mammals. Aquatic vegetation is an important habitat for fish, both for young-of-the-year and desirable sport fish. For these reasons, aquatic plants are integral components of lake and river ecosystems and the presence of aquatic plants is desirable. However, excessive growth can have detrimental effects as well (Table 1). The following discussion of specific impacts of aquatic weeds is based on the information provided by Ross and Lembi (1985), Lembi et al. (1988), Lembi (1997), and Lembi (2003). The reader should consult these sources directly for more information.

Table 1. Negative impacts associated with excessive growth of aquatic plants

1. Prevent or restrict recreational activities, boating, fishing, and swimming.
2. Present hazards due to entanglement or slippery areas caused by algal films.
3. Cause foul taste and odors of drinking water supplies
4. Cause stunting of fish populations and "fish kills" due to decomposition.
5. Block flow in irrigation and drainage systems.
6. Cause water loss due to evapotranspiration from floating or emergent species.
7. Catch debris and sediment hastening the filling in of water bodies.
8. Prevent commercial navigation of waterways.
9. Provide habitat for disease vectors such as mosquitoes and snails.
10. Produce and release toxins into the water.
11. Lower aesthetic appeal of waterfront property reducing its value.
12. Exclude native plant species.
13. Reduce access of wildlife to wetland areas.
14. Monetary losses due to control efforts.

In habitats with high nutrient levels (usually phosphorus) excessive growth of microscopic algae may form "blooms." *Microscystis*, *Anabaena*, and *Aphanizomenon* are species of cyanobacteria or blue-green algae that are typically associated with these conditions. When the algae die, decomposition results in anoxic conditions in the lower portion of the lake. This affects fish and aquatic invertebrates. This situation may be especially serious in aquaculture systems. Microscopic algae produce and release compounds, which impart unpleasant taste and odors into drinking water supplies. In a northern California water system the number of taste and odor complaints by customers is highly correlated with the seasonal occurrence of algae blooms. Two compounds 2-methylisoborneol and geosmin have been identified and are problems when present at concentrations of 12 and 7 ng L^{-1}, respectively. The only way to remove these compounds is to use costly activated charcoal filters. Similarly, fish from aquaculture ponds may develop off-taste if geosmin is present. Then fish must be removed from the pond and transported to a clean pond where they are held for a period of time until the off-taste dissipates. Some species of blue-green algae produce toxins that may be fatal if ingested by domestic animals or may cause skin irritations. Blue-green algae may be less acceptable as food for zooplankton, which may in turn have food-chain consequences.

Filamentous algae (*Cladophora, Spirogyra, Hydrodiction*, and *Rhizoclonium*) form unsightly floating mats in shallow areas of ponds and lakes. The mats inhibit swimming and fishing. In the western U.S. these species are especially troublesome in irrigation canals where they clog intake pumps, trash racks, siphons, and drains. Lembi et al. (1988) cite examples indicating expenditures in the millions of dollars per year to control *Cladophora* in a single Arizona water delivery system, and the U. S. Bureau of Reclamation used 3000 mt of copper sulfate per year to control filamentous algae in California canals during the 1980s.

Nitella and *Chara* are green algae, which resemble rooted aquatic plants in appearance although they lack true leaves, roots, and vascular tissues. In shallow systems they may grow to the surface and interfere with boating, fishing, and swimming.

Cook (1990) defines aquatic macrophytes as vascular plants (ferns, fern allies, and seed bearing plants) whose photosynthetic parts are permanently or at least for several months of the year submerged in water or float on the surface of water. Within this group, there are three functional types: submersed plants, growing entirely underwater; emergent plants, growing in shallow areas with the underground portions underwater and with stems and leaves above the water surface; and floating plants, which have roots or root-like structures that hang into the water from the main plant body which floats on the surface of the water.

Hydrilla (*Hydrilla verticillata*), Eurasian watermilfoil (*Myriophyllum spicatum*), Brazilian elodea (*Egeria densa*), coontail (*Ceratophyllum demersum*) and various pondweeds (*Potamogeton* spp., *Stukenia pectinata*) are the most often encountered problems within this group in California and other western states. In non-flowing situations these plants grow to the surface and continue to elongate or branch so that their stems spill over and form a dense canopy of intertwined stems. If growth is extensive, these cause the problems described in Table 1. Dense canopies reduce light penetration into the water column, which can lead to reduced photosynthesis and growth by adjacent species that may not grow to the water's surface. Several studies have shown this effect when the above species were grown in combination with desirable native species (Spencer and Ksander 2000 and references therein). Reductions in growth eventually lead to elimination of native species. Madsen et al. (1991) established permanent plots in Lake George, NY and recorded the abundance of Eurasian watermilfoil and native plant species over time. Within three years, the Eurasian watermilfoil canopy increased from 25% to 97% cover. At the same time, the number of species present decreased > 50% from 21 to 9, confirming observations from many lakes invaded by this species.

Submersed aquatic plant canopies change depth profiles of temperature, dissolved oxygen (DO), and water chemistry (Frodge et al. 1990, Petr 2000). Madsen (1997) recorded hourly DO readings over a 48-day period in replicate ponds planted with Eurasian watermilfoil, hydrilla, water hyacinth, a floating-leaved pondweed, or a mix of native plants. For all ponds except the native plants, daily minimum values were near or below 5 mg L^{-1} (the level at which fish experience oxygen stress). Daily mean values were lower for the ponds planted with weedy species (water hyacinth, 4 mg L^{-1}; hydrilla, 5.9 mg L^{-1}; Eurasian watermilfoil, 7.9 mg L^{-1}; pondweed, 8.4 mg L^{-1}) than for the ponds that contained a mixture of native species (13.8 mg L^{-1}). Low oxygen levels would put fish under stress. The number of fish species present, the number of fish, and the sizes of individual fish were substantially reduced at low (0.5 mg L^{-1}) dissolved oxygen concentrations in Mercer Bayou, Arkansas (Killgore and Hoover 2001).

Submersed plant beds also influence fish populations through impacts on predator prey relations. Results from several studies indicate that the growth rate of prey fish is reduced when they are confined to macrophytes beds. Olson et al. (1995) reported that resulting high densities of bluegill have strong negative effects on young-of-the-year bass. This is because of increased competition among the immature fish for their food sources (Petr 2000). Aquatic macrophytes are also believed to reduce the probability that prey fish will encounter piscivorous predators. For example, predation rates on bluegill declined with increasing plant density (Savino et al. 1992).

Submersed plants in rivers and irrigation canals increase the bed and bank roughness increasing drag and decreasing flow (Pitlo and Dawson 1990). As plant biomass increases seasonally this effect is magnified. Plant biomass displaces part of the canal's cross sectional area resulting in higher water levels and increased likelihood of flooding.

Floating plants increase water loss through evapotranspiration. Brezny et al. (1973) reported evapotranspiration for water hyacinth was 130 to 150 % higher than evaporation from a free water surface under equivalent conditions while Timmer and Weldon (1967) reported values 370% higher than a free water surface. Floating plants clog waterways, plug water pumps, stop or slow boat traffic, close marinas, prevent access for fishing, prevent water access by waterfowl and wildlife, and causes an increase in mosquitoes. Costs of dealing with floating plants can be high. According to the *Sacramento Bee*, prior to 1984 the federal government spent $500,000 per year to haul away some 22,000 truckloads of water hyacinth in order to prevent clogging of the Tracy, CA pumping station. Since that time California has spent at least $125,000 per year to control this species in waterways of the Sacramento / San Joaquin Delta.

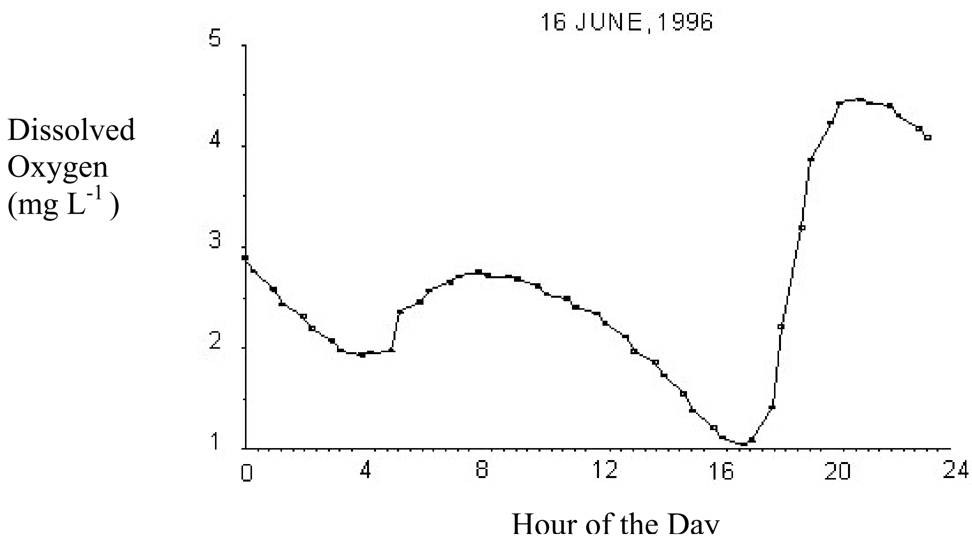

Figure 1. Diurnal changes in dissolved oxygen under a water hyacinth mat in the Consumnes River.

Abundant growth of floating plants reduces light penetration into the water column resulting in hypoxic or anoxic conditions In a Sudanese lake infested with water hyacinth DO levels were 1.8 mg L^{-1} 30 cm below the mat when there was no water current, high concentration of CO_2 were also measured. Similar measurements from the Parana River floodplain in Argentina indicated a maximum of 2.3 mg L^{-1} within the first 1 m depth, but DO values of 1 mg L^{-1} were more common (Petr 2000). Dissolved oxygen measurements taken under the edge of a water hyacinth mat in the Consumnes River, CA were lower than the level reported as causing oxygen stress to fish (Figure 1).

Emergent plants such as rushes, sedges, and alligator weed enhance water loss through evapotranspiration (Brezny et al. 1973, Boyd 1987). In irrigation canals and drainage ditches, they slow or prevent water movement increasing the likelihood of flooding. The emergent plant, giant reed (*Arundo donax*), has extensive rhizome systems, grows up to 9 m tall and forms in-stream stands that altar water flow patterns increasing bank erosion. When *Arundo* displaces native trees and shrubs that overhang the water, its more upright form provides less shading that in turn increases water temperature. This affects animals and plants living in the stream. *Arundo* is less desirable as wildlife habitat. It's biomass dries in summer and the frequency and intensity of fires increases. Because it is strongly anchored in the substrate and resists uprooting by flooding, over time this species causes riparian systems to switch from flood-dominated communities to those that are more tolerant of fire (Bell 1997).

Although not yet widespread in California, purple loosestrife (*Lythrum. salicaria)* has transformed North American wetland habitats in eastern and northern U. S. By 1959, a large percentage of shallow marshes in the lower Hudson area of New York had become solid stands of purple loosestrife and were considered degraded as waterfowl production sites. In upstate New York, it was noted that, with age, invading purple loosestrife ultimately dominated wetland habitats with tall, dense, brush like stands that were impenetrable to boats. These stands also excluded desirable waterfowl food plants. Changes in plant abundance affect wildlife distributions as well. Muskrats and long-billed marsh wrens were reported to use cattail stands almost exclusively, whereas red-winged blackbirds preferred purple loosestrife (Thompson et al. 1987).

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Tuesday, January 21
Poster Presentations
Moderator: Cathy Pinto

Competition Between Cowpea Cover Crop Varieties and Weeds

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Abstract

Field experiments in 2000 and 2001 examined the competitive abilities of three cowpea (*Vigna unguiculata* (L.) Walp.) varieties with similar maturity and vegetative vigor but different growth habit. Iron-Clay (IC) grows erect, IT89KD-288 (288) semi-erect and UCR 779 (779) prostrate. A short stature species, purslane (*Portulaca oleracea* L.), and a tall competitor for light, sunflower (*Helianthus annuus* L.) were planted within the cowpea row as weeds. After 3 weeks after planting, cowpea canopy height, cowpea canopy width and light intensity above and below sunflower and cowpea canopies were measured weekly for four times and biweekly for 1-2 times. One meter of row (0.76 m^2) was sampled at the same day to measure leaf area and dry weight. Relative growth rate (RGR), leaf area growth rate, and canopy height and width growth rate of cowpea varieties and weeds were calculated to compare varietal differences in competition with sunflower and purslane.

Sunflower reduced the amount of light that cowpea received and cowpea varieties reduced the light received by purslane. Cowpea biomass production was reduced by sunflower in either year. Purslane did not affect cowpea biomass in 2000 and reduced the biomass of variety 288 and 779 in 2001. IC was not affected by purslane in either year. Sunflower biomass was reduced only by variety IC in 2000 and by all cowpea varieties in 2001. Purslane biomass production was reduced by variety 779 and IC in 2000 and by all three cowpea varieties in 2001. The RGRs of cowpea and weeds show the similar results. Leaf area of cowpea was reduced when sunflower was present. Purslane had very small effects on cowpea leaf area. Sunflower leaf area was reduced by cowpea varieties 288 and IC and purslane leaf area was reduced by cowpea variety 779 and IC in 2000. Sunflower and purslane leaf area were decreased by all three cowpea varieties in 2001. The cowpea canopy height growth rates increased when competing with sunflower, decreased or unaffected with purslane. The experiments suggest that cowpea varieties differed in their ability to compete with purslane and sunflower. IC was the most tolerant variety to weed competition. The results also indicated that erect growth habit might be more effective in suppressing weeds than semi-erect and prostrate growth habit, although additional tests with more varieties are needed.

Nomenclature: Cowpea, *Vigna unguiculata* (L.) Walp.; Purslane, *Portulaca oleracea* L.;
Sunflower, *Helianthus annuus* L.
Key word: Competition; Cowpea Cover Crop; Sunflower; Purslane.

ROUNDUP READY ALFALFA IN THE CENTRAL SAN JOAQUIN VALLEY OF CALIFORNIA

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Abstract

Roundup Ready alfalfa will be commercialized in the next few years. Studies were established to evaluate Roundup Ready alfalfa weed management systems with conventional weed control systems and strategies during stand establishment and in established alfalfa. Since the Roundup Ready alfalfa variety used in these studies was not a commercially available variety, these studies did not compare treatments based on yield and quality parameters. Weed control efficacy, alfalfa phytotoxicity and percent composition by alfalfa and weeds were measured. The main objectives of these studies are to develop weed control systems for Roundup Ready alfalfa during stand establishment and in established, producing stands. Roundup rate and timing interactions were compared for optimal control of perennial, poisonous or other problem weeds commonly found in alfalfa operations managed for high quality forage. Post emergent weed control strategies for Roundup Ready alfalfa were compared with conventional weed management systems in seedling alfalfa. Results of the seedling year study are reported with the established study being conducted this next year.

Key words: alfalfa, weed management, Roundup Ready, Roundup, Pursuit, Raptor, Buctril, Prism, common groundsel, oats, annual bluegrass, swinecress, chickweed

Introduction

A number of different annual, perennial and poisonous weeds infest alfalfa hay grown in the San Joaquin Valley of California. The type of weed infestations in any given area is usually associated with planting time (fall, winter or spring), previous cropping history and environmental characteristics of the production area. Any of these weeds left uncontrolled can seriously reduce yields or cause a complete loss of the stand, especially in the establishment year. If a loss of stand does not occur, infestations can weaken young alfalfa seedlings, retard growth and delay the first cutting. Weeds also reduce the quality and value of alfalfa hay as many or less palatable and less nutritious than alfalfa.

Properly establishing and managing an alfalfa stand are the first steps to effectively controlling weeds. But, most often weeds still become problems and growers are required to use herbicides. Currently available herbicides can provide adequate control, but additional weed control options, including Roundup Ready alfalfa will provide additional. As the Roundup Ready system is integrated into the California production system, additional concerns will need to be directed toward weed species shift and resistance management.

Procedures

A Roundup Ready alfalfa line, fall dormancy group, was seeded during the month of September. Once germination and emergence occurred, the seedling alfalfa was divided into plots and replicated four times in a randomized complete block design. Herbicide treatments were applied at three different timings: when alfalfa was in the unifoliate to one trifoliate leaf stage, 3 to 4 trifoliate leaf stage and 6 to 10 trifoliate leaf stage. All treatments were applied with a CO_2 sprayer with 8002 flat fan nozzles, delivering 20 gallons of spray solution per acre at 40 psi. Treatments included: Roundup Ultra Max at 1 and 2 qts/A, Raptor at 5 oz/A, Pursuit + Prism at 1.5 oz + 12 oz/A, Pursuit + Buctril at 1.5 oz + 0.75 pts/A and sequential applications of Roundup Ultra Max either following a Roundup Ultra Max treatment or a Pursuit + Prism or Buctril treatment. Pursuit + Prism was followed by itself and Buctril followed Pursuit alone.

Results

Volunteer oats, common groundsel, annual bluegrass, swinecress and chickweed were all controlled between 95 and 100 percent with the Roundup treatments at all rates alone and when followed by either Pursuit, or Pursuit + Prism when applied at both the 3 to 4 and 6 to 9 trifoliate leaf stage. When applied at the unifoliate to one trifoliate leaf stage, a followup treatment of Roundup was needed to provide 100 percent control. Pursuit + Prism, either applied once at the 3 to 4 leaf stage or a second application at the 6 to 9 leaf stage provided excellent control, but somewhat less than the Roundup treatments. Pursuit when followed by Buctril or applied tank mix did not control either annual bluegrass or volunteer oats, but provided 99 to 100 percent control of swinecress and chickweed. Raptor applied at the 3 to 4 leaf stage provided the least control of all weed species in the tests.

Evaluations of alfalfa phytotoxicity for all rates and timings of Roundup Ultra Max, Pursuit + Prism, and Raptor exhibited minimal to no injury at all dates of evaluation. Pursuit in combination with Buctril applied at the 7 to 9 trifoliate leaf stage did exhibit slight reduction of growth 21 days after treatment. Harvest data for percent composition showed 95 to 100 percent alfalfa for all Roundup and Roundup combinations. The Pursuit, Buctril treatments were 70 - 85 percent alfalfa and 15 to 30 percent weeds. The Raptor treatment in one trial was 25 percent alfalfa, and 75 percent weeds (volunteer oats), but in another 95 percent alfalfa and 5 percent weeds. The control plots in one study was 50 percent alfalfa and 50 percent weeds while the other was 5 percent alfalfa and 95 percent weeds or volunteer oats.

Compost as a Mulch and Corn Gluten Meal as a Preemergence Natural-based Product for Roadside Vegetation Control

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Compost consists of organic matter, such as leaves, landscape trimmings, food scraps, or woody debris, that has undergone varying degrees of decomposition. Applications are made to roadsides on a limited basis for vegetation control. Corn gluten meal (CGM), the protein fraction of corn and a byproduct of corn wet-milling, is a natural-based granular applied material. Research at Iowa State University has shown CGM, which is 10% nitrogen by weight, to be an effective preemergence weed control and fertilizer treatment in turf grass settings. Initial root development was found to be inhibited by five biologically active dipeptides that were isolated from CGM.[1] ISU researchers continue to study the mechanism(s) by which CGM and the dipeptides exert their inhibitory effects; it is apparent that the combination of a CGM-restricted plant rooting system and a period of water stress can cause seedlings to wilt and die.[2,3] However, without proper application timing of CGM during which the drying-out period is adequate, seedlings will continue root and shoot development, using CGM as a plentiful nitrogen source. This is an important reason why CGM is effective in controlling weed seedlings in turf grass: seedlings with poor root formation under water stress cannot compete well with the established plants (turf).

Based on testimonials and observations, CGM has been either effective or ineffective for vegetation control in vineyards, home gardens and non-crop rights-of-way. We determined that CGM should be applied and tested in a scientific manner, in both greenhouse and field studies, to determine its potential for control of vegetation along roadsides. Experiments were conducted to determine whether compost and CGM could effectively control vegetation along roadsides by combining shade effects and biological activity, respectively, at a cost comparable to currently registered herbicides.

Field sites were established at the Hopland Research and Extension Center (HREC1 and HREC2) and Jackson Demonstration State Forest (JDSF1 and JDSF2). Vegetation at HREC was dominated by a few annual grasses with several broadleaf species, while a mix of annual forbs and grasses, jubatagrass (*Cortaderia jubata* Lemoine) and French broom (*Cytisus monspessulanus* L.) were most common at JDSF. Following the removal of existing vegetation, CGM was applied at 12206, 24412, and 48824 kg/ha with and without compost at both HREC and JDSF on October 1, 2000. Compost alone and a preemergence herbicide treatment of isoxaben and oryzalin at 1.1 kg ai /ha and 4.5 kg ai /ha, respectively, were also applied. October 1, 2001, repeat applications of CGM at 12206 and 24412 kg/ha with and without compost were applied in addition to compost alone and isoxaben and oryzalin at the same rates as the previous

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year. March 2001, the highest rate of CGM (48824 kg/ha) without compost was the most effective treatment for controlling vegetation at HREC1 and JDSF1.

Initial indications after one year of control showed that the highest rate of CGM alone (48824 kg/ha) was the most effective treatment for controlling vegetation at HREC1 and JDSF1. The lower rates (12206 and 24412 kg/ha with and without compost) did not consistently control vegetation for all locations. The addition of compost as a mulch to all treatments played a role in lowering weed pressure, especially at HREC

In 2002, vegetation control was less than 68% for single applications of CGM with or without compost and greater than 65% for two applications of CGM with compost at HREC1 and with or without compost at JDSF1. Vegetation control for the remaining treatments at HREC1, 2 and JDSF 2 was unacceptable (near 0) in 2002. Except at HREC1, weed control with compost declined between 2001 and 2002. Vegetation vigor and cover increased as the control decreased more significantly for CGM than for the standard treatment. Annual applications of CGM at $11,230/ha (48824 kg/ha) for roadside vegetation control is not comparable to synthetic preemergence herbicides, isoxaben and oryzalin at $303/ha and $159/ha, respectively, even in urban interchanges. The cost of a roadside application of 48824 kg/ha of CGM was $11,230/ha ($1.12/kg of CGM[4]). The cost of a standard synthetic preemergence treatment of isoxaben ($303/ha[5]) and oryzalin ($159/ha[6]) would equal approximately $462/ha.

Annual applications of CGM for roadside vegetation control are not comparable to synthetic preemergence herbicides, isoxaben and oryzalin, even in urban interchanges. CGM is not a viable alternative for vegetation control along Caltrans rights-of-way. The high cost and poor efficacy are the major limiting factors in using CGM.

[4] Price from CGM distributor in California.
[5] Prices quoted from Caltrans District 1 Vegetation Control Specialist
[6] Prices quoted from Caltrans District 1 Vegetation Control Specialist

Allium spp. Amendments, Soil Temperature, and Exposure Time Affect Seed Viability for Weed Management in California

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Summary

A two-year study was conducted during 2000-01 in microcosms to evaluate amendment with onion (*Allium cepa*) and garlic (*A. sativum*) residues as an approach for reducing weed seed numbers in soil. Additional factors, including amendment concentration, soil temperature, and exposure time also were tested for their effects on the amendment treatments. Seeds of barnyardgrass (*Echinochloa crus-galli*), common purslane (*Portulaca oleracea*), London rocket (*Sisymbrium irio*), and black nightshade (*Solanum nigrum*) were used in the study. Results showed that 39 C soil temperature was consistently deleterious to seed survival, as compared to 23 C. Significant effects of the *Allium* spp. amendments on weed seed viability were common, but less consistent than with the other experimental factors. No differences in weed seed viability due to soil amendment with onion versus garlic were found in the 2000 experiment, and only in barnyardgrass and black nightshade in the 2001 experiment. On the other hand, seed viability differences due to amendment concentration (1% versus 3% by weight) were found in barnyardgrass, black nightshade, and London rocket in the 2000 experiment, but no concentration differences were found in the 2001 experiment. In both experiments, barnyardgrass, common purslane, and London rocket seeds were less viable after longer incubation in the microcosms, while black nightshade was not significantly affected by exposure time.

Introduction

Soilborne pests and pathogens, including weed propagules, nematodes, fungi, bacteria, and certain other agents, can be limiting factors in the production of crops. One of the principal strategies used by growers of high-value horticultural crops to combat these organisms is pre-plant soil disinfestation, either with pesticides, or other physical or biological methods. Soil fumigants are the most effective soil disinfestation chemicals, and historically, methyl bromide (MB) has been the most important soil fumigant chemical used by growers in California and around the world[5].

Until recently, consumption of MB for pre-plant fumigation in California was estimated at 16 million pounds annually - nearly 50% of the total amount used in the USA. However, MB was identified as a risk to the stratospheric ozone layer in 1992 and targeted for worldwide phase-out in 1997, by means of the Montreal Protocol, an international treaty. Under the current terms of the agreement and of the federal Clean Air Act, pre-plant consumption of MB in the USA is scheduled to be gradually phased out by 2005[5].

With the impending suspension of methyl bromide for most agricultural uses, and the extremely high cost of methyl bromide fumigation now, there is an urgent need for implementable, alternative methods of soil disinfestation for use in production agriculture. In addition, the increasing acreage devoted to organic production requires the development and implementation of usable tools for soil disinfestation. Biofumigation is one such emerging tool. The term biofumigation refers to the use of organic amendments and crop residues to release biotoxic volatile compounds during degradation in soil. Changes in soil microbiota resulting in biological control of soilborne pests may also contribute to the lethal effects. Biofumigation can be a useful option for soil disinfestation, especially when combined with soil heating (solarization)[2-4].

Most of the previous biofumigation research has focused on use of various cruciferous crop residues, such as broccoli and cabbage, to control pathogens and nematodes[2,3]. To be useful to a larger portion of the agricultural sector, it is important that other rotational crops with high pesticidal activity via the biofumigation process be identified and guidelines for their use in weed management developed. For this reason, the present study evaluated *Allium* spp. amendments, using onion and garlic specifically, for potential as biofumigants for weed management. The additional factors of amendment concentration, soil temperature, and exposure time also were studied for their effects on the treatments. The approach described in this paper could be used by organic as well as conventional producers, and is practicable for fields at the urban-rural interface where chemical fumigants face buffer space restrictions. An earlier, preliminary report was published[1].

Materials and Methods

Soil, weed seeds, and *Allium* amendments. Hanford fine sandy loam soil was collected at the University of California Kearney Agricultural Center in Parlier. Soil was sifted through a 3-mm mesh sieve to remove roots and other surface debris. The four weed species tested in both 2000 and 2001 were barnyardgrass (*Echinochloa crus-galli*), common purslane (*Portulaca oleracea*), London rocket (*Sisymbrium irio*), and black nightshade (*Solanum nigrum*). The *Allium* soil amendments included garlic (*A. sativum* 'California Early') and onion (*A. cepa* 'Mission'), which consisted of culls and residues normally left in the field following harvest in the central San Joaquin Valley. The *Allium* spp. were dried, and ground in a Thomas-Wiley mill using a 1-mm mesh screen prior to use.

Preparation of weed seeds for treatment. Ten seeds (in 2000) or 20 seeds (in 2001) of each species were placed in 3.5-cm diameter nylon organdy bags and tied tightly. 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 baths. The exception was common purslane, which was dipped only one hour prior to treatment, as it germinates quickly following imbibition.

Preparation of microcosms and treatment. Soil was moistened to approximately field capacity (14-15%) before amendments were added. Samples consisted of 200 g of soil with either 1 or 3%, by weight, of onion or garlic amendments, or nonamended soil. Amended samples were thoroughly mixed, then placed in a 355-ml, ‘Kal-Klear’ plastic cup. Six bags of weed seeds, one of each species, were placed halfway down in the center of the cup and buried in soil. Each cup was covered with 1-mil, clear polyethylene film and secured with a rubber band. 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 a smaller water bath maintained at ambient temperature (22-23 C). Temperatures of soil samples and water baths were monitored with ‘HOBO’ data loggers.

Germination and viability testing. At intervals of 2, 4, and 7 days of incubation, microcosm samples of each amended or nonamended treatment were removed from baths. Following removal, weed bags were extracted from soil, opened and weed seeds were checked for germination and viability. Additional samples of each species were placed in the incubator according to the germination protocol to serve as the time ‘0’, nontreated control.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. Weed seeds were checked for germination at regular intervals of 3-5 days. Germinated seeds were counted and discarded. Seeds were counted as germinated if the radicle had emerged and the plumule emerged to a length of 3 mm. Nongerminated seeds were gently squeeze-tested to determine viability. Tetrazolium testing was done on nongerminated black nightshade seeds. Percentage of seed viability was determined for each species.

Results and Discussion

Results of the two-year study showed both similarities and differences in weed species seed viability response to the experimental treatments.

As described in a previous, preliminary report[1], the effect of temperature (39 C versus 23 C) in the 2000 experiment was consistently significant for the four weed species tested, indicating that the higher soil temperature was deleterious to seed survival over the course of the seven-day incubation period. This finding was confirmed during the 2001 experiment (Table).

Significant effects of the *Allium* spp. amendments on weed seed viability were common, but less consistent than with the other experimental treatments. No differences in weed seed viability due to soil amendment with onion versus garlic were found in the 2000 experiment, and only in barnyardgrass and black nightshade in the 2001 experiment. On the other hand, seed viability differences due to amendment concentration (1% versus 3% by weight) were found in barnyardgrass, black nightshade, and London rocket in the 2000 experiment, but no concentration differences were found in the 2001 experiment (Table).

Consistent differences in seed viability attributable to length of exposure to the treatments were found. In both the 2000 and 2001 experiments, barnyardgrass, common purslane, and London rocket seeds were less viable after longer incubation in the microcosms, while black nightshade was not significantly affected by exposure time. These results were duplicated in the 2001 experiment (Table). Several significant and consistent treatment interactions also were found during the study. These will be discussed in subsequent publications.

Conclusions

Results of this study showed that exposure to 39 C soil temperature was consistently deleterious to seed survival in barnyardgrass (*Echinochloa crus-galli*), common purslane (*Portulaca oleracea*), London rocket (*Sisymbrium irio*), and black nightshade (*Solanum nigrum*), as compared to 23 C. Significant effects of the *A. cepa* and *A. sativum* amendments on weed seed viability were common, but less consistent than with the other experimental factors. No differences in weed seed viability due to soil amendment with onion versus garlic were found in the 2000 experiment, and only in barnyardgrass and black nightshade in the 2001 experiment. On the other hand, seed viability differences due to amendment concentration (1% versus 3% by weight) were found in barnyardgrass, black nightshade, and London rocket in the 2000 experiment, but no concentration differences were found in the 2001 experiment. In both experiments, barnyardgrass, common purslane, and London rocket seeds were less viable after longer incubation in the microcosms, while black nightshade was not significantly affected by exposure time. The results indicate that the *Allium* spp. amendments, especially when combined with elevated soil temperature (solarization), may contribute to effective weed management strategies for both conventional and organic production.

Significance of experimental factors on weed seed viability (2000-01).

Factor, Year	Weed species			
	E. crusgalli	*P. oleracea*	*S. irio*	*S. nigrum*
	Statistical Significance Level			
Soil amendment				
2000	ns*	ns	ns	ns
2001	<0.0001	ns	ns	0.0005
Amendment concentration				
2000	<0.0001	ns	<0.0001	0.0037
2001	Ns	ns	ns	ns
Soil temperature				
2000	<0.0001	<0.0001	<0.0001	0.0072
2001	<0.0001	<0.0001	<0.0001	0.0036
Exposure time				
2000	<0.0001	<0.0001	<0.0001	ns
2001	<0.0001	0.0021	<0.0001	ns

*ns = not significant at $P<0.05$.

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New Methods For Yellow And Purple Nutsedge Control In The San Joaquin Valley

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University of California Cooperative Extension

Introduction

Yellow and purple nutsedge are major weed pests in cotton. Previous studies show that a 6-week weed free period is needed after cotton emergence. This is because nutsedge competes with cotton for water, sunlight, space and nutrients, which can result in reduced vigor of the cotton causing reductions in yield and quality of the crop. Past research also shows that the only effective chemical method of controlling nutsedge is MSMA, but MSMA can cause serious injury to cotton in the early stages of growth. Consequently, there is a need for new materials that can effectively control Nutsedge without injuring the cotton.

Material And Methods

Uniform fields of Acala DP6100RR and Riata cotton planted in early April 2002 and heavily infested with Nutsedge were divided into 4 replications of 4 to 17 treatments is a randomized complete block design. The trials were conducted in Firebaugh (Trial A & B), Madera (Trial C) and Visalia (Trial D). Trial A was treated on May 3rd, 13th, and 22nd. Trial B was treated on May 3rd and May 13th. Trial C was treated on May 16th and Trial D was treated on May 8th and June 4th. All treatments were applied with a CO_2 sprayer delivering 20 GPA at 30-40 psi. Nutsedge control and cotton injury was evaluated at 19, 25, 31, and 39 days after the 1st treatment (DA1stT) in fields A and B. Field C was evaluated at 7,15,and 22 DA1stT and field D was evaluated at 7,14 and 39 DA1stT

RESULTS

Trial A

At 19 DA1stT, no treatment exhibited satisfactory nutsedge control with the greatest control at 53% and the least at 3%. At 25 DA1stT, sequential applications of Touchdown IQ followed by CGA362622 exhibited the greatest nutsedge control at 72-80%. By 31 DA1stT, control had dropped below acceptable levels. At 39 DA1stT, most of the treatments exhibited less than 20% nutsedge control. Treatments 4, 14 & 10, exhibited 20-65% which, while better. was still unacceptable. Treatments 11, 12, 13 & 15 exhibited good nutsedge control at 80-100%. At 19 DA1stT, MSMA exhibited the greatest cotton injury at 15-20%. At 25 DA1stT, MSMA still exhibited the greatest injury. By 31 DA1stT, Roundup UltraMax exhibited slight injury at 16%, and at 39 DA1stT, all treatments except Touchdown IQ or Roundup UltraMax exhibited varying stages of cotton injury with a range of 2-16%.

Trial B

At 19 DA1stT, no treatment exhibited acceptable nutsedge control, with a range of 4-48%. At 25 DA1stT, control by the Roundup UltraMax treatments had increased to acceptable levels ranging from 76-80%. By 30 DA1stT, control for all treatments had started to drop, and at 39 DA1stT, control continued to drop to unacceptable levels with Treatment 1 at 49%, Treatment 2 at 69%, Treatment 3 at 0%, and Treatment 4 at 11% control.

At 19 DA1stT, all treatments except the lowest rate of CGA362622 exhibited 9-13% cotton injury. By 25 DA1stT, Roundup Ultra Max treatment exhibited 13-15% injury. At 31 DA1stT, all treatments exhibited less than 5% injury, but by 39 DA1stT, injury from the CGA362622 treatments had increased ranging from 12-18%.

Trial C

At 7 DA1stT, the greatest nutsedge control was exhibited by MSMA at 11%. By 15 DA1stT, MSMA or MSMA tank mixed with Roundup UltraMax exhibited the greatest control at 49-45%. At 22 DA1stT MSMA tank mixed with Roundup UltraMax still exhibited the greatest control at 58%, but was not significantly different from either MSMA or Roundup Ultra Max tank mixed with ammonium sulfate at 38 and 45% respectively.

All treatments exhibited less than 13% cotton injury at 7 DA1stT, and continued to drop at 15 and 22 DA1stT, until the greatest cotton injury was 3% for the high rate of Staple and CGA362622.

Trial D

At 7 DA1stT the greatest nutsedge control was exhibited by CGA362622 at 48%. By 14 DA1stT treatments 1,2,5,9,12,13,and 14 were between 75-83% control and treatments 3,4,6,7,8,10,11,and 15 were between 68-73% control, By 39 DA1stT the treatments had all dropped below acceptable control levels except CGA 362622+Touchdown at 71% control.

All treatments exhibited less than 23% cotton injury at 7 DA1stT, and continued to drop at 15 and 39 DA1stT until there was 0% injury to the cotton

Conclusion

CGA 362622 alone does not provide effective control of nutsedge, however when used in rotation with glyphosate, CGA362622 may become an effective tool in nutsedge control. Presently there does not appear to be any advantage to tank mix CGA362622 with Staple or MSMA.

Glyphosate provides effective control of nutsedge when applied in sequential applications. However when used as a single application for nutsedge control, glyphosate does not provide effective control.

Transition Management of Overseeded Bermudagrass and Weed Impacts

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Introduction

In areas where bermudagrass has long winter dormancy it is commonly overseeded with cool season turfgrasses in the fall to maintain green color throughout winter months. Annual and perennial ryegrass and occasionally creeping red fescue are the most common overseeding species. Annual ryegrass and creeping red fescue are intolerant of warm temperatures and fade out relatively quickly in spring allowing for bermudagrass to emerge from dormancy without significant competition. Perennial ryegrass is the preferred choice for overseeding because of its darker green color and disease resistance. However, perennial ryegrass remains competitive with the bermudagrass for a much longer time period and can delay emergence from dormancy if the transition is not properly managed. Additionally, bermudagrass vigor in summer is diminished by perennial ryegrass competition, if the ryegrass remains in the turf stand.

Because of the higher quality associated with perennial ryegrass and the chemical tools that are available to large-scale commercial turf managers its popularity has increased. Pronamide (Kerb®) is the herbicide most commonly used to selectively remove perennial ryegrass from bermudagrass. This product is a restricted use material and not readily available to home gardeners and those that manage residential lawns (assuming they are unlicensed). Smaller residential landscape managers are also adopting the use of perennial ryegrass for overseeding and finding that the transition to a vigorous bermudagrass is more difficult since Kerb is not an option.

Objectives

This field study has several objectives. One is to compare overseeded grass species and their effect on the transition of bermudagrass from dormancy to spring greenup. Another objective is to compare cultural methods of transition management from perennial ryegrass to bermudagrass.

Materials and Methods

Two separate experiments were conducted on the CSU Fresno campus on a common bermudagrass turf. Experiment 1 evaluated three overseeding species compared to a check for their ease of transition back to bermudagrass. Experiment 2 investigated seven treatments on perennial ryegrass for their impact on facilitating bermudagrass spring green up. The site for both experiments was very uniform and not heavily trafficked. Some weeds were present. Each experiment was fertilized at an annual rate of 4 pounds nitrogen per 1000 square feet. Four one-pound applications were made in April, May, July and August.

Individual plot size was 5' x 10' and with four replications arranged in a randomized complete block design (RCBD).

Each experiment was overseeded when air temperatures averaged 58°F and soil temperatures averaged 65° for several successive days. The overseeded grasses were grown using standard cultural practices for cool season turf through the winter and early spring months. Treatment evaluations began when air temperatures averaged 60°F and soil temperature averaged 55°F. These are temperatures when bermudagrass begins to emerge from dormancy (reference). Weather data was downloaded from the California Irrigation Management Information System (CIMIS) station located on the CSUF campus.

Experiment 1: Comparison of Three Cool Season Overseeding Species –Annual Rye, Perennial Rye and Creeping Red Fescue

On November 15, 2001 plots were overseeded with selected species at recommended rates.

- Annual ryegrass was hand seeded at 13 lbs.
- Creeping red fescue was seeded at 8 lbs.
- Perennial ryegrass (var. Pinnacle) was seeded at 10 lbs per 1000 square feet.

Experiment 2: Comparison of Transition Management Treatments in Perennial Ryegrass to Facilitate Spring Green-up

On November 15, 2001 perennial ryegrass (cultivar Pinnacle) was overseeded at 10 lbs per 1000 square feet. Cultural and management treatments using nitrogen, compost, contact herbicide and close mowing were evaluated for their effect on removing perennial ryegrass from overseeded bermudagrass to facilitate spring green up. The treatments included:

1. Two additional pounds of nitrogen per year (one pound in March and one pound in September) to encourage bermudagrass growth.
2. Two additional pounds of nitrogen per year PLUS close mowing.
3. Two additional pounds of nitrogen per year PLUS an application of Diquat.
4. Close mowing to ¼" height to open the turf canopy and encourage bermudagrass growth.
5. Application of Diquat (a contact herbicide) to burn top growth of perennial ryegrass.
6. Topdressing ¼" compost (as an alternative to synthetic nitrogen application).
7. An untreated check, i.e. bermudagrass with no perennial ryegrass overseeding and no additional management treatments.

Data Collected

Quality, weeds, and turfgrass density were evaluated over time in both experiments. The transition management treatments were initiated when the average air temperature reached 60°F and the average soil temperature reached 55°F. Evaluations began one week after initial treatment (1 WAIT).

Turf quality was visually evaluated based on a 1-9 subjective rating scale that included such factors as color, density of turf, uniformity and presence/absence of weeds or disease, irrespective of turf species. A rating of 5 is considered minimally acceptable turf quality. A rating of nine is exceptional and one is extremely poor.

Weed populations in turf plots were visually evaluated bimontly using a scale of 0 to 99 percent weed cover. Individual weed species were noted but all weed species were combined in the evaluations.

Shoot densities for all turf species within a plot were calculated by counting the actual number of shoots of each species in a 1 inch by 6 inch area (2.5 cm x 15.2 cm=39 cm2) and extrapolated to 1 square meter. Counts were made on a weekly basis to determine changes in turf density by species during the transition phase.

Results and Discussion

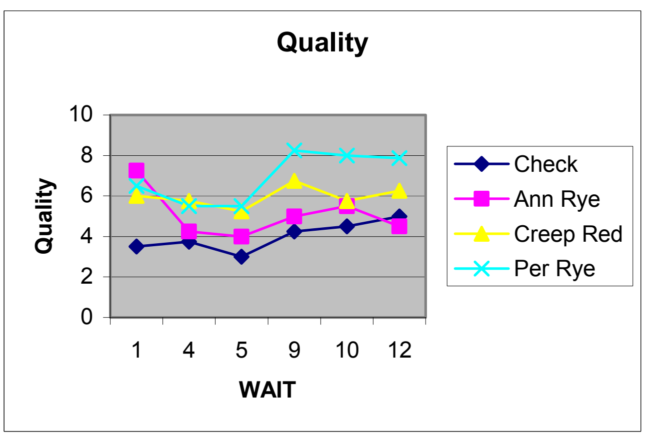
Experiment 1: Quality

In experiment 1 three overseeded grasses were compared to an unoverseeded bermudagrass check. All of the overseeded plots entered the transition period with a quality rating of 6 or better and were not significantly different from each other. Bimonthly quality evaluation of the bermudagrass check plots ranged from 4.5 to 5.5 over the twelve-week evaluation period which began on March 22nd through June 5, 2002. The quality for the check was that a minimally acceptable turf.

Perennial rye plots maintained the highest turf quality throughout the 12-week transition phase. Early in the transition phase at week 4, there was a sudden warm spell, which negatively affected quality of all overseeded species. However, by 9 WAIT perennial rye recovered and maintained a high quality (8 or above) for the remainder of the transition period.

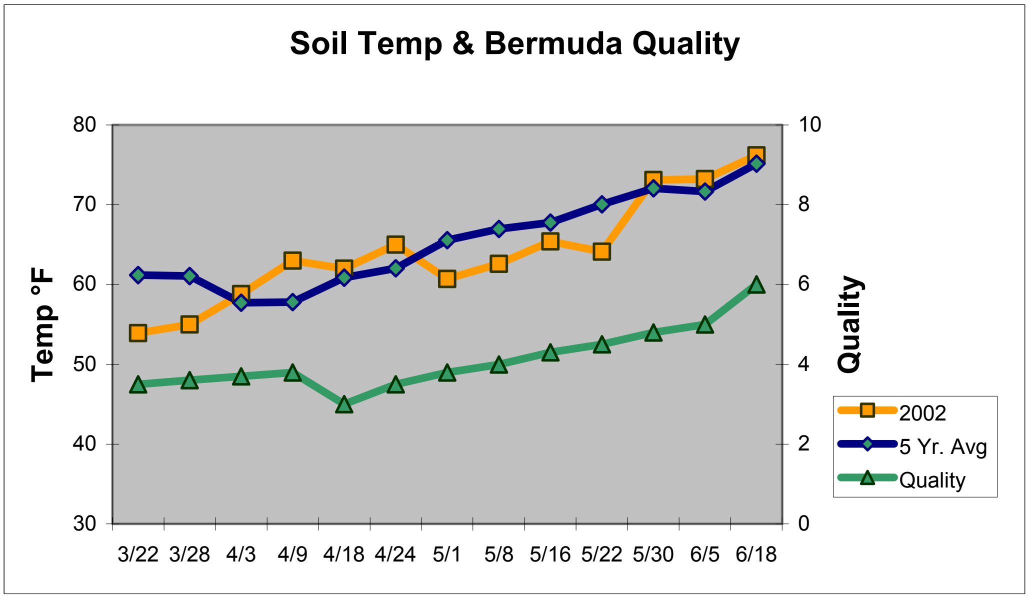
Creeping red fescue quality was not affected by temperatures as much as the ryegrasses and was able to maintain a steady turf quality that ranged from 5.7 to 6.2 throughout the transition.

Annual ryegrass quality at 1 WAIT was high at 7.5. At 4 WAIT, when the first warm temperatures of the season developed, quality dropped to a 4. Quality of annual rye plots was not significantly different than the check throughout the remainder of the transition period.



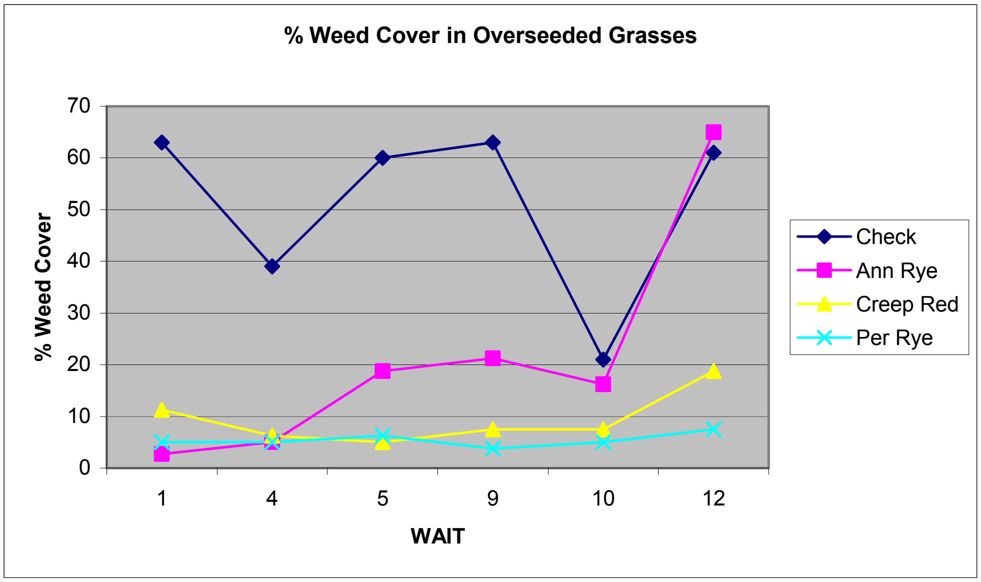
Experiment 1: Percent Weed Cover

In the winter months, annual bluegrass was the dominant weed species. During the transition period bluegrass died out and crabgrass emerged as the dominant summer weed species. This trend was observed in the check plots. Weed cover remained high in the check plots reflecting bluegrass weed populations at WAIT 1-4, then dipped down at WAIT 5 as bluegrass faded. Weed populations rose quickly to 60% with the emergence of crabgrass as temperatures increased between WAIT 9-12.



Percent weed cover was significantly less in overseeded plots compared to the bermudagrass check. The highest weed populations were in the check ranging from 65% at 1WAIT to a low of 20% at 10 WAIT. At 12 WAIT the weed population increased up to 60% and this increase was likely due to transition from winter to summer weeds. Overseeding with creeping red fescue and perennial rye kept weeds below 10 percent throughout the transition period.

Overseeding with annual rye kept weeds low for the first 5 WAIT but then weed populations increased and were as high as the check plots at the end of the transition period. Crabgrass likely had an easier time emerging in overseeded annual rye plots due to reduced competition as annual ryegrass died out with warmer temperatures.



Experiment 1-Bermudagrass Shoot Density in Overseeded Turf

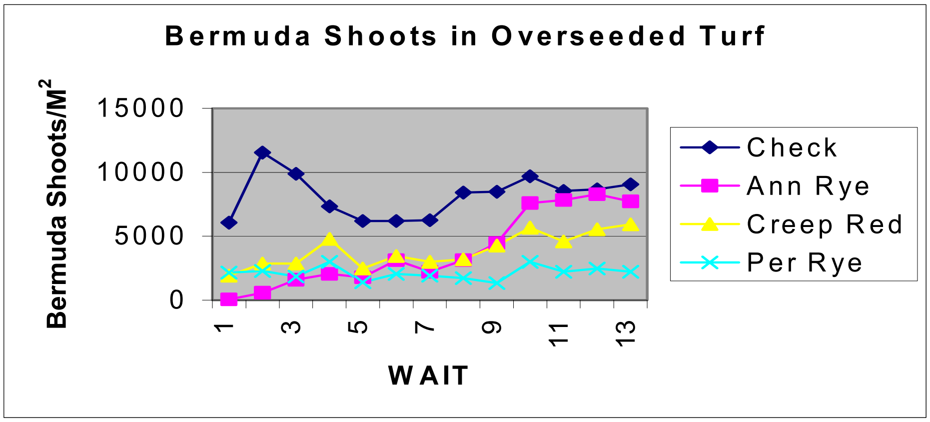
Bermudagrass shoot counts in untreated plots maintained a relatively stable shoot density from 6000-10,000 shoots per meter sq. The exception is 12,000 dip in the first 2 WAIT—perhaps this sudden shift can be explained as an error in shoot counts in the early learning phase of counting shoots.

Bermudagrass shoot density was significantly lower in overseeded plots from weeks 1-9 WAIT when compared to untreated plots. In 9-13 WAIT bermudagrass growing in overseeded annual rye plots reached shoot densities equal to the untreated check plots.

Bermudagrass shoot density in perennial rye treated plots remained constant at about 2000 shoots per meter sq. throughout the transition period. They didn't increase and were significantly less than the check throughout the entire period.

Bermudagrass shoots in creeping red fescue plots increased slowly throughout the transition and was not significantly different from the check by 12 WAIT.

In summary, overseeding with perennial ryegrass prohibited bermudagrass shoot development throughout the transition period and persisted into the summer months.



As expected, the reverse of these trends was true as well. As the transition period progressed the shoot density of the overseeded turf species decreased in all cases. At 2 WAIT, shoot densities of all overseeded grasses ranged between 30,000-40,000 shoots per meter squared. Between 4-6 WAIT there was a dramatic decrease in overseeded shoot densities with annual rye dropping from 33,000 to 5,000; creeping red fescue dropped from 39,000 to 15,600 and perennial rye went from 30,000 down to 13,000. By week 12 all overseeded grass densities decreased significantly with perennial rye shoot density stabilizing at 12,000 shoots per meter square.

Shoot Density Per Meter Square Of Overseeded Grasses

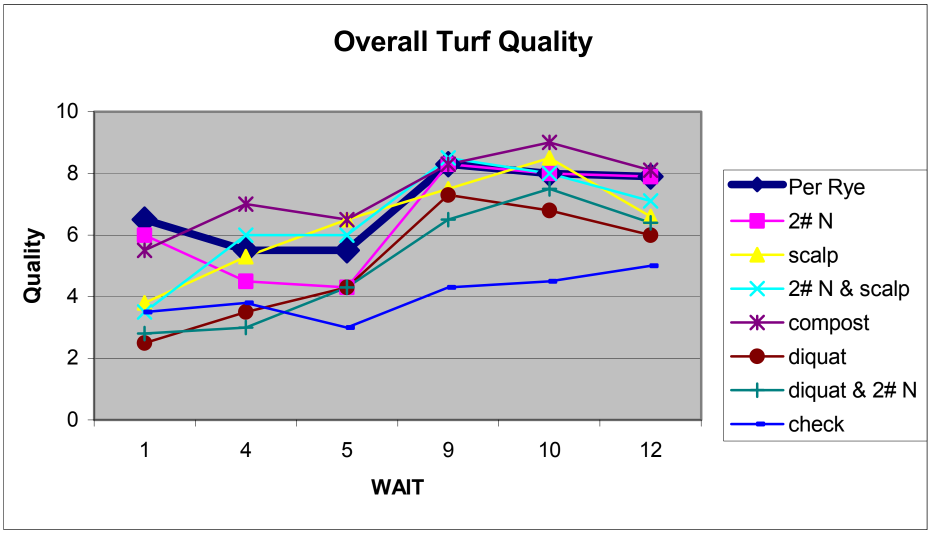
	Weeks After Initial Treatment (WAIT)				
	2	**4**	**6**	**8**	**12**
Annual Rye	33,482	17,666	5,038	7,653	1,594
Creeping Red Fescue	39,158	34,949	15,625	10,842	7,589
Perennial Rye	30,931	30,229	13,074	12,819	12,627

Experiment 2: Transition Management of Perennial Rye Overseeded Plots:

Quality

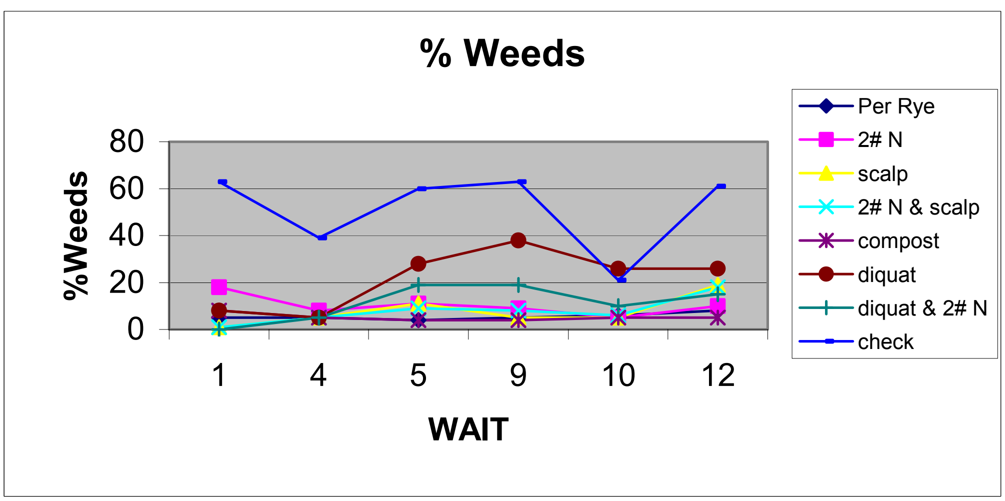
Quality was evaluated over the twelve-week transition period. Overall, the check plots had the lowest quality with a low of 3.7 to a high of 5 and were significantly lower in quality than all treatment plots. By 5 WAIT all plots overseeded with perennial rye had much higher quality than the check. All plots were fertilized at 5 WAIT and at 9 WAIT and all plots showed an increase in overall turf quality.

The highest quality ratings were observed at 10 WAIT with the best quality in plots treated with ¼ inch of compost. There were no significant differences in any of the other plots except those treated with a contact herbicide. Plots that had the least quality were those that were treated with a contact herbicide and treatment effects were observed throughout the period likely because it opened the plots to increased weed invasion. Following 11 WAIT, there was a drop off in quality of the overseeded turf, likely in response to increasing temperatures.



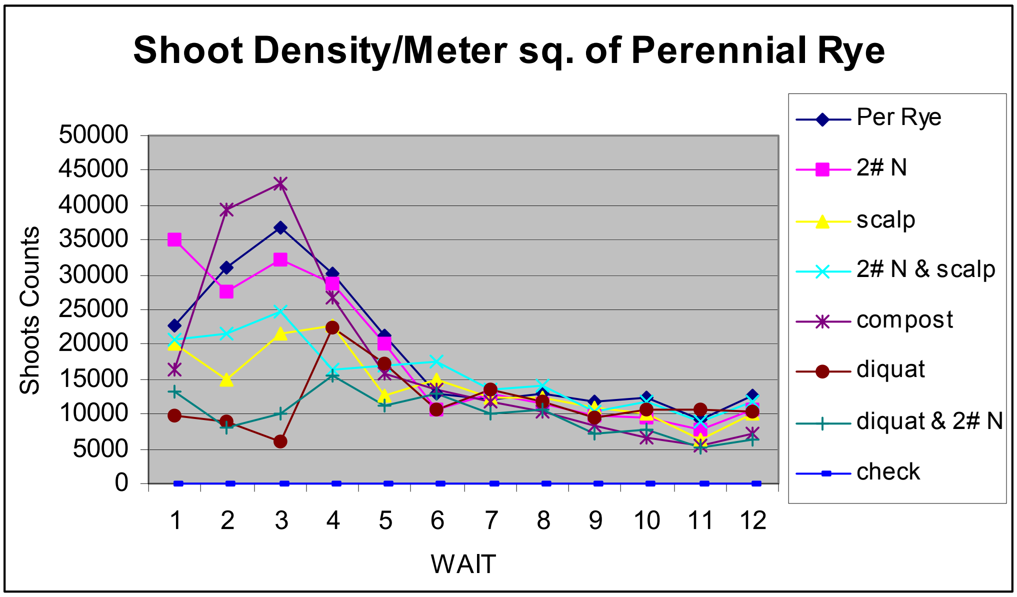
Experiment 2: Percent Weeds

In this experiment, the highest weed populations were in the check ranging from 65% at 1WAIT to a low of 20% at 10 WAIT. At 12 WAIT the weed population increased up to 60% and this increase was likely due to transition from winter to summer weeds. The next highest weed populations were found in plots treated with a contact herbicide with or without additional nitrogen. Once again, the treatment likely opened the turf to increased competition. However, scalping treatments had little effect on weed populations. Perhaps the recovery period was shorter in scalping treatments than with herbicide treatments and as such weeds did not have such a broad window for germination. There were few significant differences within the other treatments over the transition period. The key trend is that overseeding with perennial rye limits germination of competing weed species that effect is retained over time.

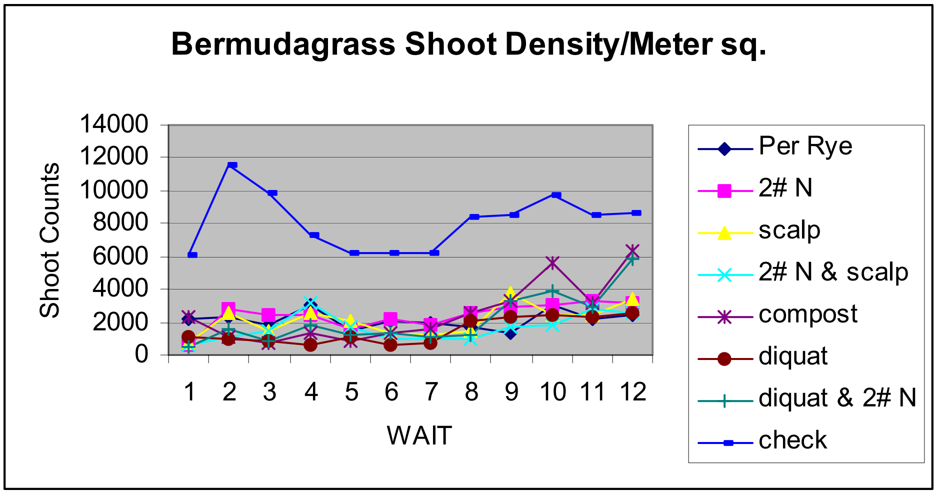


Experiment 2: Shoot Density of Perennial Rye

Shoot density per meter2, in 1-3 WAIT were highest in plots receiving some form of nitrogen with compost treated plots being highest and in just perennial rye plots. These plots retained a fairly high shoot density up until 4 WAIT at which time all plots show a marked decrease in perennial rye shoot density to a point where there was no significant difference between treatments. In the early part of the transition phase, the plots that have the lowest shoot density are those plots being treated with a contact herbicide and those that are scalped with or without additional nitrogen. These plots never recover to the point of being higher in shoot density than the perennial rye alone indicating that these treatments do impact the development of perennial rye. By the end of 12 WAIT, a significantly fewer perennial rye shoots were found in the plots treated with compost and those treated with a contact herbicide and additional nitrogen.



The inverse was also true in this experiment in that the bermudagrass shoot densities tended to increase as perennial rye decreases though the transition period. However, there are no significant differences until 10 WAIT at which time those plots treated with compost have an increase in bermudagrass shoots from a low of 1000 up to 6000. As well, those plots that were scalped and treated with additional nitrogen also show an increase in bermudagrass shoots over the other treatments and were not significantly different than the compost treated plots.



Conclusion:

In summary for Experiment 2, there was an overall improvement of turf quality and a decrease in weed populations by overseeding with Perennial rye. There was also a significant reduction in bermudagrass shoot density, which only very slowly increased over the transition period. In terms of transition management, none of the cultural treatments stood out as being exceptionally better at reducing the shoot counts of perennial rye and encouraging the growth of bermudagrass shoots with the exception of the plots treated with compost. These plots generally had the best quality during the transition period, had the most bermudagrass shoots and the least number of perennial rye shoots by the end of the transition period. Compost treated plots also had the fewest number of weeds.

Tall Annual Morningglory Control Studies in Acala Cotton

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University of California Cooperative Extension, Tulare Co. – 2002

Abstract

Annual morningglories (*Ipomoea Spp)* are difficult to control with existing cultural and herbicide practices in cotton. In 2002, six studies were conducted in Acala cotton evaluating herbicides for control of tall annual morningglory (*Ipomoea purpurea*). The first study evaluated Roundup Weather Max (*MON78270*) with different tank mixes, the second study evaluated CGA 362622 (*trifloxysulfuron*) with different tank mixes sprayed over-the-top and directed, the third study evaluated different glyphosate formulations, the fourth study evaluated Shark (*carfentrazone-ethyl*), Valor (*flumioxazin*), and Harvade (*dimethipin*) with different tank mixes, the fifth and sixth studies compared Goal 4F and the Goal 2XL formulations (*oxyfluorfen*) with different application methods for control of tall annual morningglory. Herbicide combinations were most effective, but needed two applications. Both formulations of Goal caused significant injury. These studies showed that most treatments with two applications helped to reduce tall annual morningglory but complete control was not achieved using the post-directed herbicides in these studies.

Introduction

Annual morningglories (*Ipomoea Spp*) climb and twist over cotton plants, interfere with defoliation and harvest, and are difficult to control with current cultural and herbicide programs. Ivyleaf morningglory (*Ipomoea hederacea*) and tall morningglory (*Ipomoea purpurea*) are the predominant species in the San Joaquin Valley. Both species are a native of tropical America. Tall morningglory has a fibrous root system, unlike ivyleaf morningglory (*Ipomoea hederacea*), which has a taproot with stems up to twenty feet long. The stem length in tall morningglory (*Ipomoea purpurea*) varies from 5 to 13 feet, and all of the leaves are heart shaped, unlobed, and pointed on the tip uniformly throughout the plant. The calyx on both species is noticeably hairy and ½ to ¾ inch long. The leaves are extremely similar making tall morningglory and ivyleaf morningglories almost indistinguishable.

Materials and Methods

The first study evaluated Roundup Weather Max (*MON 78270*) with different tank mixes; the second study evaluated CGA 362622 (*trifloxysulfuron*) with different tank mixes sprayed over-the-top and directed spray, and the third evaluated different glyphosate formulations. These three studies were conducted in DP6100 Roundup Ready cotton with a heavy population of tall annual morningglory. The plot sizes were divided into 4-38" rows x 25' and four replications using a randomized complete block design. The first application of herbicides was applied June 5, 2002 using a CO2 backpack with 8002 flat fan nozzles, over-the-top, 30 psi, 15 gpa, and a walking speed of 3.5 mph. The cotton height was 1-3" tall, and 2-4 nodes during the first application. The second application for studies one and three were applied July 2, and it was a directed spray. The cotton was 11-13" tall with 9-11 nodes during the second application. The temperature for both applications was approximately 80-85 degrees Fahrenheit with winds at 0-3 mph.

The fourth study evaluated Shark (*carfentrazone-ethyl*), Valor (*flumioxazin*), and Harvade (*dimethipin*) with different tank mixes and was also conducted in DP6100 Roundup Ready Cotton.

The field was divided into a randomized complete block design. The plots were 4-38” rows x 25’ with four replications. The average temperature was 85 degrees Fahrenheit, wind of 0-3 miles per hour, and 35 percent relative humidity. The treatments were applied July 2nd, 2002, and ratings were taken weekly. The cotton was 11-13” tall with 9-10 nodes. A heavy population of tall annual morningglory cotyledons was at the twinning stage. Herbicides were applied over-the-top with a CO2 backpack, 8002 flat fan nozzles, with a walking speed of 3.5 mph, 15 gpa, and 30 psi.

The fifth study evaluated Goal 4F and 2XL (*oxyfluorfen*) for control of tall annual morningglory applied over-the-top of BXN-47 cotton. The plot sizes were divided into a randomized complete block design. The plots were 4-38” rows x 25’ with four replications. The first application of herbicides was applied June 21, 2002 using a Hagie high cycle with a TXVS 10” nozzle, over-the-top, 40 psi, 15 gpa, and a speed of 4.3 mph. The cotton height was 15-18” tall, and 12-14 nodes when the first application was sprayed. The temperature was 80 degrees Fahrenheit with winds at 0-3 mph and 35 percent relative humidity. The tall annual morningglory was at the 6 leaf stage and heavy in population.

The sixth study compared the Goal 4F and the Goal 2XL (*oxyfluorfen*) formulations for control of tall annual morningglory as a directed spray in BXN-47 cotton. The plot sizes were divided into 4-38” rows x 25’ with four replications. The first application of herbicides was applied July 25, 2002 using a Hagie high cycle with TXVS 10” nozzles, directed spray, 40 psi, 15 gpa, and a speed of 4 mph. The cotton height was 42” tall and 20 nodes when the application was sprayed. The temperature was 98 degrees Fahrenheit with winds at 0-3 mph and 47 percent relative humidity. The soil temperature was 88 degrees Fahrenheit. The tall annual morningglory was twinning up the plants.

Results and discussion

In the first study evaluating Roundup Weather Max *(MON78270)* with different tank mixes, all treatments gave less than fair control (39-58 percent) of tall annual morningglory initially at 14 DAT, but gave fair to good control (65-79 percent) of tall annual morningglory at 41 DAT. The second application was applied 27 days after the first application because adequate plant size was not yet achieved. The tall annual morningglory was very heavy in population when the second application was sprayed. There was no cotton injury on the first application, but the second application resulted in moderate cotton injury (0-50 percent) at the 41 DAT (Table 1).

The second study evaluated CGA 362622 with applications of different tank mix treatments. Directed sprays of CGA 362622 + Touchdown (*glyphosate*), CGA 362622 + Roundup Ultra Max (*glyphosate*), and CGA 362622 + MSMA (*mono sodium salt of methylarsonic acid*) gave acceptable control (75-80 percent) of tall annual morningglory at 13 DAT. The treatments sprayed over-the-top had no cotton injury, and the directed spray had low injury, 0-9 percent (Table 2, 3).

In the third study evaluating glyphosate formulations, all treatments gave fair control of tall annual morningglory at 14 DAT (65-75 percent) and at 41 DAT (68-79 percent). The second application was again applied 27 days after the first application due to the cotton being too small to spray. There was no cotton injury (Table 4).

The fourth study evaluated Shark, Valor, and Harvade with different tank mixes. The following treatments gave good control: Valor (70 percent), Valor + Roundup Ultra Max (80 percent), and Shark + Roundup Ultra Max (75 percent). Valor and Valor + Roundup Ultra Max had the highest cotton injury at 40 percent and 45 percent (Table 5). Injury may have been higher than normal since the tall annual morningglory was twining up the middle of the cotton. Further evaluations were not taken because the grower needed to over spray the trial with glyphosate.

The fifth study was to compare Goal 4F and 2XL for control of tall annual morningglory applied over-the-top of BXN-47 cotton. Buctril (*bromoxynil*) gave the best control of tall annual morningglory at 17 DAT (86 percent). Goal 2XL gave higher control of tall annual morningglory (60 percent) than Goal 4F (40 percent). Cotton injury was high (20-28 percent) with both formulations of Goal at 6 DAT, but the injury decreased by the 17 DAT (Table 6).

The sixth study was to compare the Goal 4F and the Goal 2XL formulations for control of tall annual morningglory using a directed spray. Goal 4F at 4oz. gave better control (76 percent) than Goal 2XL at 8 oz. (58 percent). Buctril (*bromoxynil*) gave the highest control of tall annual morningglory at 7 DAT (85 percent) but control was reduced at 14 DAT (63 percent) when another flush of tall annual morningglory emerged. Cotton injury symptoms were low (0-8 percent) at 7 DAT and disappeared at 14 DAT (Table 7).

Table 1. 2002 Roundup Weather Max (MON78270) Tank Mix Study for Control of Tall Annual Morningglory, Tulare Co

		A. Morningglory Percent Control		**Cotton Injury Percent**	
Treatment	Rate Product/A	**14 DAT**	**41 DAT**	**14 DAT**	**41 DAT**
1. Roundup Weather Max B. Roundup Weather Max + Direx	22 oz 22 oz + 16oz	44	70	0	30
2. Roundup Weather Max B. Roundup Weather Max	22 oz 22 oz	44	68	0	10
3. Roundup Weather Max B. Roundup Weather Max + Aim	22 oz 22 oz + 0.112 oz	58	65	0	13
4. Roundup Weather Max B. MON 78404	22 oz 31.8 oz	50	76	0	50
5. Roundup Weather Max B. Roundup Weather Max + Amplify	22 oz 22 oz + 0.016 oz	53	71	0	29
6. Roundup Weather Max B. Roundup Weather Max + Valor	22 oz 22 oz + 0.08 oz	56	74	0	29
7. Roundup Weather Max B. Roundup Weather Max + Valor	22 oz 22 oz + 0.144 oz	48	79	0	43
8. Roundup Weather Max B. Fire Power	22 oz 31.9 oz	49	69	0	14
9. Roundup Weather Max B. Roundup Weather Max + Strongarm	22 oz 22 oz + 0.032 oz	45	71	0	18
10. Roundup Weather Max B. Roundup Weather Max + CGA362622	22 oz 22 oz + 0.112 oz	49	75	0	0
11. Roundup Weather Max B. Roundup Weather Max + CGA362622	22 oz 22 oz + 0.0192 oz	48	70	0	13
12. Untreated	---	0	0	0	0
LSD .05	**---**	**20.04**	**8.80**	**-**	**-**
% CV	**---**	**31.32**	**9.22**	**-**	**-**

Table 2. **2002 CGA 632622 Tank Mix Study for Control of Tall Annual Morningglory- Over-the-top, Tulare Co.**

		A. Morningglory Percent Control		Cotton Injury Percent	
Treatment	**Rate Product/A**	**14 DAT**	**41 DAT**	**14 DAT**	**41 DAT**
1. CGA 362622	0.019 oz	16	50	0	0
2. CGA 362622 + Touchdown	0.02 oz + 2.6 pt	30	66	0	0
3. CGA 362622 + Roundup Ultra Max	0.02 oz + 1.6 pt	43	65	0	0
4. CGA 362622 + MSMA	0.02 oz + 2.4 pt	8	65	0	0

***All treatments received 0.25%v/v of Agridex**

Table 3. 2002 CGA 632622 Tank Mix Study for Control of Tall annual morningglory- Directed spray, Tulare Co.

		A. Morningglory Percent Control	**Cotton Injury Percent**
Treatment	**Rate Product/A**	**13 DAT**	**13 DAT**
1. CGA 362622	0.02 oz	75	8
2. CGA 362622 + Touchdown	0.02 oz + 2.6 pt	80	3
3. CGA 362622 + Roundup Ultra Max	0.02 oz + 1.6 pt	80	4
4. CGA 362622 + MSMA	0.02 oz + 2.4 pt	80	9
5. Untreated	---	0	0

***All treatments received 0.25%v/v of Agridex**

Table 4. 2002 Glyphosate Formulation Study for Control of Tall annual morningglory, Tulare Co.

		A. Morningglory Percent Control		Cotton Injury Percent	
Treatment	Rate Product/A	**14 DAT**	**41 DAT**	**14 DAT**	**41 DAT**
1. Touchdown IQ B. Touchdown IQ	2.6 pt 2.6 pt	66	78	0	0
2. Roundup Ultra Max B. Roundup Ultra Max	1.6 pt 1.6 pt	68	74	0	0
3. Glyphosate B. Glyphosate	2.0 pt 2.0 pt	74	73	0	0
4. Glyphomax B. Glyphomax	2.0 pt 2.0 pt	65	79	0	0
5. Clearout B. Clearout	2.6 pt 2.6 pt	73	68	0	0
6. Glyphos B. Glyphos	2.6 pt 2.6 pt	75	75	0	0
7. Untreated	---	0	0	0	0
LSD .05	**---**	**10.56**	**10.33**	**---**	**---**
% CV	**---**	**11.84**	**10.93**	**---**	**---**

***All treatments received 0.25%v/v of Agridex**

Table 5. 2002 Herbicide Tank Mix Study for Control of Tall Annual Morningglory, Tulare Co.

		A. Morningglory Percent Control	Cotton Injury Percent
Treatment	Rate Product/A	**13 DAT**	**13 DAT**
1. Shark	0.051 oz	58	16
2. Shark + MSMA	0.051 oz + 2.4 pt	65	13
3. Shark + Roundup Ultra Max	0.051 oz + 1.6 pt	75	23
4. Shark + Caparol	0.051 oz + 1.0 pt	58	15
5. Valor	0.157 oz	70	40
6. Valor + Roundup Ultra Max	0.157 oz + 1.6 pt	80	45
7. Harvade	7.8 oz	55	15
8. Untreated	---	0	0
LSD .05	**---**	**13.52**	**---**
% CV	**---**	**15.99**	**---**

***All treatments received 0.25%v/v of Agridex**

Table 6. 2002 Tall Annual Morningglory Control Study with Goal – Applied Over-the-Top, Tulare Co.

		A. Morningglory Percent Control		Cotton Injury Percent	
Treatment	Rate Product/A	**6 DAT**	**17 DAT**	**6 DAT**	**17 DAT**
1. Goal 4F	2 oz	31	38	23	2
2. Goal 4F	4 oz	32	40	20	2
3. Goal 4F	8 oz	37	43	27	4
4. Goal 4F	16 oz	33	40	28	4
5. Goal 2XL	2 oz	43	48	23	2
6. Goal 2XL	4 oz	55	64	20	2
7. Goal 2 XL	8 oz	60	62	28	3
8. Buctril 4EC	16 oz	85	86	0	0
LSD .05	**---**	**22.33**	**24.94**	**---**	**---**
%CV	**---**	**29.89**	**29.77**	**---**	**---**

Table 7. 2002 Tall Annual Morningglory Control Study with Goal – Directed Spray, Tulare Co.

		A. Morningglory Percent Control		Cotton Injury Percent	
Treatment	**Rate Product /A**	**7 DAT**	**14 DAT**	**7 DAT**	**14 DAT**
1. Goal 4F	2 oz	65	65	3	0
2. Goal 4F	4 oz	74	76	5	0
3. Goal 4F	8 oz	68	63	5	0
4. Goal 4F	16 oz	74	76	8	0
5. Goal 2XL	2 oz	44	51	0	0
6. Goal 2XL	4 oz	58	48	4	0
7. Goal 2XL	8 oz	66	58	5	0
8. Buctril 4EC	16 oz	85	63	0	0
LSD .05	**---**	**11.33**	**NS**	**---**	**---**
% CV	**---**	**11.58**	**28.27**	**---**	**---**

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Tuesday, January 21
Session A: Trees and Vines
Moderator: Ben Faber

AFFECTS OF SPRAY DRIFT ON TREES AND VINES

W. Thomas Lanini, Extension Weed Ecologist, University of California, Davis

Herbicide application through spray nozzles results in some herbicide droplets potentially moving off target, with droplet size being the most important factor influencing spray drift. In some cases, herbicide drift reaches nearby crops in concentrations sufficient to cause injury. The relative tolerance of adjoining crops to the herbicide being used, might be used to help set buffer zones needed to insure crop safety. In a series of field studies, we observed the response of grape vines and various tree species to simulated drift of herbicides commonly used for weed management.

The most common postemergence herbicides associated with drift are glyphosate (Roundup or Touchdown), oxyfluorfen (Goal), halosulfuron (Sandea or Sempra CA), sulfometuron (Oust), paraquat, or 2,4-D. Glyphosate blocks production of aromatic amino acid which leads to growth inhibition → chlorosis → necrosis → and finally plant death. Symptoms of glyphosate first appear in immature leaves and growing points. Glyphosate applied in the fall to young trees with green stems can be stored in the stems and symptoms appear the following spring when new leaves are emerging. When this occurs, internodes are often shortened and leaves yellowed - sometimes only one or a few branches are affected. Glyphosate drift onto established trees and vine crops causes a yellowing of the leaves, but internode length is not generally affected.

ALS type herbicides, such as Sandea, Oust, and Pursuit act by blocking production of branched chain amino acid, which leads to growth inhibition → chlorosis → necrosis → and plant death. Symptoms first seen in immature leaves and growing points. The pattern of yellowing is often blotchy. Like glyphosate, ALS herbicide symptoms can persist for a long period of time.

Growth regulator type herbicides, including 2,4-D and dicamba (Banvel), cause a twisting of stems → swelling at nodes → leaf cupping → leaf abnormalities→ and can result in crop death. When a growth regulator type herbicide is suspected of drift, check for twisting of the stems of any weeds in the field, as few broadleaf plants can escape without showing some symptoms.

Contact herbicides, such as paraquat (Gramoxone), disrupt cell membranes, which leads to chlorosis → necrosis. Injury is limited to exposed tissue, with no damage to later emerging tissue. Drift symptoms often appear as spots on leaves, with little or no long lasting effects.

Preemergence herbicides can also cause injury to trees and vines, although this injury is rarely the result of drift. In most instances, excessive rates of application for the soil conditions or adverse weather conditions can move the herbicide into the root zone of the crop.

Conclusions: Don't assume that abnormal crop growth is always herbicide injury – other factors such as disease, nutrient deficiencies, water stress, or adverse weather conditions can also cause injury similar to herbicide injury. Take pictures and compare symptoms to those observed on other plants. For pictures of common herbicide injury symptoms on crop plants, see the University of California, Weed Research and Information website at http://wric.ucdavis.edu/.

Effects of Mulches on Trees

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When mulch is placed under trees, there are a number of effects that can result in benefits to the tree's culture. In grove or orchard situations these benefits occur mostly on newly planted (young) trees where there is a large area of open ground. As the canopy of the growing trees close cover on exposed ground some of the effects of mulching are diminished. The same is true for landscapes but is harder to measure experimentally because of the diverse nature of landscaped areas. We believe however, that mulching where the ground would otherwise be bare, changes the entire environment around a tree. If mulching is continued, it will make significant long term changes to the soil under the tree and to tree growth rates.

When mulch is placed around row crops, it changes the reflected light quality and quantity that reaches the young plant canopy (Decoteau et al., 1990). In our work on sycamore we found that mulches significantly increased the amount of photosynthetically active radiation at canopy level compared to unmulched trees (data not shown). As tree canopy size increases this effect will diminish to zero. However, during early establishment, light reflection may play a role in increasing growth rates.

When mulch is applied to bare soil, it intercepts and slows the movement of water droplets emitted from micro sprinklers of from rainfall. This allows more time for the water to soak in and lessens runoff. In studies of newly planted avocado, we found that trees with mulch had zero runoff while trees without mulch had significant runoff during irrigations. This is partly due to slowing water movement and partly due to the physical changes made to soil by dissolved organic carbon. As mulch degrades and is brought into lower soil profiles by earthworms and other animals it is incorporated into soil polymers that bind soil in micro-aggregates (Martens and Frankenbeger, 1990; Tisdall and Oades, 1982). The result is a long noticed change in soil--more porous and open soil that has a greater infiltration rate (Stephenson and Shuster, 1945; Robinson, 1988 and Merwin et al. 1994). We observed this in a tensiometer study of water movement in an avocado orchard. Tensiometers under mulched trees responded faster than tensiometers at the same depth near unmulched trees. This is because the soil under mulched trees had a greater infiltration rate and water reached the porous cup of the tensiometer faster (figure 1). Rapid infiltration of water and greater water holding capacity result in more efficient utilization of water resources and reduced cost to growers and landscapers.

The particle size of mulches is important if they are to be effective as weed control barriers for annual weed seeds. We found that when a fine textured mulch (biosolids compost) is used, that weed seeds will soon land in it and grow there, but that coarsely chipped tree branch mulches (eucalyptus) or even composts of chips are used, that weed seeds will not germinate and grow in them (figure 2).

When mulches are applied for weed control, there is a threshold thickness of about 3.5" that will control most annual weed seeds (figure 3). If more mulch is applied there will be no greater control. However, in thick mulch applications the control will last longer. Mulch longevity is fairly predictable. Organic substrates such as yardwaste lose carbon at about 66%

by weight per year. This will be somewhat faster or slower depending on moisture and temperature at a given site. Mulch also disappears because of “loft” or fluffiness. If an application is put on at 6” depth, it may soon shrink to 5 or 4 inches without losing mass simply due to compaction. There appears to be little harm from applying thick layers of mulch, so it is best to apply a thick mulch layer. When mulch levels fall below 3.5 inches, annual weed seeds will start to emerge through the mulch. In thick mulches, we have often seen yellow nutsedge and bermudagrass as well as field bindweed. We have also seen eucalyptus and other tree species such as *Washingtonia* palm growing in yardwaste mulched soils. In some cases these emerged through mulch from underlying soil and in others they were brought in with the mulch. Thus, mulches are not a cure-all for weed problems but in the right situation they can control almost 100% of annual weeds.

One long sanding fallacy about wood chip mulches is that they draw nitrogen away from underlying soils thus depriving the tree from nutrition. Certainly “nitrogen draft” can occur when high C:N ratio substrates such as sawdust are **mixed** with soil. However, if mulches lay undisturbed on the soil’s surface and are broken down naturally by fungi and animals (earthworms) they will in fact contribute significant amounts of nitrogen to the soil. We found in a study of citrus that as deeper and deeper amounts of yardwaste mulch were applied, the levels of nutrients were significantly increased, especially total nitrogen. There is some concern that if excessive amounts of yardwaste are used, nitrogen may be oversupplied. Since all the elements found in plants are in mulch there is also a possibility of contributing toxic ions. Correlations of salinity with mulch depth were inconsistent; not significant in one analysis but significant in another (figures 5 and 6). Somewhat of a concern is the buildup of chloride and boron. While chloride will be lost through leaching events, the chemistry of boron is more troublesome and may indicate a problem in situations where thick mulches are applied to boron sensitive crops or ornamental plants in non-sandy soils.

In the final analysis, mulching with recycled yardwastes has benefits and detriments, but we believe that the advantages outweigh the disadvantages. Mulching is however, not a horticultural panacea for growers, it is a practice that requires knowledge and more not less monitoring of an orchard or landscape to ensure that quality plants are grown. The payback is reduced herbicide, water and fertilizer applications. There are also other benefits to mulching that we have not touched on here such as reduction of root diseases.

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Figure 1. Response of tensiometers to irrigation in mulched (circle) and unmulched (square) soils. Bars represent the standard error of 60 replicates. (adapted from Downer et.al. 2002)

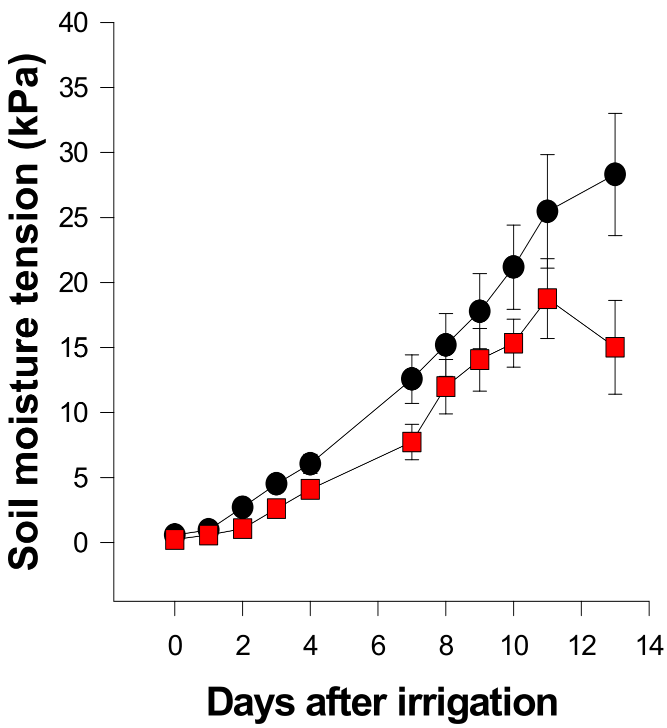


Figure 2. Bars represent percent cover in mulched plots. -mulch is unmulched; PB is pine bark; BC is biosolids compost; EC is composted *Eucalyptus cladocalyx*; FELC is fresh *Eucalyptus cladocalyx* large chips and; FESC is fresh *Eucalyptus cladocalyx* small chips. The two large bars are statistically different from other treatments but not from each other according to ANOVA and $LSD_{0.05}$.

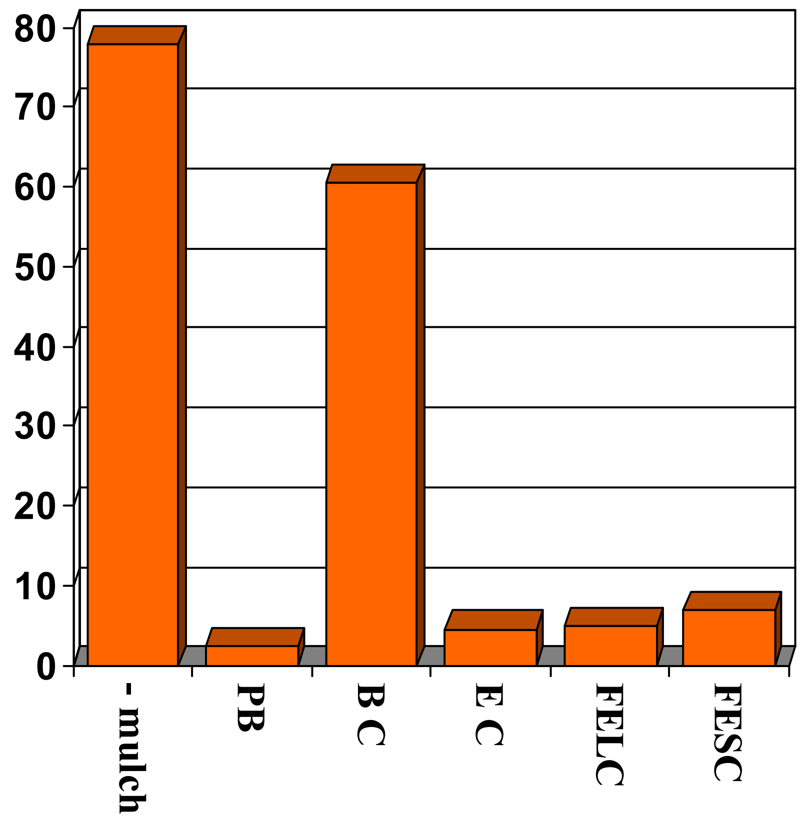


Figure 3. Weed seed germination in response to mulch thickness

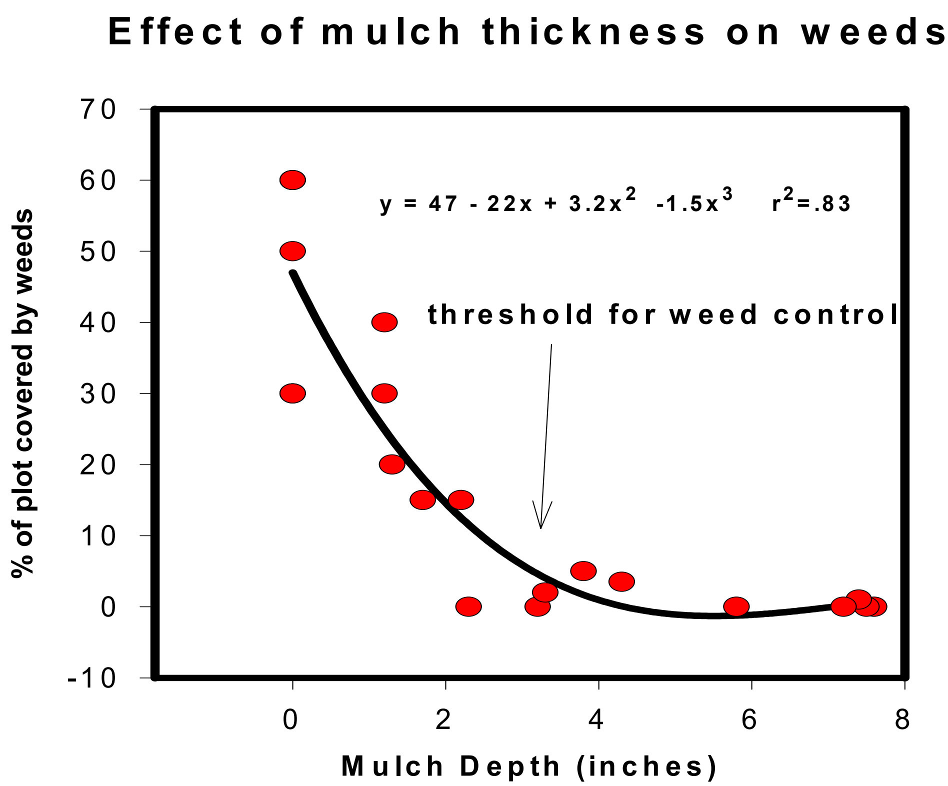
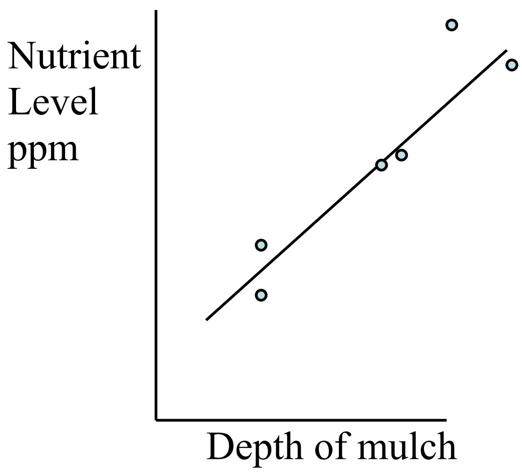


Figure 4. Relationship of nutritient level to depth of mulch application. P is the probability of a significant relationship at the ** 0.01 level.



measurement	r^2	p
EC	.129	NS
pH	-.336	**
Ca	.168	NS
Mg	.338	**
Na	-.028	NS
TKN	.918	**
P	.632	**

Figure 5. Nitrogen, phosphorus and potassium concentration in soils underlying: 0; 1; 3; or 6 inches of mulch. The bars within a cluster are significantly different according to ANOVA and $LSD_{0.05}$ if the letters are different..

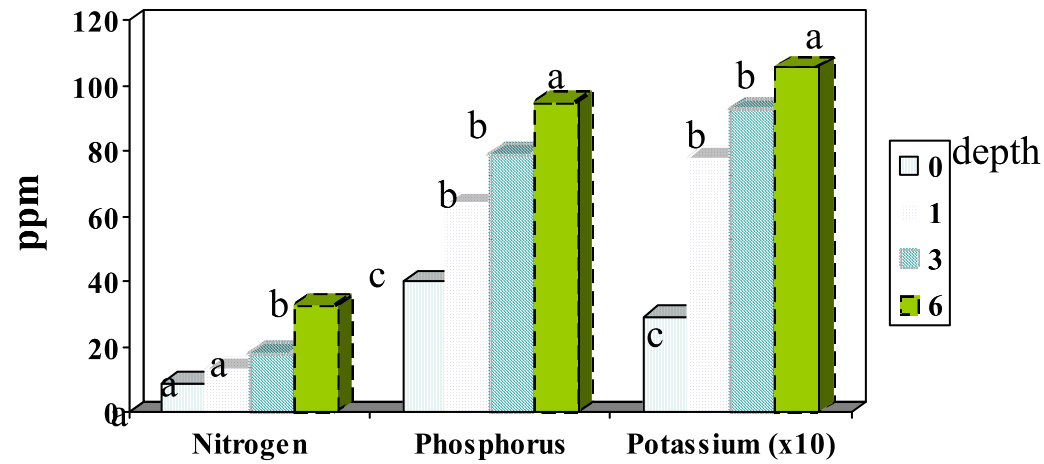
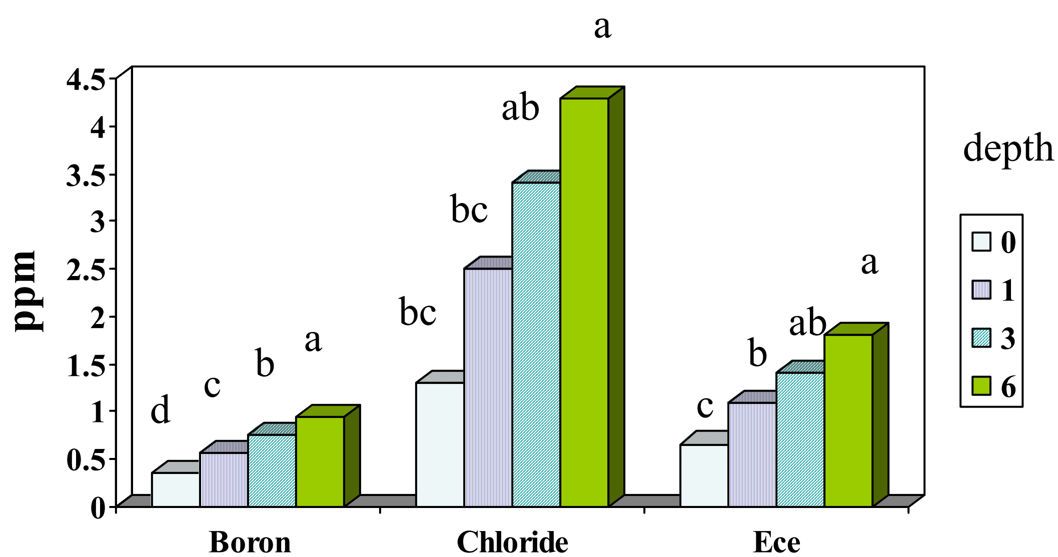


Figure 6. Effect of mulch depth on salinity and specific ions in soil profiles. Labels and statistics the same as in figure 5.



Clopyralid Problems in Mulch and Compost

John Karlik
University of California Cooperative Extension, Kern County

The composting process is expected to degrade chemical compounds produced by living organisms, such as complex carbohydrates, and also to degrade pesticides. In compost piles, high temperatures, microbial activity, and chemical processes such as hydrolysis cause breakdown of large organic molecules into simpler molecules.

Nevertheless, the herbicide clopyralid has been reported in compost in Washington state (Rynk 2002), the Pennsylvania State University (Houck and Burkhart 2001) and in compost made in San Diego County (Green 2001). Advances in analytical chemistry may allow detection of concentrations of a herbicide below those affecting plants. However, the concentrations of clopyralid reported from Washington (see Table), of 10-75 ppb at Penn State (Houck and Burkhart 2001) and 50-1500 ppb in San Diego (Green 2001) are sufficient to have herbicidal activity against sensitive plants. The herbicide was first detected in Washington because vegetable plants showed phytoxicity symptoms in gardens where city compost was used.

Clopyralid was introduced in 1975 as a selective postemergence herbicide for broadleaf weed control in grains and some broadleaved crops (Cremlyn 1991). It was first introduced for agricultural production, and is an effective material (Transline^{TM}) against the invasive exotic weed yellowstar thistle. It is also used for other broadleaf and thistle control (e.g. Canada thistle) in crops such as grass hay (Uhlar-Hefner 2002). Clopyralid has also been introduced into the lawn care market (Confront^{TM}, Millennium^{TM}) and from there apparently made its way into municpal compost.

Clopyralid is a pyridine derivative, with a six-membered aromatic ring of five carbon atoms and one nitrogen atom characteristic of pyridine-based compounds. A chemically similar compound is include picloram (Figure 1), one of the more persistent herbicides (Cremlyn 1991). The structure of clopyralid (Figure 2) is also similar to that of 2,4-D (Figure 3) and indeed clopyralid has the same mode-of-action, acting as an analog of the naturally occurring plant hormone indole-3-acetic acid (Figure 4). Clopyralid stimulates RNA synthesis and protein formation at low concentrations while inhibiting oxidative phosphorylation at high concentrations (Cremlyn 1991). The herbicide is quite water soluble, 1000 mg kg^{-1} (Farm Chemicals Handbook 1995) and is therefore mobile in soil It is active at the low rates of 50-400 g active ingredient per hectare (Cremlyn 1991), approximately equivalent to 3/4-5 oz per acre. Clopyralid shows activity against tomatoes and peppers at concentrations as low as 10 ppb (Rynk 2002). Most plants are not as sensitive to clopyralid as are these crops.

In general, pesticides currently marketed have short half-lives and do not persist in the environment as did many chemical compounds sold in the 1950's and 1960's, but clearly a range of persistence is still to be found. Because of the structure of clopyralid, specifically with regard to its aromatic ring subtended by two chlorine atoms, it is perhaps not surprising that this compound has been detected in compost. Because of its potency at low doses, again perhaps it is not surprising that clopyralid could be found to be injurious even at low levels after the composting process. However, the discovery of clopyralid residues in compost in several locations now negates the earlier generalization that pesticides are degraded to below-active levels through the composting process.

Table. Examples of clopyralid concentrations found in compost in Washington state (from Rynk 2002).

Compost material	Clopyralid concentration (ppb)
Mixed yard trimmings	25
Commercial yard waste	24
Mixed yard waste, immature compost	86
Mixed yard waste, mature compost	124
Leaves and grass	23

The discovery of clopyralid activity from compost is particularly significant in California because of the emphasis on greenwaste diversion from landfills to composting facilities. To conserve landfill space, the California legislature mandated diversion of at least 50% of the waste stream away from landfills by municpalities, and in Los Angeles about 2000 tons per day of leaves, brush and grass clippings are collected at curbside for composting (Green 2001). At Penn State, damage to plants occurred after about four weeks, suggesting short-term bioassays may not be adequate to assess herbicide presence (Houck and Burkhart 2001).

On April 11, 2002, Dow Agrosciences (Dow 2002) announced it was proceeding to discontinue registration of clopyralid for residential turf in California, and on June 26, 2002 extended this label change to the entire U.S. Professional applicators would have to notify property owners not to compost clippings from grass treated with the compound. Clopyralid would remain available for farm and ranch use.

Figure 1. Structure of picloram.

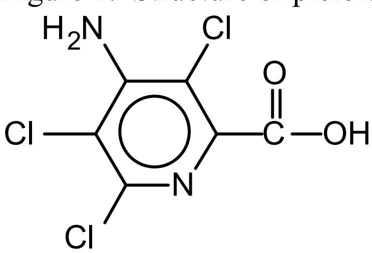


Figure 2. Structure of clopyralid.

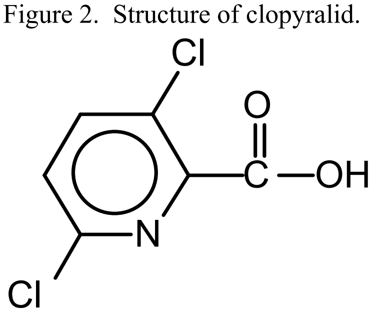


Figure 3. Structure of 2,4-D.

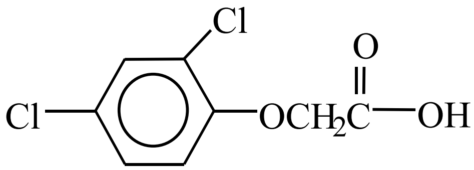
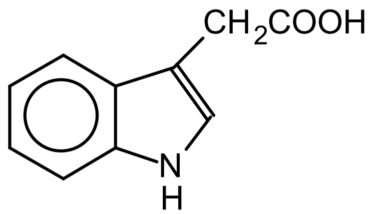


Figure 4. Structure of indole-3-acetic acid (IAA), a naturally occurring auxin.



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Factors Affecting Cost of Weed Management in Trees and Vines

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Managing weeds in orchard and vineyard settings is no easy task. No single weed control program will work for all growers or in all situations. In some cases, multiple strategies may need to be used over the life of the crop as weed types and populations change. Numerous factors can affect management decisions and costs for controlling weeds. Some important ones include, types of weeds, stage of weed growth, degree and length of control, availability of herbicides, equipment, labor, and cost. Cost of implementing various tools is often a driving factor behind the type of strategy employed. Growers and managers must weigh the risks associated with chemical and non-chemical options with the costs of using those techniques. In economic hardships, market value of a commodity may, in part, be a driving force behind the options used.

Regardless of the type of strategy employed, there are several steps that can be taken to help reduce overall costs associated with the selection and use of chemical and non-chemical tools. These steps include routine weed monitoring, proper sprayer calibration, accurate and timely applications, adjust the herbicide rate as needed, and eradicating perennial weeds before they become established.

Routinely monitoring fields for weeds will help you to determine the success of the current program strategy. It is inexpensive and does not add to the overall cost of control, but rather reduces it, allowing one to make adjustments to the program before problems arise. Weed surveys can easily show if current weed control measures need to be modified. The procedure is rather easy, requiring five steps: 1) walk several locations of the field every three months and identify any weed problems, 2) rate the weed infestation and record the findings, 3) note any new weeds, weed escapes, or a shift in the types of weeds, 4) map out areas of the field that are of particular concern, and 5) maintain the records in a file where they can be easily retrieved and updated.

It cannot be overemphasized how important it is to have a properly calibrated sprayer. Applying herbicides through spray equipment that is in proper working function and has been accurately calibrated will help insure the proper doses of herbicides are applied. This maximizes control and reduces unnecessary waste of product and resources, potential crop injury, down time, and contamination of the environment. Some herbicides, like halosulfuron methyl, require a low use rate (2/3 to 1 1/3 oz/acre), so it is critical that the proper dose of this and other herbicides be made. Replace or repair worn or damaged nozzles, hoses, pumps, and other parts that may contribute to poor or erratic spray discharge.

Herbicides should be applied uniformly and timely. Pre-emergence herbicides are applied before weed seeds germinate. Some weeds have prolonged or multiple germination periods and may require higher doses or split-applications for adequate residual control. Since winter and summer annual weeds germinate at different times of the year, it is important to understand the life cycle of weeds to better time pre-emergence sprays. Adjusting the timing of application to best meet the periods of weed seed germination will help maximize the effectiveness of control.

It is equally important to apply the spray to the soil in a manner that insures proper pattern overlap. This will help reduce overlapping or weedy streaks in the field.

Post-emergence herbicides must also be applied properly and in a timely manner. The weeds should be small (less than 4" tall), and the foliage should be thoroughly wetted for adequate control. This is especially true when using contact-type herbicides, like paraquat, diquat, and glufosinate. Consider adding a spray surfactant to the tank to control hairy weeds like hairy fleabane or cudweed. As weeds increase in size, it becomes more difficult to control them, even with higher rates of herbicides, so spray them when they are young and actively growing. For example, research by Tim Prather in 1999 showed that the hairy fleabane control was affected by growth stage and amount of glyphosate was applied (see table 1).

Table 1. Influence of growth stage of hairy fleabane on control with glyphosate

Hairy fleabane stage	Glyphosate (Lb ai/A)	Herbicide cost/A ($)
3 – 6 leaf	0.5	1.25
7 – 12 leaf	1.0	2.50
13 – 19 leaf	1.5	3.75
20 – 21 leaf	2.0	5.00
> 25 leaf	no control	NA

Timothy Prather, 1999

"Smart spray" applicators can be used to significantly reduce amount of herbicide needed and cost, by only applying post-emergence sprays where weeds are growing and not the bare soil. For example, using the Patchen Weed Seeker® to treat an orchard or vineyard berm that has a weed cover rating of 100%, would require 64 oz/acre of product (like glyphosate) if mixed at a rate of 2% by volume (25 gpa) and sprayed broadcast. A 20% and 5% weed cover rating would use 12.8 and 3.2oz/acre, respectively. Under this scenario, the herbicide cost (currently $40/gal) for the three treatments would be $5/A (64 oz), $1/A (12.8 oz), and $0.25/A (3.2 oz).

Controlling weeds mechanically (especially within the planted row) should also be done when weeds are less than four inches tall. Small-seeded broadleaves and grasses are fairly easy to dislodge from the soil when they are small, because they have not yet developed strong root systems. Most perennial weeds growing in the tree or vine row are not effectively controlled with in-row equipment. Johnsongrass, however, can be controlled in mature vineyards by using a French plow to remove the large underground rhizome segments from the row and brought to the row middles. There they can be disked and chopped into small segments, making control easier with pre- and/or post-emergence herbicides. An operation like this may run $100 or more per acre, but can provide effective control. Always adjust and operate the equipment as recommended by the manufacturer to improve the efficiency and effectiveness of control.

Herbicide labels usually show various rates that can be applied, depending on the type and stage of weeds present, soil type, and other factors. Use the lowest rate possible to control the spectrum of weeds that best describes your field. In some cases, lower doses of herbicides will provide equally effective control as higher rates, which can save money. Tank-mixing certain herbicides can also be an effective method of providing effective control while using reduced rates. For example, combining low rates of diuron and simazine can be an effective method of controlling a broad spectrum of weeds at a reduced cost, compared to either alone used at higher rates. These materials are inexpensive by themselves, and can be added with other herbicides to broaden control, without significantly increasing costs.

It is possible to reduce the number of pre-emergence sprays needed, depending on how clean the field is. By reducing the weed population in a field over time to a point where the ground appears nearly bare, spot treating with post-emergence sprays may be all that is needed to maintain control. Here, a pre-emergence treatment could be applied every third or fourth year as part of a maintenance program to maintain a low seed bank level. For this to work, it is important to prevent new weed seed from entering the field. This isn't always possible, however, since many weed species disseminate their seed by air and can readily invade a field.

Studies have been conducted comparing the cost of pre- and post-emergence herbicide programs to mechanical programs. In trials conducted in almonds from 1995 to 1998, it was determined that overall program costs were similar between the different management strategies tested (see table 2). It was noted however, that programs involving pre- and post-emergence herbicides resulted in a reduction in the total number of applications needed plus trips through the field, compared to a mechanical mowing program. This led to a significant reduction in the amount of time and labor needed to achieve control, freeing up labor to perform other tasks.

Deciding on whether to use mechanical means, pre- or post-emergence herbicides, or a combination of tools should be based on local conditions and cost of treatment. Tables 3 and 4 show some of the typical mechanical equipment and common herbicide costs used in orchards and vineyards, although specific prices may vary within the state. Weed control program costs vary greatly, depending on the growing region, cost of equipment and herbicides, personal preference of methods used, soil and field conditions, weed spectrum, desired degree of control, availability of equipment and labor, crop market price, and other factors. In other words, there is no one right answer. You should select the program that meets your specific needs.

Table 2. Accumulated costs for orchard floor management; January 1995 through August 1998

Treatment	Chemical Cost ($)	Application Cost ($)	Mowing Cost ($)	Total Cost/A ($)
Mechanical Mowing + preharvest Roundup	84 (5)*	25 (5)	149 (28)	258 (33)
Chemical Mowing w/Roundup, mechanical mowing, and preharvest Roundup	136 (11)	55 (11)	91 (17)	281 (28)
Low Residual w/Surflan + Roundup, mechanical mowing, and preharvest Roundup spot treatment	144 (9)	45 (9)	75 (14)	264 (23)

* (x) = total number of times the application or operations were conducted

J.H. Connell et al. 1999. CWSS Proceedings. 51:66-70.

Finally, it is advantageous to eradicate perennial weeds before their populations become "unmanageable". It is difficult, if not impossible, to put a price on the cost of eradicating tough perennial weeds (like purple or yellow nutsedge) once they become established throughout the field. The least expensive method of control is to keep them out in the first place. Don't allow them to produce seed or reproductive structures. Resources should be spent controlling them along field edges, roadsides, irrigation ditches and canals, and other locations, so that they don't get into your field. I believe the old adage goes "An ounce of prevention is worth a pound of cure". Once located within an orchard or vineyard, assign a person to stay on top of these areas and dedicate resources to eradicating it. It will take some time and resources, but far less compared to once they become established.

Simply comparing costs of the various chemical and non-chemical options available and making management decisions based solely on those costs does not lend itself to cost-effective weed management. The final strategy should be made based on taking into consideration all the information available and using that information for making smart, cost-effective decisions.

Table 3. Sample cost of different equipment used for weed control

Equipment	Tractor	Outlay Cost	Speed (MPH)	Operating Cost/Hr.	Labor Rate/Hr.*	Use in Hrs./A	Total Cost/A
Perfect In-row Mower	60 HP, 4WD	$8,500	1-2	$14.22	$12.70	1.38	$37.15
Kimco In-row Mower	60 HP, 4WD	9,000	1-2	14.22	12.70	1.38	37.15
Rears In-row Mower	60 HP, 4WD	2,500	1-2	14.22	12.70	1.38	37.15
Chris Grow Mower	60 HP, 4WD	8,000	3-4	31.22	12.70	0.80	35.14
Flail Mower	60 HP, 4WD	3,966	3-4	31.22	12.70	0.80	35.14
Hand-held Weed Eater	-----	225	---	6.75	12.70	9.00	175.05
Kimco In-row Tiller	60 HP, 4WD	11,000	1-2	22.53	12.70	1.38	48.62
L&H In-row Tiller	60 HP, 4WD	4,500	2.5	8.53	12.70	1.10	23.36
L&H In-row Hoe Plow	60 HP, 4WD	4,200	3-3.5	15.22	12.70	1.00	27.92
In-row Cultivator	60 HP, 4WD	4,222	2.5	14.22	12.70	1.10	29.61
Spader	60 HP 4WD	2,600	3	14.22	12.70	0.92	24.77
Disc, Offset 8’	60 HP, 4WD	9,410	3	11.97	12.70	0.92	22.70
Mulch Spreader	60 HP, 4WD	10,000	2-3	16.22	12.70	1.10	31.81
Propane Flamer	60 HP, 4WD	3,000	1-2	22.53	12.70	1.38	48.62
Steamer	60 HP, 4WD	4,000	1-2	22.53	12.70	1.38	48.62
Enviromist Sprayer	ATV	6,000	3	10.72	12.70	0.92	21.55
Patchen Weed Seeker	ATV	6,000	3	12.72	12.70	0.92	23.39
100-gal Weed Sprayer	60 HP, 4WD	3,404	3	19.22	12.70	0.92	29.37
50-gal Weed Sprayer	60 HP, 4WD	2,300	3-3.5	19.22	12.70	0.92	29.37

*Includes benefits, taxes, and miscellaneous expense paid by the grower

Table 4. Sample costs of various herbicides and combinations of herbicides

Pre-emergence Treatments	Lb a.i./A	Product/A	Cost ($)	Cost/A ($)*
Goal 2XL®	1.0	0.50 gal	96/gal	12.00
Goal 2XL® +	1.0	0.50 gal	96/gal	12.00
Surflan A.S. ®	4.0	1.00 gal	90/gal	22.50
				34.50
Princep Caliber 90® +	2.0	2.22 lb	3.20/lb	7.11
Surflan A.S. ®	2.0	0.50 gal	90/gal	11.25
				18.36

Post-emergence Treatments	Lb a.i./A	Product/A	Cost($)	Cost/A ($)*
Rely®	1.0	1.00 gal	65/gal	16.25
Touchdown®	1.0	0.33 gal	48/gal	3.96
Roundup Ultra®	1.0	0.25 gal	40/gal	2.50
Gramoxone Extra®	0.5	0.20 gal	39/gal	1.95
Sprayable Ammonium Sulfate	---	0.16 lb	18/lb	0.72

*Assumes treating a 3' berm on a row spacing of 12' in a vineyard; figures do not include cost of application

Selection and Effects of Cover Cropping in Vineyards and Orchards

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Many growers use or have tried cover crops to obtain economic or environmental benefits. Typical benefits include increased water penetration, reduced soil erosion and water runoff, improved accessibility on wet soils, addition of organic matter and nitrogen, and enhanced wine quality. Of course, there are also drawbacks to using cover crops, and the decision to plant them depends on whether the expected benefits outweigh the drawbacks. The main factors to consider when selecting a species or mix are tillage practices, irrigation method, nitrogen needs, frost concerns, erosion control needs, and costs.

Cover Crop Types

Annual Cover Crops

With tillage. Mixes that produce large amounts of biomass can be used to add organic matter to the soil. Although disking destroys organic matter, the periodic addition of organic matter enhances soil microbes, improving soil structure and nutrient cycling. High biomass mixes contain large seeds and are usually quite easy to grow. In general, they are sown each fall and disked in the spring as a "green manure" cover crop. Where furrow irrigation is used, they are disked before the soil dries excessively to enable the disk to penetrate the soil.

Pure legume blends are used to add a large – and potentially excessive to vineyards – amount of readily available nitrogen to the soil. Solid plantings of grasses, such as barley, oats, triticale, or cereal rye, are used to improve soil tilth and water penetration. Legume/grass blends provide some benefits of both. Typical blends often consist of bell beans, common vetch, peas, and oats or barley. Other common cereals include triticale and cereal rye. Barley/vetch or oat/vetch blends are fairly inexpensive and are frequently used.

Non-tillage. No-till cover crops provide firm footing during wet periods for harvest, spraying, and pruning. Some growers sow winter annual species that reseed and die in the spring and regenerate each fall – usually with rainfall alone. Such species and mixes include annual clovers, bur medic, 'Blando' bromegrass, and 'Zorro' fescue. If not properly managed or if allowed to become too weedy, in time these species will simply become minor components of the ground cover. Periodic replanting every three or four years, if desired, can ensure dominance by these species and build the seed bank.

Bur medic is well adapted to California's climate and grows well in neutral to high-pH soils; it is occasionally a major component of resident vegetation. It effectively reseeds even under fairly close mowing and, because of its high percentage of hard seed, it usually reestablishes well even when tillage is used. Commercial varieties of bur medic are spineless. Subterranean clover, or subclover, usually performs best in acid to neutral soils. Many subclover cultivars are available that have been planted for feed on California rangeland; consult with a local UC rangeland Farm Advisor for those best adapted to your area. Rose clover does well under dry conditions, such as rocky soils and terraces. Crimson clover produces considerable biomass and very attractive red flowers.' 'Blando' brome and 'Zorro' fescue, are popular low-growing grasses that are often used in monoculture for erosion control. They germinate easily and reseed themselves each year. 'Blando brome' is cheaper than 'Zorro' fescue.

Perennial Cover Crops

Perennial grasses and legumes provide a permanent cover that offers year-round traction. Perennial clovers, such as white and strawberry, are low growing and add nitrogen, but are invasive and can strongly compete with vines for water. Birdsfoot trefoil, a legume, is slow to establish but forms a dense cover. Vigorous, summer-active perennial grasses, such as perennial ryegrass and tall fescue, devigorate vines and should only be planted where vigor is excessive or where soils are deep and fertile.

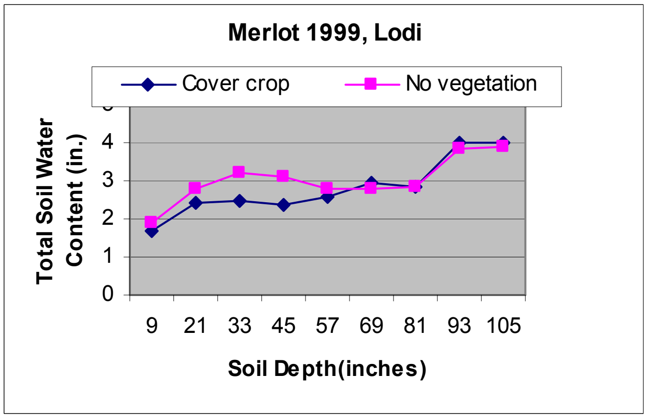
California native perennial grasses are increasing in popularity in some regions. The most popular species are California brome (*Bromus carinatus*), blue wild rye (*Elymus glaucus*), meadow barley (*Hordeum brachyantherum*), and California barley (*Hordeum californicum*), but many other species are being tested and used. Many native grasses are very vigorous and may compete excessively with trees or vines during the spring. In drip-irrigated vineyards in drier regions, these grasses will almost completely shut down growth during the summer, and thus offer little competition with trees or vines. In cooler coastal regions, native grasses can continue to grow and compete with vines through the summer. The seed is quite expensive initially, but is inexpensive over the life of the cover crop.

Recent Research on Cover Crops in Vineyards

Devigoration of Vines

Cover crops, particularly those that grow actively year-round or through late spring, can devigorate vines. Devigoration can be desirable with vigorous vines on rich valley soils, although it can lower yields excessively and damage vines. The use of species that grow actively in late spring, such as native perennial grasses or ryegrass, can potentially reduce shoot growth and improve red wine quality of vigorous vines with little reduction of yield, as long as adequate summer irrigation is provided. However, very little research has been conducted to test the effects of cover crop management practices on wine quality. Some growers have used cover crops in this way and have improved wine quality, only to find that vine vigor and yield declined excessively after two or three years.

Cover Cropping as Component of a Deficit Irrigation Program. Research in a Lodi vineyard has shown that moderate pre-veraison water stress can improve red wine quality (T. Prichard and P Verdegaal, unpublished data). On soils that can hold enough soil moisture to prevent water stress until after veraison, cover crops can help deplete the soil profile by bringing on water stress earlier, thus helping to reduce vegetative growth. In a mature, drip-irrigated Merlot vineyard, a cover crop of annual ryegrass reduced soil moisture at budbreak by nearly 2 in. over the 105-in. soil depth during the third year of the experiment (see figure). Most of the differences occurred within the top 48 in. In 1999 there was about 14 in. of winter rainfall.



In this trial, a comparison was made between cover crop vs. no cover crop in a standard deficit treatment. The irrigation regime for both was non-irrigation until the vines reached -13 bars leaf water potential (stress) then irrigated weekly using 60% of the full vine water requirement. This irrigation regime resulted in about 18 in. of vine water use for both treatments, of which 7 in. was applied as irrigation. Vine shoot growth was significantly reduced in the cover crop treatment, with a maximum shoot length reduction of 15% in June and July.

Harvest dates, sugar content, and juice pH were very similar. The malate (malic acid) content of the juice was significantly reduced in the cover crop (1600 vs. 2125 ppm) owing to less vegetative growth and more light to the fruit. This in turn resulted in a lower titratable acidity (4.8 vs. 8.4 g/L), of which malic acid is a component. Titratable acidity of the wine was much higher in the cover crop than the control due to the fermentation of the higher malic acid in the control. The wine color intensity was significantly higher in the cover crop wine at all measured spectrums. Hue was also improved.

Cover crops grow very actively in the spring, using soil moisture in proportion to their biomass and ambient warmth. Therefore, the larger and later a cover crop grows, the more water it uses, and the rate of water use can be regulated by choosing low biomass species and/or by mowing or tilling in the spring. The annual ryegrass used above is a vigorous, late-maturing cover crop that died out in late spring due to lack of water, before it reseeded. This species would likely resemble several tall-growing perennial grasses in its water use. Another key factor in water use is the width of the herbicide (or cultivated) strip: the closer the cover crop grows to the vine row, the greater the competition with the vines for water and nutrients. Water use (and costs and frost hazard) can also be reduced by sowing alternate rows.

Cover Cropping and Nitrogen Cycling. Annual legume cover crops can be a valuable source of nitrogen for vines. Nitrogen is released rapidly through decomposition of leaf litter from the legume hay after mowing and/or tilling. Over time, soil productivity will also be enhanced. In a vineyard, the use of a cover crop mix that includes legumes could mean that most if not the entire annual grapevine N demand can be met.

The effectiveness of cover crops as a source of nitrogen depends on the timing of nitrogen release from the cover crop, which must coincide with the period of nitrogen uptake and use by the grapevine. One critical period when cover crop N is needed by the vines is during rapid shoot growth and early fruit set. Research in a drip irrigated vineyard in Sacramento County has shown that the N content of vine leaves increased by 15 to 20% in the first 2 to 4 weeks after either mowing or tilling (R. Smith, A. Patrick, and A.M. Berry, unpublished data).

Using natural isotopes of N as tracers, the N derived from the cover crop accounted for 20 to 30% of the leaf N.

Effects on the vineyard ecosystem. In a Sacramento County vineyard study, four cover crop mixes were compared for three years in a drip-irrigated Merlot vineyard with 7 x 11 ft. spacing (C. Ingels, K. Scow, and D. Whisson, unpublished data). The treatments were: 1) California native perennial grass mix, 2) bell bean/ vetch/pea mix, 3) barley/oat mix, 4) reseeding annual clover mix, and 5) disked control. Total soil microbial biomass was greater in the two nontillage treatments (native grass & clover mixes) than in disked cover crop treatments, the disked control, and the non-tilled berm, each of which had similar microbial biomass.

To evaluate gopher activity, each cover crop treatment block in the study was divided into 350 "cells." Each cell comprised the area between vines and rows. In January, February and March 1999, we searched each cell for signs of pocket gophers (fresh mounds and feed holes). The far majority (>85%) of the sign each month was recorded in the clover treatment. With pocket gophers exhibiting such a preference for clover, it was not possible to determine the relative preference of other cover crops to pocket gophers in the absence of clover. It is therefore likely that pocket gophers would switch to a different cover if clover weren't present.

The native grass mix is relatively slow in getting started, so weeds were present in the first year, but far fewer weeds were present in years 2 and 3. On the contrary, the reseeding annual clover mix had the fewest weeds in year 1, but by the third year, this treatment had far more weeds than the other treatments. However, weeds are not a great concern in orchards and vineyards because they can simply be mowed as resident vegetation.

There were no differences in yield or juice quality during the 3 years of the study. To evaluate wine quality, small wine lots were made from 50 lbs. of grapes and the wine was blind-tasted by 11 individuals. Each taster was asked to rank the five wines based on their personal preference. None of the tasters rated the disked control wine first in preference, and this wine was found by some tasters to be noticeably thin and out of balance.

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Session B: Industrial and Aquatics
Moderator: Chuck Synold, Target Specialty Products

Situation Report on the Invasion of California by Non-Native Plant Species

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Non-crop areas represent the majority of the land surface of the state, with forestlands, rangelands, and scrublands totaling 70% of the surface area of California. Wetlands, riparian areas, and water surfaces make up an additional 8%. Thus, the threat of invasive species in California's wildland can be significant.

Of the more than 1100 non-native species that are naturalized in California, the vast majority of them (81%) are in non-agricultural areas. Among this large number only about 16% are considered significant problems. Though some species are well established and recognizable, including yellow starthistle (*Centaurea solstitialis*), Russian thistle (*Salsola tragus*), perennial pepperweed (*Lepidium latifolium*), and medusahead (*Taeniatherum caput-medusae*), others are just beginning to expand their range and become more troublesome. Among these species, often referred to as Red Alert species, include stinkwort (*Dittrichia graveolens*), rattlebush (*Sesbania punicea*) which is also known as scarlet wisteria tree, onionweed (*Asphodelus fistulosus*), Geraldton carnationweed (*Euphorbia terracina*), and perennial veldtgrass (*Ehrharta calycina*).

Stinkwort is an erect, fall-flowering, aromatic annual with sticky glandular-hairy foliage and flower heads that consist of short yellow ray flowers and yellow to reddish disk flowers. Stinkwort is native to Europe and is related to the cudweeds (*Gnaphalium* spp.), but more closely resembles plants in the tarweed group (*Holocarpha, Hemizonia*). Stinkwort is not included in most California floras, and inhabits disturbed places, roadsides, pastures, fields, riparian woodlands, levees, washes, and margins of tidal marshes primarily in the San Francisco Bay region, especially the southern portion. It is also found sporadically in San Diego and near Sacramento and is expanding its range very rapidly.

Rattlebush is a deciduous shrub or small tree with even-pinnate compound leaves and red to orange-red pea-like flowers. It is grown as an ornamental in many countries, but has escaped cultivation and invaded riparian areas and other moist habitats in South Africa, the southern U.S., particularly Georgia and Florida, and California. Foliage, flowers, and especially immature seeds contain sesbanimides and saponins and are toxic to humans and animals when ingested. A dose of less than 0.1% of body weight in seeds ingested over a period of days can be lethal to livestock. Rattlebush was introduced from South America and is found in California in the southern Sacramento Valley, San Joaquin Valley, and southern North Coast Ranges.

Onionweed is native to southern Europe, but in California is a troublesome annual or short-lived perennial with thick tuber-like stem bases, slender grass-like leaves. Unlike onions, it lacks the characteristic onion or garlic scent when crushed. In pastures and on rangeland, onionweed is avoided by livestock and can develop dense populations that exclude grasses and other desirable forage species. It is a government-listed noxious weed in Australia, where it is most problematic on pastureland in the southern areas. It is found primarily along the South Coast and southern San Joaquin Valley in fields, pastures, roadsides, coastal dunes, agronomic crops, and other disturbed places, especially those with sparse vegetation.

Geraldton carnationweed is an uncommon, but potentially noxious perennial or biennial. It often forms dense patches and inhabits disturbed areas, including disturbed grasslands, coastal bluffs, dunes, salt marsh, riparian areas, and oak woodlands in the South Coast. It was only recently introduced from southern Europe and the Mediterranean.

Perennial veldtgrass is a densely tufted cool season perennial. Although it is native to South Africa, it was imported to California from Australia in the late 1920's as a potential forage grass and was later utilized for erosion control. Since then, it has escaped cultivation in some areas and is rapidly invading dunes and scrublands along the Central Coast. It is found in coastal habitats from central to southern California, including dunes, scrub, chaparral, live oak woodlands, disturbed grasslands, roadsides, and other disturbed places, typically on sandy, well-drained soils.

Although there is very little information on the control of these newly expanding invasives, information on the biology, ecology and management of many other invasives is available in a number of sources. The California Exotic Pest Plant Council (CalEPPC) book entitled "Invasive Plants of California's Wildland" (caleppc.org) provides not only biological and historical information, but also control options. The new publication of "Aquatic and Riparian Weeds of the West" serves as a source of information for the identification of 175 species associated with aquatic sites. Internet sources of information are also available on invasive species biology and management. Perhaps the most useful are the CDFA Encycloweedia website (pi.cdfa.ca.gov/weedinfo), the CalEPPC website (caleppc.org) which includes the entire "Invasive Plants of California's Wildland" book in electronic form, The Nature Conservancy Wildland Invasive Species website (tncweeds.ucdavis.edu/esadocs.html), and the Weed Research and Information Center website (wric.ucdavis.edu).

Other new developments pertinent to invasive plants in California include the addition of eight new species to the California Department of Food and Agriculture state Noxious Weed List. These new additions are Malta starthistle (tocalote) (*Centaurea melitensis*), Spanish broom (*Spartium junceum*), giant reed (*Arundo donax*), Cape ivy (*Delairea odorata*), jubatagrass (*Cortaderia jubata*), saltcedar and tamarisk species (*Tamarix* spp.), tree-of-heaven (*Ailanthus altissima*), and bull thistle (*Cirsium vulgare*). All have been placed in the C list. In addition, CalEPPC has developed a new criteria for evaluating established invasive plant species through a series of questions associated with the impacts, invasive potential and distribution of each species. This will ultimately lead to the publication of a new scientifically defensible list of "Invasive Non-Native Plants that Threaten Wildlands" which should be completed in late 2003 or early 2004. The list will rank species by categories that include High, Moderate, Low invasiveness, with a Red Alert subsection within High and Moderate categories.

Despite the increase in funding opportunities expected at the federal level with the passage of Senate Bill 198, CDFA has been required to cut their weed management budget by about $1,500,000. Consequently, the status of California Weed Management Areas is not certain in the next couple of years. Despite these cuts, CDFA is moving forward with the development of the California Weed Action Plan which should be completed in late 2003.

In other developments over the past couple of years, some new herbicides targeting invasive plant species have been registered in California. In the late 1990s, clopyralid became available primarily for the control of yellow starthistle. Around the same time, imazapyr was registered in the state for control of many invasive woody species. In 2003, chlorsulfuron will be registered for use in rangelands. This will provide a very effective solution for the control of perennial pepperweed and other invasive broadleaf species. In 2004, it is expected that imazapic will be registered for use in California. This is likely to play a key role in the control of noxious annual grasses.

Biological control programs for invasive plants continues with most of the effort concentrating on yellow starthistle, Cape ivy and *Tamarix* spp. The release of a pathogen for yellow starthistle control was approved for the 2003 season. This rust species, *Puccinia jaceae*, will be tested in trials by USDA and CDFA scientists and is hoped to provide an additional stress on yellow starthistle that will reduce its aggressiveness and spread. Several insects are currently under quarantine for the potential control of Cape ivy. These include a leaf-feeding moth (*Diota rostrata*), gall forming fly (*Parafreutreta regalis*), and leaf mining and stem boring moth (*Acrolepia* new species). Results look promising, particularly with the leaf-feeding moth. It has been two years since the release of the saltcedar leaf beetle (*Diorhabda elongata*). Initially it was released under cages, but in 2002, the cages were removed and the beetles were allowed to spread on their own. At one site in Lovelock, Nevada, the beetles have been very effecting in defoliating a large patch of saltcedar. It is not known whether this will continue to prove successful in subsequent years, but scientists are closely monitoring the site.

Many positive changes have occurred in recent years in education, control, and funding efforts on invasive plants in California. These efforts are expected to continue as the impact of invasive plants becomes a higher priority at the federal, state, and county level.

A Decade of Change and Its Effects on the Vegetation Management Landscape

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Habitat restoration and the protection of native habitats have taken on increased importance in the 1990s. Farmers, ranchers, and land resource managers are more concerned with maintaining natural landscapes, greenbelts to conserve beneficial insects, and concentrating on controlling invasive weeds. Ironically, environmentalists trying to save and restore native habitats are battling other environmentalists over herbicide use and animal rights; and are having to navigate the very regulatory maze which they helped create.

Joseph Sexton was a prominent farmer and nurseryman in Santa Barbara County in the late 1800s. Among his many accomplishments include the creation of the Santa Barbara soft shell walnut from which many of today's walnut varieties are descended. The palm trees lining Cabrillo Boulevard, planted in 1893, were from the Sexton Nursery. Joseph Sexton, however, is also famous or perhaps infamous for being the "pampas grass king."

In 1872, Joseph Sexton, began experimenting with pampas grass for cut flower production. Pampas grass had originally been introduced to California by sailors of clipper ships around the time of the Gold Rush. Sexton found that by removing the sheath from immature plumes and letting them dry in the sun, the plumes from the female plant would become fluffy white and durable, while the plumes from the male plant would dry stiff and hang heavily. He earned fifty cents each for his first shipment of a few plumes to the San Francisco flower market.

By 1889, he was producing over half a million plumes a year from 5,000 plants at his San Jose Creek ranch. The plumes were mainly used to decorate horses in military and funeral parades in Europe as an alternative to the more expensive, (and traumatizing for the ostrich), ostrich feather. Sexton received $200 per thousand plumes for his first shipment. Production increased and prices fell to $30 per thousand, but a boom year in 1888 saw prices as high as $60 per thousand. However as the 20th Century approached, the ostrich feather and pampas plume fad fell off and the pampas grass plume industry expired.

Unfortunately, pampas grass is still being sold in nurseries[7]. Gardeners buy it for its fountain-like growth habit, the showy plumes and wind break feature. The plant growth traits desired by Joseph Sexton and horticulturists in general – rapid growth, high seed production, ease of growth, etc. – are the same traits of a successful weed. Hence, pampas grass and other invasive ornamental plants, such as fountain grass, ice plant, and English ivy, have spread far beyond the boundaries of the home garden.

In 1990, Greg Archbald, then the Director of Volunteer Development for the Golden Gate National Recreation Area, was alarmed by the proliferation of invasive exotic weeds like French broom, gorse, freeway daisy, and pampas grass in natural areas of the San Francisco Bay Area.

[7] Carloyn Martus, a Cal-EPPC member in Carlsbad, California was able to convince Wal-Mart to discontinue the sale of pampas grass in California. In late November 2002, Linda Prendergast, the company's horticultural buyer for Wal-Mart stores west of the Rockies, removed pampas grass from the list of plants available to the one hundred Wal-Mart stores in California. Once current stock in stores is gone, pampas grass will no longer be sold by Wal-Mart in California.

Over lunch at the 17th Annual Natural Areas Association Conference in Concord, California, Greg along with other far sighted individuals like John Randall, Carla Bossard, and George Molnar, saw that invasive exotic plants were displacing native plants and creating flood and fire hazards in many native ecosystems throughout California, but there wasn't any central place to obtain information on biology and management, public awareness was very low, and there wasn't any government infrastructure to assist with this issue on natural areas.

George Molnar's presence was serendipitous as he had just moved to California from Florida where he was instrumental in the formation, in 1985, of the Exotic Pest Plant Council there. Already in the five years since its founding, the Florida Exotic Pest Plant Council had many significant achievements in the protection of native habitats from invasion by exotic weeds in Florida. Florida's EPPC board of directors had recently authorized the creation of new chapters and agreed to assist chapter organizational efforts.

In December of 1991, Greg and his new friends invited a number of botanists working in the invasive weeds field to an exploratory meeting in Tiburon, California. There they planned a symposium to bring together California's leading academic experts, non-profit and public agency personnel, and concerned citizens to present lectures and have discussion groups on the issue of invasive plants.

The symposium was held in Morro Bay on October 9, 1992. The 200 or so attendees were asked if they would like to form a new, professionally based organization to provide a regular forum for the exchange of ideas, promote research and funding, enhance public awareness, and advocate effective solutions for the invasive weeds problem. The attendees responded affirmatively and thus, the California Exotic Pest Plant Council was born to eventually incorporate as an independent non-profit organization. CalEPPC has since become the authoritative source of new information on all aspects of wildland weed management in California.

Up until the mid 1980s, the Santa Barbara County Agricultural Commissioner's Office was heavily involved in weed management. We had an 800 gallon weed sprayer, contracts with the state department of transportation to assist them with the control of roadside weeds, and staff devoted to the control of noxious weeds such as Johnson's grass and yellow starthistle. A popular duty in our office was to share a ride on the cattle barge, enduring pitching seas and the smell of cow pies, to spend a week on Santa Rosa Island surveying and controlling yellowspine thistle. Then, on June 6, 1978 the Jarvis-Gann Initiative, Proposition 13, was passed and significantly reduced property taxes. It took a few years for the passage of the initiative to directly affect us, but in response to the resulting loss of revenue, our department sold our weed sprayer, eliminated our weed and vertebrate management program, and shifted personnel to other funded priorities. The response was similar in other counties in California.

Through the 1990s, the Santa Barbara County Agricultural Commissioner's Office did not have a budget to spend on preventing the spread of lower rated noxious weeds in the County. (We did still pay attention to the control of "A" rated noxious weeds, with the assistance of the CDFA.) However, in 1998, because of the efforts of an extraordinary alliance of ranchers and environmentalists, money was brought back to weed management programs through the establishment of weed management areas. Assembly Bill 1168 was the first bill to kick off weed management area funding. That bill was spurred on by El Niño rains and the ranching community's outcry for yellow starthistle control. The California Exotic Pest Plant Council, California Native Plant Society and the Nature Conservancy also supported the bill. In September of 2000, Senate Bill 1740, sponsored by the Regional Council of Rural Counties, appropriated 5 million dollars more for the fight against noxious weeds.[8]

With money supplied by Senate Bill 1740, the Santa Barbara County Agricultural Commissioner's Office with the assistance of Darlene Chirman and the Santa Barbara chapter of the Audubon Society formed the Santa Barbara County Weed Management Area in the winter of 2000. Various public agencies, land resource managers, and agricultural associations were invited to help develop a strategic plan and memorandum of understanding. Fortuitously, Greg Archbald had retired to Santa Barbara County and was very helpful in the development of the plan and MOU.

Previous to the formation of the Weed Management Area, the Agricultural Commissioner's Office was primarily concerned with agricultural noxious weeds. Now as part of the WMA coalition, we chose to target three noxious weeds – yellow starthistle (*Centaurea solstitialis*) which clearly presents problems for rangeland agriculture as well as natural areas, *Arundo donax*, a weed of riparian areas, and the pampas grasses (*Cortaderia selloana* and *C. jubata*), which are primarily pests of coastal wildlands. Yellow starthistle is designated a "C" rated noxious weed by the California Department of Food and Agriculture. Arundo and jubata grass (*C. jubata*) have recently been nominated for addition to the CDFA's noxious weed list. Native habitat advocates attempted to get *Cortaderia selloana* added to the list, but the regulations prevent the designation of any species as a noxious weed if that designation would be detrimental to agriculture.

Ironically, the Santa Barbara County Weed Management Area's first project, the removal of pampas grass on Ward Drive, is next door to the historic Sexton House and Nursery. With a backhoe and shovels, we removed over 80 tons of pampas grass from the area, which is also adjacent to the Goleta Slough. The project is a companion project to the work of the Goleta Slough Management Committee. Formed in 1991, the Committee has been gradually removing non-native plants from and restoring the Slough. We hope to convince managers at the Pacifica Suites Hotel, the current owners of the Sexton House, to let us remove the remaining 5 or so pampas grass plants found on the Sexton House grounds.

Despite the good intentions of native habitat restoration projects, they do not always proceed without controversy. In response to high coliform bacterial counts discovered on Santa Barbara beaches, especially after it rains, 70 % of Santa Barbara voters voted for a 2% increase in the hotel bed tax to fund a clean water program. The tax increase raised nearly 2 million dollars in the first year. The City of Santa Barbara created a Creeks Restoration/Water Quality Program.

A component of the Creeks Program is the restoration of Old Mission Creek. Their goal for the restoration of riparian and aquatic habitat is to improve water quality through natural filtration and stabilize the banks to reduce erosion and sedimentation. In the summer of 2002,

[8] Unfortunately, the financial forecast may become gloomy again, as recent budget cuts in the California Department of Food and Agriculture have impacted the department's weed management program hardest. Of the requested 1 million dollars of cuts that the CDFA had to make, $750,000 came out of the department's biological control, vertebrate control and weed eradication programs

the City obtained approval for a restoration project in the natural riparian areas of Bohnett Park. Their plan is to remove non-native ornamental trees, like eucalyptus, palms, and figs, and replace them with native species. A perennial city council speaker and west side activist questioned the wisdom, to the council and in letters to the local newspaper, of removing fully grown, specimen ornamental trees and replacing them with less grand, sapling size willows and cottonwoods.

Other citizens and the editors of the Santa Barbara News Press have also expressed their discontent with recent restoration attempts. An August 2002 letter to the editor expressed dismay at the arrogance of National Park Service biologists who have determined which species should be allowed to live on the Channel Islands. The letter writer called restoration projects a "crazy invasive species scam", questioned the support for the "pseudoscience of nativism", and claimed that big chemical companies are behind the "scam" in order to sell more chemicals. His plea to CalTrans and the Park Service: "Pick up the litter and leave the fennel alone."

Ironically, we and other habitat restorationists are finding that we have to navigate the same regulatory maze which we helped create as environmentalists, and in the case of the Agricultural Commissioner's Office, which we help enforce.

Arundo is a fast growing weed, up to 4 inches a day, of riparian areas in California. While it was once planted intentionally for erosion control, (which it does not do well), it is now despised as a detriment to native habitats. The Weed Management Area has obtained approval to remove arundo from a portion of Arroyo Burro Creek in Santa Barbara. But it wasn't easy.

The benefits of arundo removal outweigh the impacts to the system, but it took a little prodding to get a city official to put that down in writing so that we could proceed with obtaining a streambed alteration permit. Additionally, the city's regulations required that we get approval from their Architectural Board of Review. While they did allow us to consolidate nine applications into one, that review required a fee of $576, despite that our project will be working, free of charge to the city, on city property, for the benefit of the city.

Technology, culture, economics, and the environment impact the way we manage weeds. Change is unrelenting. Those of us who are newly involved in wildland invasive species management must be prepared for those changes. Are you ready?

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Out-of-the-Box Thinking and New Tools for Aquatic Plant Management

Shaun M. Hyde and Mike Netherland
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The weed control methods aquatic plant managers utilize are categorized into mechanical, physical, biological and chemical approaches. When assessing chemical control options, managers are limited to six US EPA registered aquatic herbicides; fluridone, diquat, endotholl, 2-4.d, copper complexes, and glyphosate. In 2003, triclopyr will be the seventh chemistry registered by US EPA for aquatic use and the first since 1986. With a limited bag of tools to select from, the most successful aquatic plant management programs have included some "out-of-the-box" thinking and the incorporation of new technologies in order to reach management goals. These out-of-the-box approaches and tools include; 1) developing new applications techniques using existing herbicides 2) development of improved herbicide formulations to fit challenging treatment sites, 3) incorporating new aquatic plant management technologies.

1) Implementing a new application approach with current herbicide formulations can provide successful control in otherwise challenging situations. The technique of sequential treatments of contact herbicides, Nautique and acrolein, have improved the ability to maintain control of hornded pondeweed in Idaho irrigation canals. Sonar AS ™ treatments conducted in static irriation canals, during post irriation periods of October/November, have resulted in a significant decrease in sago pondweed biomass the following season in California irrigation canals. The use of impermeable isolation barriers in Lake Shoecraft, Washington has proven successful in the eradication of Eurasian watermilfoil using the aquatic herbicide Sonar AS in a unique partial lake application technique.

2) SePRO Corporation has developed two new Sonar formulations to improve the efficacy of difficult to control plants and in challenging water systems. Experiments conducted by SePRO and research cooperators demonstrated the impacts of differing Sonar formulation and lake sediments have on the actual release profile and residence time of Sonar. Sonar Precision Release ™ pellets have improved treatment programs in areas with organic substrate, with potential for dilution in partial lake applications and in flowing water sites. Sonar Quick Release™ pellets are designed provide an accelerated release of Sonar compared to other pellets formulations. The Sonar Q pellets immediately expand as they enter the water and continue to release an accelerated level Sonar as they remain on top of soft organic sediments. The improvements to the Sonar formulations have provided aquatic plant managers with more efficient treatment options and improved the ability to systemically control weeds with Sonar.

3) *How do we document and monitor herbicide residues during and after treatments?* FasTEST ™ immunoassay provides rapid laboratory analysis of water samples to determine Sonar and Renovate residues during and following a treatment program. *How can we selectively control an exotic species while minimizing the impacts to desired vegetation?* The use of two new plant assays can improve the ability too successful manage and monitor aquatic plant control programs. PlanTEST ™ is a pre-treatment aquatic plant bioassay that determines the susceptibility of plants in a given area to be treated with Sonar. EffecTEST™ is an aquatic plant biochemical sampling test which allows one to monitor the level of Sonar injury of the treated plants and make adjustments during a treatment program.

The use of Geographical Information System (GIS) and Global Positioning Systems (GPS) mapping technologies have enhanced the success of aquatic plant management programs. The use of hydroacustics mapping systems will improve the ability to accurately measure water volumes, accurately apply aquatic herbicides, monitoring pre-treatment and post-treatment plant biomass and provide a means of documenting changes in plant populations overtime.

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Session C: Turf and Ornamentals
Santa Ynez Room
Moderators: Cheryl Wilen, Area IPM Advisor, University of California Cooperative Extension and Michelle Le Strange, Farm Advisor, University of California Cooperative Extension

Landscape Herbicides: What Happens after Application?

Jay Gan[1], Cheryl Wilen[2] and Dennis Pittenger[1]
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[2]UC Statewide Integrated Pest Management Program & UCCE San Diego County

Abstract

Recent monitoring studies show that the majority of urban streams in the U.S. are contaminated by pesticides, and the contamination is primarily a result of urban runoff. Implementation of risk-reduction measures, however, is hampered by the lack of an understanding of the interaction of urban landscape planting systems with pesticide behavior. We investigated the effect of landscape plantings on the persistence of two commonly used herbicides, 2,4-D and dicamba. The herbicides exhibited greatly different persistence in the different planting systems. In the 0-10 cm surface layer, the half-life of 2,4-D was 31 days in soil under trees, which was about 20 times longer than in soil planted with turfgrass (1.6 days). The half-life of dicamba was much longer in soil under a tree canopy (149 days) than in a mulched soil (7.9 days).

This study suggests that landscape planting practices can modify the chemical and biological activities of soil, which in turn may affect pesticide persistence and hence the runoff potential. Such information may be used for developing landscape systems that are resistant to pesticide runoff, thus alleviating water quality impact by pesticides used by homeowners.

Introduction

In the United States home lawns occupy 20-25 million acres. The total area of environmental horticulture in California was estimated to be 1.4 million acres. Residential landscapes serve as the direct target of pesticides applied to home lawns and gardens and the first-tier buffer for pesticides applied to structures. However, pesticide use in residential settings has apparently led to contamination of urban streams. For example, surveys by the U.S. Geological Survey (USGS) have shown that 99% of the tested urban streams contain at least one pesticide, with 70% containing 5 or more pesticides (*1*). The presence of pesticides at trace levels may cause short or long-term impairments to aquatic ecosystems, such as toxicity to aquatic organisms (*2*). Runoff of pesticides resulted in the establishment of diazinon and chlorpyrifos TMDLs for San Diego Creek in Orange County, CA (*3*).

Currently little is known about the behavior of pesticides in the heterogeneous residential landscapes. Because pesticide movement in urban settings is driven by stormflow, the runoff potential is related to pesticide persistence. Planting practices can modify a soil's chemical and biological properties. The objectives of this study were to evaluate the interaction of planting with soil chemical and microbial reactivity, and the effect on the persistence of two common herbicides, 2.4-D and dicamba. The results from this study may be used for identifying high-risk landscape systems, and for developing practices to reduce pesticide runoff to urban streams.

Experimental Procedures

Soils: Soil samples were collected from a field located at the Agricultural Experiment Station on the campus of University of California in Riverside, CA. The field consisted of plots with different planting covers that were established in 1995. The soil was a Hanford fine sandy loam. The planting systems included Bradford pear tree, "shortcut" tall fescue grass, mulches (chipped tree branches and leaves), and a low growing ground cover. Soil was collected from the 0-10 cm layer using a hand auger. Chemical and physical properties of these soils are shown in **Table 1**.

Table 1. Selected properties of soils for the various landscape systems

Soil	OM (%)	Clay (%)	Silt (%)	Sand (%)	CEC (meg/100g)	pH
	Surface soil (0-10 cm)					
Tree	0.35	10	24	66	6.3	5.4
Grass	0.82	9	24	67	7.7	6.7
Ground cover	1.16	8	26	66	8.4	6.3
Mulch	1.95	8	24	68	10.7	6.9

Degradation Experiments: Degradation of 2,4-D and dicamba in the different landscape soils was determined by incubating spiked soil samples at 20ºC. The initial soil water content was 8% (w/w). The initial herbicide concentration was 2.0 ppm. At different times after treatment, replicate samples were removed and extracted with methanol. Analysis of 2,4-D and dicamba was carried out by HPLC.

Enumeration of Herbicide Degraders: In a separate experiment, the population density of 2,4-D degrading microorganisms was determined in the surface soils using the most probable number (MPN) method (*4*).

Results and Discussion

Effect of Planting on Soil Organic Matter Content: The different planting covers over a period of about six years caused significant differences in soil organic matter content (OM) (**Table 1**). While the OM in the soil from the tree plots remained essentially unchanged, soils from the turfgrass, ground cover, and mulch plots showed 170, 280, and 550% increases over the original level, respectively. Because soil organic matter plays a critical role in soil microbial ecology and hence in the degradation of many contaminants, it may be expected that 2,4-D and dicamba would be degraded at different rates in the different soils.

2,4-D Persistence: Significantly different degradation patterns were observed among the different soils (**Table 2**). The most rapid degradation occurred in the turfgrass soil, the half-life of 2,4-D was only 1.6 days (d). The half-life in the ground cover (3.9 d) or mulched soil (3.7 d) was slightly longer. The half-life of 2,4-D in the tree soil, at 30 d, was the longest among all the soils. The persistence of 2,4-D therefore followed an order of tree soil > ground cover soil ≈ mulch soil > turfgrass soil. It may be envisioned that if a rain storm occurred following 2,4-D treatment, the potential for the herbicide to move in storm runoff would increase in the order of turfgrass soil < mulch soil ≈ ground cover soil < tree soil.

Table 2. Rate constants and half-lives of 2,4-D in various landscape soils

Soil	k (day^{-1})	$T_{1/2}$ (day)	R
	Surface (0-10 cm)		
Tree	0.0226	30.7	0.97
Grass	0.4256	1.6	0.97
Mulch	0.1851	3.7	0.96
Ground cover	0.1798	3.9	0.99

- *Mitigation implication* 1: With its large biomass and dense, fibrous root system and its ability to quickly degrade 2,4-D, turfgrass may likely act as a "filter" for 2,4-D and similar pesticides. Grassed strips may therefore be placed on the border of residential landscapes to reduce pesticide runoff.
- *Mitigation implication 2:* Conversely, 2,4-D applied to exposed soil surfaces such as in areas around trees or bushes may be highly susceptible to runoff, and pesticide application in these areas should be avoided when possible.

Dicamba Persistence: In the surface soils, the fastest degradation occurred in the mulched soil, which was followed by the ground cover soil and then the turfgrass soil (**Table 3**). The half-life of dicamba in the turfgrass, mulch and ground cover soils ranged from 7.9 to 19.6 d, which was much longer than that for 2,4-D in the same soils (1.6-3.9 d). The overall ranking of dicamba persistence was tree soil > turfgrass soil > ground cover soil > mulch soil. This order was different from that for 2,4-D, indicating that there were different predominant factors in the degradation of 2,4-D and dicamba in the landscape soils.

Table 3. Rate constants and half-lives of dicamba in various landscape soils

Soil	K (day^{-1})	$T_{1/2}$ (day)	R
	Surface (0-10 cm)		
Tree	0.0047	147	0.95
Grass	0.0354	19.6	0.99
Mulch	0.0873	7.9	0.98
Ground cover	0.0620	11.2	0.98

- *Mitigation implication 3:* The much longer persistence in the tree soil suggests again that dicamba applied on exposed soil such as in the area around trees or bushes may represent an increased runoff risk and such applications should be discouraged.

- *Mitigation implication 4:* The overall longer persistence of dicamba than 2,4-D implies that different pesticides may have different runoff risks. The use of persistent products should be reduced or avoided during the raining season when surface runoff is more frequent.

Role of Soil Chemical and Microbial Reactivity: Excellent correlation was found between the degradation rate of dicamba and soil OM (R = 0.98). This dependence suggests that the different plant covers altered soil OM and hence the degradability of dicamba. The population of 2,4-D degrading microorganisms was estimated to be 2,300, 230,000, 49,000, and 13,000 cells g^{-1} soil. Regression analysis showed that there was a linear relationship between the number of 2,4-D degraders in the soil and the degradation rate constant k (d^{-1}) (R = 0.94). This suggests that the different plant practices played a selective role in soil microbial ecology, which led to the different degradability of 2,4-D.

Conclusions

Different planting types or practices drastically modified soil chemical and microbial properties. These changes consequently caused the landscaped soils to degrade these herbicides at different rates. Of all the landscape systems tested, herbicide persistence was consistently prolonged in the soil around trees that was low in both organic matter content and herbicide-degraders. Therefore, high runoff risks may be expected in such landscape systems.

The knowledge of high or low-risk planting systems or practices may be used by city planners, developers, landscape architects, and professional landscapers for designing landscapes that are resistant to pesticide runoff. The same information may be also used for education of the general public (e.g., homeowners) that may lead to reduced or guided pesticide use in residential landscapes.

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Wholesale Nursery Practices that Minimize Environmental Impact

Gene Arthur, Bordiers Nursery, Somis, CA

Environmental Evaluation Review

Areas that may be affected by runoff irrigation

I. Neighboring fields and crops

II. Protected wildlife zones

III. Streambeds, creeks and rivers

IV. Residential neighborhoods

Possible contaminates in nursery runoff

I. Nutriments including fertilizers and minerals

II. Pesticides

III. Silt and other secondary pollutants

Regulatory Agencies

I. State Fish and Game Departments

II. Environmental Protection Agency

III. Regional Water Quality Boards

IV. City, County and all other governing agencies

Physical Improvements to Reduce Irrigation Runoff

A. Engineering and design to minimize runoff

B. Proper irrigation design and installation

C. Recycling systems

D. Silt collection facilities

E. Bio-filtering zones

Cultural Improvements and Best Management Practices

A. Irrigation management

I. Timing and volume of irrigation cycles

II. Crop usage

III. Testing of runoff irrigation

B. Pesticide Management

I. Selection of products with minimal environmental impact

II. Timing of applications

III. Post-application irrigation and rainfall

IV. Ongoing review of efficiency and movement of pesticides

Weeds as Indicators of Environmental Conditions

Cheryl A. Wilen, Area Integrated Pest Management Advisor
UC Cooperative Extension and UC Statewide IPM Program

We sometimes forget that weeds are just plants and certain plants are well adapted to where they grow. For example, azaleas grow best in acid soils and iceplant grows best in full sun. Just as these well-known landscape plants have a set of optimal environmental conditions for their growth, so do weeds. In fact, one of the characteristics of certain weeds that make them successful competitors or invaders is that they can grow well under conditions that desirable plants do not, and over time, can take over a landscape bed or a turfgrass area.

Weeds can be classified as 'generalists,' which are plants that have enough phenotypic plasticity that they can adapt to a wide range of environmental conditions, or 'specialists,' plants that are well adapted to localized environmental conditions. A good example of a generalist is annual bluegrass. Annual bluegrass will grow up to about 6-8 inches if not mowed and will readily produce seed heads. However, under mowed condition, it will change its growth habit by adapting to the condition and producing seed heads lower than the mower blade. In very low mown areas such as golf greens, the seed heads are almost prostrate. This is in contrast to species which do not have much phenotypic plasticity such as common sowthistle. Mowing annual sowthistle, before seeds are formed is an acceptable method of control and one reason why it is only rarely found as a weed in turfgrass.

On the other hand, specialists are well adapted to certain conditions and usually become weeds not because they crowd out other desirable species but because the other species cannot grow well under the given environmental conditions. An example of a specialist is prostrate knotweed. This plant is often the only one growing in compacted areas such as dirt paths or around picnic tables. Prostrate knotweed has adapted to grow under these conditions and desired species, such as turfgrass, has not.

In order to manage weeds, one should be aware of the conditions that favor their growth. Soil fertility, soil moisture, compaction and other physical and chemical environmental conditions can be modified to reduce the conditions that would favor weed growth. The chart on the following page can be used to help determine why certain weeds are prevalent in landscape and turf areas. A caveat to using this chart is one should be aware that there may be locally adapted species that have been selected to grow in the local environment but these adaptations may not apply to the population in general. Another point to consider is that finding one or a few plants in an area does not necessarily mean that *the entire area* is compacted or has poor drainage or has another environmental condition conducive to that species' growth.

Table 1: Potential environmental conditions indicated by weed populations

	Dry soil	Wet soil	Compacted soil	Low N	High N	Low mowing	Thin turf or newly seeded	Shade	High pH (alkaline)	Low pH (acid)	High salt	High organic matter	Low organic matter
Annual bluegrass		X	X		X	X		X					
Bentgrass		X			X	X				X			
Bermudagrass			X		X								
Black medic	X			X									
Broadleaf plantain			X	X					X				
Chickweeds		X	X		X	X	X	X	X			X	
Clovers			X	X		X							
Crabgrass		X	X			X	X						
Dallisgrass		X				X							
English daisy										X			
Goosegrass	X	X	X										
Liverwort		X											
Mallow					X	X							
Moss		X	X		X	X		X		X			
Nettles										X			
Nutsedge		X											
Pearlwort		X				X							
Pineappleweed			X				X						
Prostrate knotweed	X		X							X			
Purslane					X		X						
Russian thistle											X		X
Ryegrass		X	X			X							
Sedges		X											
Shepherdspurse									X		X		
Sowthistle		X			X								
Spurge (prostrate)	X		X	X		X							
Wild carrot		X											
Woodsorrel (Oxalis)	X	X			X								
Yarrow	X			X									

A New Generation of Golf Course Weed Management

David L. Wienecke, United States Golf Association, Green Section, Southwest Region

The last several years have shown tremendous innovation and change in golf course weed management. Some highpoints of recent developments include the following:

Management of Poa annua encroachment on putting greens has experienced a revolution over the last several years due to the use of turf growth regulators such as Primo (trinexepac-ethyl) and Proxy (ethephon).

Kikuyugrass (Pennisetum clandestinum) has gone from being a noxious weed to being a highly desirable grass on many coastal influenced golf courses. In addition, the spring of 2002 brought the new registration in California of Drive (quinclorac). As a result we now have a very effective and safe selective herbicide for removing kikuyugrass from bermudagrass.

Overseeding of cool season grasses including as Roughstalk bluegrass (Poa trivialis) and Perennial ryegrass (Lolium perenne) into warm season bermudagrass (Cynodon dactylon) continues to present unique weed and turf management challenges for golf course managers. New research is providing us with new uses for selective herbicide especially for the sulfonylurea herbicides.

Poa annua putting green management using turf growth regulators

Poa annua is one of the most prevalent grass species in the world. In golf course management, if the turf is fertilized and irrigated, the question is not if but when Poa annua encroachment will occur. Historically research focused on finding selective herbicides for managing Poa annua encroachment. Selective herbicide use has not proven successful due to the stressed condition of the extremely low mowed putting surface turfgrasses. Every selective herbicide attempt has resulted in phytotoxic results to all monocot species growing on the putting green. In addition the disruptive cultivation practices of vertical mowing, core aeration, and sand topdressing required for producing firm smooth putting surfaces has proven ideal for spreading Poa annua seeds.

Over the past 20 years many herbicides, fungicides, and even bacteria have been used with little success. Most recently ethofumesate (Prograss), mefluidide (Embark), paclobutrazol (Trimmit), endothal, and Rubigan (fenarimol) were used. With the registration in California of the turf growth regulators trinexepac-ethyl (June, 2002), and ethephon (November, 2000), the tools are now available for eliminating the texture and smoothness degradation problems of Poa annua encroachment and have allowed turf managers for the first time to grow the former weed grass as an outstanding turf.

Primo (trinexapac-ethyl) is a turf growth regulator (TGR) first researched as a tool for roadside bermudagrass vegetation management. While the research results were promising, it has not been used for roadside vegetation management. Historically turfgrass TGR use has focused on labor savings achieved from reduced mowing frequency in golf course management. Trinexapac-ethyl has shown dramatic results for many turfgrasses including Poa annua by significantly increasing turf density and decreasing leaf texture. This combination is ideal for producing a smooth even textured putting surface thus reducing the negative effects of creeping bentgrass and Poa annua polystands. Frequent application at low rates (1/16 oz/1,000 square feet every two weeks or 1/8 oz/1,000 square feet every four weeks) has resulted in TGR effects lasting from two to eight weeks depending on local growing conditions.

Proxy (ethephon) is TGR that significantly reduces seed initiation and growth of the Poa annua plant. Application of this product eliminates a major symptom of this plants weed encroachment by eliminating putting surface irregularity caused by the seed heads. Application of ethephon at 5 oz/1,000 square feet will stop seed head initiation and development when applied prior to seedhead development and will stop development if application follows seed initiation. Seed head suppression will last from three to four weeks depending on local growing conditions.

Kikuyugrass Management

Kikuyugrass (Pennisetum clandestinum) once regulated as a noxious weed is now a highly desirable grass on many coastal influenced golf courses. Fine tuning management procedures to optimize kikuyugrass competitiveness including the use of manganese sulfate to manage Take All Patch disease (Gaeumannomyces graminis var. avenae), TGR such as Primo, and proper cultural procedures have resulted in good quality golf turf.

For those who want to selectively remove kikuyugrass from bermudagrass, the spring of 2002 brought the new registration in California of the dinitroanaline herbicide Drive (quinclorac). As a result we now have a very effective and safe selective herbicide for removing kikuyugrass. Results spring and summer, 2002 showed very good kikuyugrass suppression within ten days of quinclorac application and bermudagrass regrowing into kikuyugrass suppressed areas within two to four weeks of quinclorac application. Quinclorac is absorbed by the foliage and roots and translocated throughout the plant. Use of methylated seed oil adjuvant is recommended to aid in plant absorption of the herbicide.

Effective selective preemergence control of goosegrass (Eleusine indica) and early postemergence control of crabgrass (Digitaria sanguinalis) have also been shown with quinclorac. Best results are achieved by tank mixes with other dinitroanaline products for residual control such as pendimethalin (Pendulum) or prodiamine (Barricade).

Sulfonylurea Herbicides Used for Selective Grass Management

Overseeding of cool season grasses including as Roughstalk bluegrass (Poa trivialis) and Perennial ryegrass (Lolium perenne) into warm season bermudagrass (Cynodon dactylon) continues to present unique weed and turf management challenges for golf course managers. Recent research with sulfonylurea herbicides including TranXit (rimsulfuron), Corsair and Telar (chlorsulfuron), and Manor (metsulfuron-methyl) are providing some promise as future weed management options in overseeded golf course conditions.

Successful overseeding of golf courses requires growing two crops of turfgrass each year since the overseeded grass is a cool season species and the base grass is a warm season species. Cool autumn temperatures cause the warm season grass to go dormant thus allowing the overseeded cool season grass to be competitive during winter months. In spring and summer, many golf courses find the perennial ryegrass persists during spring and summer creating objectionable polystands and reducing bermudagrass competitive vigor throughout the summer months. Cultural practices to encourage bermudagrass competitiveness have not been successful. Research in Arizona and California is being done with sulfonylurea herbicides to provide selective removal of the perennial ryegrass.

These sulfonylurea herbicides have extremely low animal toxicity, but are highly phytotoxic to susceptible weeds at low rates. The mode of action of these herbicides is to inhibit the production of valine, leucine, and isoleucine. These amino acids are used by plants to make proteins of which many serve as enzymes that catalyze various biochemical reactions in plants. When amino acid synthesis is prevented, key enzymes are not produced and the weed slowly dies over a one to three week period. This slow phytotoxic reaction is ideal for minimizing perennial ryegrass turf death during the summer bermudagrass transition minimizing visible sign of the herbicide activity.

Experimentation is now attempting to define optimal application timing and rates for successful selective herbicidal use of these products.

Using Grass Control Products in Ornamental Plantings

Jason Fausey, Research and Development Specialist
Valent U.S.A. Corporation, Walnut Creek, California

With the vast diversity in ornamental species, ornamental landscape plantings are one of the most difficult areas to control weeds. Weeds are commonly defined as plants growing out of place, and effective weed control programs in ornamental plantings are limited. There are many benefits to controlling weeds, especially grasses, in ornamental plantings as they reduce yield and the aesthetic value of the landscape. Weeds are often the number one cost in maintaining an ornamental planting and can threaten the health and welfare of others if not properly maintained.

Preventative, cultural, mechanical, biological and chemical weed control methods must be utilized in ornamental plantings to develop a successful and complete weed management system. One often assumes that hand weeding is the only option once grasses become established in a desired planting. In some cases this is true, but in others the use of a selective grass herbicide can be more efficacious and cost effective than alternatives such as hand weeding.

During the early 1970's two classes of chemistry, Aryloxyphenoxypropionates and Cyclohexendiones were discovered that effectively control emerged grasses while having no effect on broadleaf plants. These postemergence grass herbicides provided a new means for weed control in ornamental plantings. Up to this point in time, herbicides for use in ornamentals only displayed activity against weeds before they emerged or only controlled emerged broadleaf weeds.

Aryloxyphenoxypropionate and Cyclohexendione herbicides selectively control grasses by inhibiting lipid biosynthesis. Specifically, the site of herbicidal activity in sensitive grass species is the enzyme acetyl-CoA (ACCase) in the stroma of plastids. Interestingly, due to the presence of a non-receptive ACCase enzyme, broadleaf plants tolerate applications of these herbicides.

The discovery and subsequent labeling of postemergence grass control products for use in ornamentals is one of the most dynamic tools developed for the ornamental industry in the last 30 years. These compounds display the ability to safely and effectively control grasses growing in a planting of mixed ornamental species.

Session D: Agronmoic Crops
San Rafael Room
Moderators: Steve Orloff, County Director, Farm Advisor, University of California Cooperative Extension and Tome Martin-Duvall, SRA-University of California Cooperative Extension

Agronomic Practices That Influence Herbicide Use

Herman S. Meister, Agronomy Farm Advisor
University of California Cooperative Extension
Imperial County, California

The basis of this presentation is to emphasize the growing of a *healthy and competitive* crop through careful *planning and management* of all the farming operations to reduce the need and expense of herbicides.

The question then becomes when does "planning " start? Is it at planting, or at listing, or at pre-flood? It actually starts when a farmer decides what crop he can grow to make a profit. Then he must choose fields within his farm complex or lease fields that are appropriate for the crop.

Some of the considerations important in this weed management strategy are choice of field based on soil types and salinity, field preparation, cultural aspects, irrigation, nutrition, field sanitation, records and history, weed resistance, and application techniques.

This approach expands the IPM concept to where the PCA and grower are communicating early in the planning stages about what crops to grow and where based on *all* the information available to them concerning various pest problems and growing techniques. Farmers need to realize how their growing decisions and practices affect their PCA's ability to provide him with the best service possible.

Raptor, A New Herbicide FOR ALFALFA Weed Control

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Farm Advisors, University of California Cooperative Extension, San Joaquin, Siskiyou, Madera, and Fresno Counties, respectively

Introduction

Weed control is generally the first major decision to be made once alfalfa has germinated. Managing weeds in a timely manner is necessary to provide maximum production of high quality alfalfa hay. A poor weed management decision can lead to stand loss, poor quality hay, unacceptable weed control, alfalfa injury and a loss of money.

Weeds compete with alfalfa seedlings for water, nutrients, and light. They retard seedling growth, impede root development, lower hay quality, and reduce the alfalfa yield. Weed free alfalfa improves quality, improves harvest efficiency by speeding the drying and baling time, expands marketing opportunities and commands higher prices. The presence of poisonous weeds such as Common groundsel *Senecio vulgaris*, Coast fiddleneck *Amsinckia intermedia,* Nightshade *Solanum,* and Poison hemlock C*onium maculatum* further reduce the value or make it completely unmarketable. Today, the economic incentive to produce supreme quality hay is substantial; weed free alfalfa is one important step to insure that profitability. Developing a new alfalfa field without weeds pays dividends from the beginning and continues throughout the life of the stand.

Controlling weeds effectively begins well in advance of herbicide use. Herbicides are considered an integral part of a total weed manage system that compliment cultural approaches. Herbicides are applied to 75% of newly planted alfalfa in California.[2]. To minimize weed problems requires an integrated approach of crop rotations to reduce weeds and diseases, properly leveled fields to avoid standing water and drainage problems, soil amendments and a balanced fertilizer program will promote vigorous growth; together these are all important in maintaining a weed free field. Selecting a variety with good pest resistance will also ensure a stronger alfalfa plant to compete with weeds. Once weeds are present, proper identification of seedling weeds is essential for choosing the correct herbicide. The "Growers Weed Identification Handbook" is a good resource to identify the agricultural weeds of California. It is a university publication available through county cooperative extension offices, or online at: http://anrcatalog.ucdavis.edu.

[2]California Department of Pesticide Regulation Data Summary 2001

RAPTOR A NEW HERBICIDE

Imazamox is a new herbicide marketed by BASF Corporation under the name of Raptor® that is registered for use in alfalfa to control broadleaf and grassy weeds. Raptor is in the same chemical family as Pursuit and will become a primary herbicide choice for alfalfa growers in years to come.

Raptor is a *Selective* postemergence herbicide that can be applied to seedling alfalfa, which has reached the two trifoliolate leaf stage, and weeds 1-3" in size. It can also be applied to established alfalfa at any time for postemergence control. When applied between cuttings, harvest must be delayed for 20 days. When used in alfalfa seed production the pre-harvest interval is 70 days. Research across many locations in the state with Raptor has demonstrated the effective control of broadleaf and grassy weeds in alfalfa and the increase of forage quality. (Figure 1,2,3)

Many are familiar with Pursuit® herbicide in alfalfa weed control. Successful techniques and experiences learned with Pursuit would also apply to Raptor.

***Comparisons between Pursuit and Raptor*:**

1. Raptor has a shorter soil life approximately half of Pursuit. Even though applied post emergence to weeds, both herbicides enter the soil and can persist for months. Raptor with a shorter plant back interval is important in areas with multiple cropping patterns.

2. The ai (*active ingredient*) rate per acre of Raptor ranges from .024-.047 Lb/A and is half that of Pursuit .047-.094 Lb/A. Under cold and foggy conditions when weeds are growing slowly, higher rates are generally needed. When temperatures are warmer particularly spring applications that favor vigorous growth, lower rates have been successful.

3. Raptor controls a similar spectrum of broadleaf weeds as Pursuit but many more grass weeds. Controlling a broader spectrum of weeds can eliminate the need for combining two herbicides. However, when tolerant species occur certain tank mixes are allowed and recommended. Pursuit being weaker on grassy weeds may be the choice when keeping a nurse crop of wheat or ryegrass in a seedling stand is desired.

Suggestions for obtaining best results with Raptor:

1. **Spray weeds at the smallest size allowable.** At the 1-3" height, 95 to 100% control can be achieved for most labeled weeds. Delaying applications beyond the small growth stage generally lowers the overall control.

2. **Applications should be targeted when all alfalfa has reached the two trifoliolate leaf size.** Generally**,** the smaller the alfalfa the younger the weeds. Weeds generally grow faster than alfalfa so delaying applications usually favors the weeds. Lower rates are effective and cost reducing on smaller weeds.

3. **Avoid spraying plants under stress.** Stress is often related to conditions of low soil moisture or environmental conditions that slow a plants metabolism. Raptor

chemistry relies on translocation of the herbicide moving through the weed to the site of action. Slowing this process reduces herbicide toxicity and leads to unacceptable control.

4. **Adjuvants are always needed.** Raptor needs to be combined with an oil adjuvant or non-ionic surfactant. In addition to the adjuvant, a nitrogen fertilizer (ammonium sulfate, UAN) added to the spray solution will enhance results particularly when environmental conditions are less than ideal and less susceptible weed species are present.

Raptor will also have a fit in established alfalfa weed control during the harvest season. This is especially important since the industry is limited in what is available for use between cuttings to control broadleaf weeds. The use of 2,4-DB *Butyrac*® is restricted in many locations especially where sensitive crops such as cotton and grapes are grown. Bromoxynil *Buctril*® is restricted to use on seedling alfalfa only. Paraquat *Gramoxone*® has a 60-day pre-harvest interval that results in the loss of at least one harvest. Raptor has a 20 day PHI that will fit the normal alfalfa harvest cycle. More information on alfalfa weed control, herbicide/weed susceptibility charts and pictures of herbicide symptoms on alfalfa can be found in the New UC Publication #21615 ***"Postemergence Weed Control in Seedling Alfalfa and Phytotoxicity Symptoms".***

Managing Herbicide Resistance

Each year there are more "ALS" (*Aceto lactate Synthase*) inhibiting herbicides are being register in the western states across many crops. This chemistry, which includes Raptor and Pursuit, is susceptible to developing herbicide resistance on weeds when used repeatedly. The reality is that once resistant weeds develop it takes years to rectify the problem and the effective reuse of the herbicide. Not only is the effectiveness of Pursuit and Raptor lost but also other herbicides with in the same chemistry can become ineffective in other crops. (cross resistance) The number of spray applications required before resistance problems develop is not known and weed species differ to their susceptibility for resistance. However, to avoid the problem a good rule of thumb (all pesticides) is not to over use any one product and rotate chemistries frequently, tank mix different herbicides that have different modes of action and use the lowest rate recommended by label for the pest.

Figure1

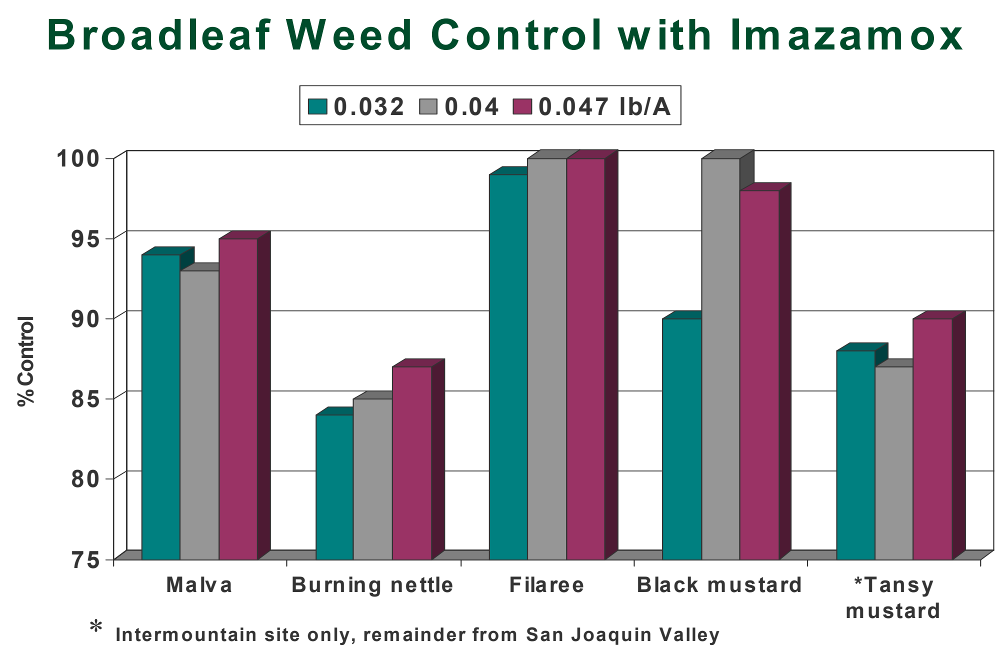


Figure2

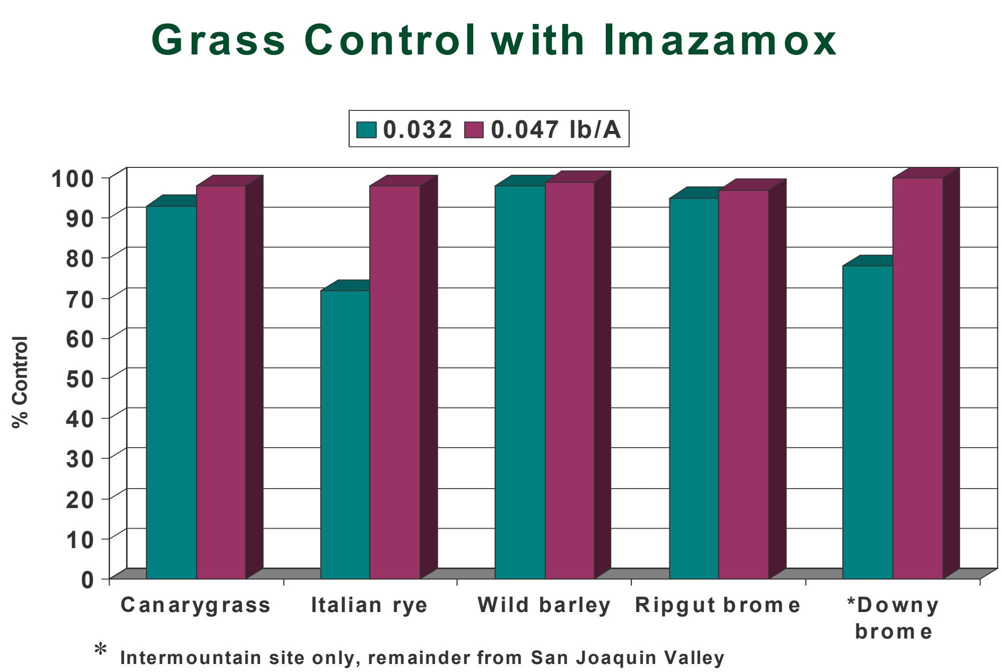
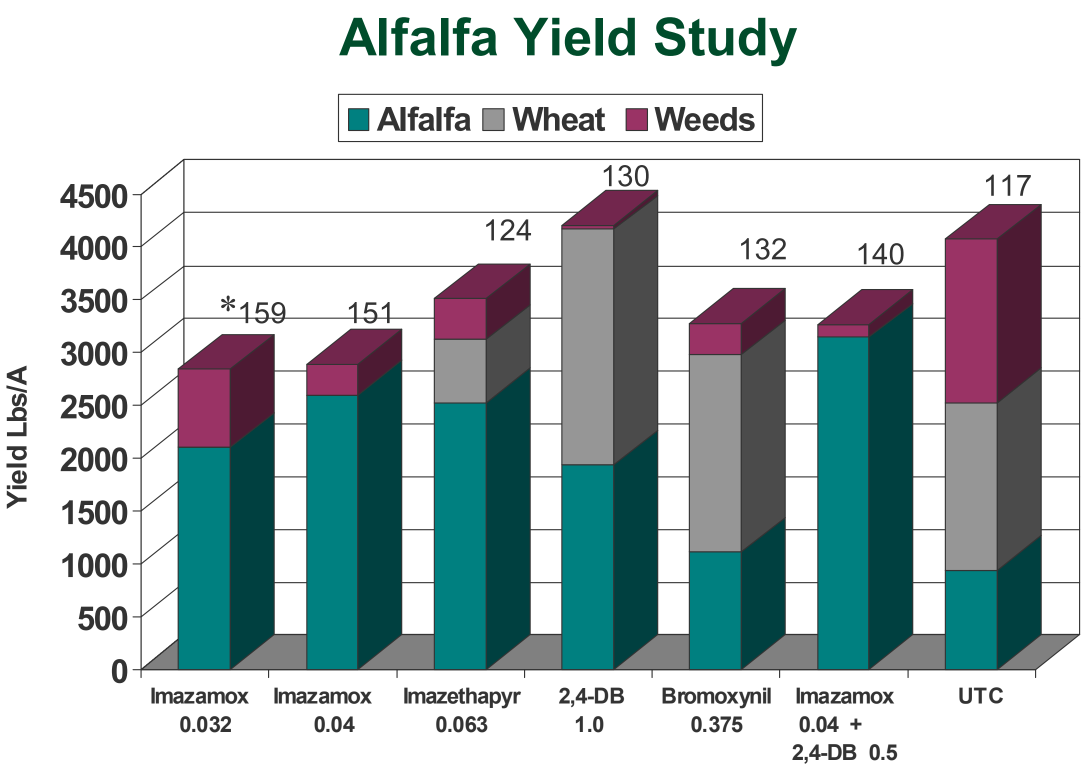


Figure 3



Weeds: Sowthistle, Shepherds Purse, Malva, Chickweed, Henbit, Wild Oat   Stockton Ca 1999

*RFV=Relative Feed Value

The Fit For Roundup Ready Alfalfa: Initial Field Results in California

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Complete weed control in alfalfa has been a continual challenge for alfalfa producers. Compared with many other crops, alfalfa competes well with weeds. However, despite alfalfa's competitive ability, weeds remain a problem. The high forage quality demands of the dairy industry in California are such that nearly perfect weed control is important. Similarly, for alfalfa hay to be suitable for sale to the horse industry, it must be almost entirely free of weeds. This has been difficult with conventional herbicides, as typically no single herbicide controls all the weeds present in many alfalfa fields. This is especially true for weed control in seedling alfalfa where herbicide tank mixes are often required and even when they are used, weed escapes are not uncommon.

Potential Benefits

Glyphosate is undoubtedly the most effective non-selective foliar herbicide available. It controls a broader spectrum of weeds, both annuals and perennials, than any other herbicide. Now with the advent of transgenic crops it can be used to control weeds in crops resistant to glyphosate. The impact that herbicide tolerant crops have had on other commodities is remarkable. In 2002, 69 percent of the cotton acreage, 68 percent of the soybean acreage, 55 percent of the canola acreage, and 26 percent of the corn acreage in the United States were planted with varieties genetically altered for herbicide tolerance.

Commercial varieties of alfalfa genetically altered for resistance to glyphosate are on the horizon. Monsanto has entered into a cooperative agreement with the alfalfa breeding company Forage Genetics to produce Roundup Ready alfalfa. Roundup Ready alfalfa varieties may be available as soon as 2004.

Conceptually Roundup Ready alfalfa as a weed control system has significant merit for alfalfa producers. Weed control costs could potentially be dramatically reduced while improving the level of weed control. Most alfalfa herbicides injure the crop to some degree. In theory, crop injury could be dramatically reduced or eliminated with Roundup Ready alfalfa. In addition, there are no effective weed control programs for some of the most difficult-to-control perennial weeds (dandelion and quackgrass) common in intermountain alfalfa stands. Control of difficult to control perennial weeds in the California's Central Valley (Bermudagrass, nutsedge, and Johnsongrass) could also be improved with glyphosate. Adequate control of these tough perennials could help extend stand life in some areas.

Unanswered Questions

Even with these potential advantages, questions remain regarding the value of the Roundup Ready System in alfalfa production systems. Glyphosate has no soil residual activity. Many, if not most, of the herbicides used for winter and summer annual weed control have soil residual activity so that they persist long enough to provide complete weed control. Similarly

Pursuit, and now Raptor, each have soil activity which helps control weeds that emerge following the herbicide application. *Could complete season-long weed control be achieved with a foliar herbicide like glyphosate given the prolonged emergence of the weeds that infest alfalfa?* Field trials were needed to compare the Roundup Ready weed management system with standard weed control strategies under the diverse environmental conditions and weed spectrum encountered in California. In addition, the Roundup Ready approach to weed control may require different application timing(s) than other conventional herbicide treatments.

California Field Trials

Uniform weed control trials were conducted in the intermountain area, Sacramento Valley, and San Joaquin Valley of California. Testing the Roundup Ready concept over varied environments allows for a better comparison of the benefits and shortcomings of the system. Roundup Ready alfalfa (fall dormancy appropriate to the production area) was seeded in the fall at each site. An additional spring-seeded trial was conducted at the intermountain site. Different glyphosate rates and application timings were evaluated. The glyphosate rates tested were 1 and 2 pounds active ingredient per acre (0.75 and 1.5 lbs. ae/A). There were three different herbicide application timings based on the alfalfa growth stage: A) unifoliate to first trifoliate, B) 3–4 trifoliate leaves, and C) 6–9 trifoliate leaf stage. The conventional standards tested were imazamox (Raptor) and tank mix of imazethapyr (Pursuit) and bromoxynil (Buctril) or clethodim (Prism). A tank mix of glyphosate and Pursuit was also evaluated. Sequential treatments (when deemed necessary) were evaluated to ascertain the need for multiple treatments to control weeds that emerged after the initial application. The treatments were nearly identical at all sites. A complete list of all the treatments and their description is presented below. The timings refer to the application timings above (*Timing D* is the second treatment for a sequential application. Treatments were applied with a CO_2 pressurized backpack sprayer, except at the Kearney Agricultural Center, where a tractor-pulled plot sprayer was used.

Description of Treatments:

1. Roundup (0.75 lb. a.e./ac) Timing A - Very early application of Roundup at unifoliate to 1st trifoliate.
2. Roundup (0.75 lb. a.e./ac) Timing B - Early application of Roundup at the standard 3-4 trifoliate stage.
3. Roundup (0.75 lb. a.e./ac) Timing C - Late application of Roundup applied at 6 - 9 trifoliate stage, which would be generally too late for most conventional herbicides and effective weed control, but late applications are a common occurrence due to herbicide timing restrictions on alfalfa or environmental limitations which prevent timely treatments.
4. Roundup (1.5 lb. a.e./ac) Timing B - Early application of Roundup at the 3-4 trifoliate stage with higher rate to address problem weeds.
5. Roundup (1.5 lb. a.e./ac) Timing C - Late application of Roundup at 6-9 trifoliate stage. Weeds are expected to be bigger and harder to kill. Higher rate to address increased weed size.
6. Conventional, Timing B (Pursuit, Prism, 2,4-DB, Poast, Buctril) - One application of Pursuit or other herbicides applied alone or in a tank mix combination at the 3-4 trifoliate stage to control the weed spectrum. Other herbicides could include Buctril, Prism, Poast or 2,4-DB.
7. Conventional, Timing B (Raptor alone) - Raptor alone applied at 3-4 trifoliate stage. No further weed control measures.
8. Conventional, Timing C (Pursuit, Prism, 2,4-DB, Poast, Buctril) - One application of Pursuit and/or other herbicides applied alone or in tank mix combinations applied at the later stage of 6-9 trifoliate alfalfa.
9. Mix Strategy, Timing B (Roundup + Pursuit) - A tank mix of Roundup (0.75 lb. a.e./ac) and Pursuit applied at the 3-4 leaf stage of alfalfa
   Sequential Treatments (D is timing of the second flush of weeds and is not tied to a stage of the alfalfa).

10. Roundup followed by Roundup, Timing A & D (0.75 lb. a.e./ac followed by 0.75 lb. a.e./ac) Roundup applied very early at unifoliate to 1st trifoliate followed by second application to control second flush if necessary.
11. Roundup followed by Roundup, Timing B & D (0.75 lb. a.e./ac followed by 0.75 lb. a.e./ac) Roundup applied early at 3-4 trifoliate followed by second application to control second flush if necessary.
12. Conventional followed by Conventional (Conventional Timing A & D) Treatment begins at the very early trifoliate stage. A second application (e.g. Prism or Pursuit, or Pursuit + Pursuit low rate) made for later weeds.
13. Roundup followed by Conventional (Timing B & D) Roundup application (0.75 lb. a.e./ac) early. Follow up with conventional herbicide to control second flush if necessary.
14. Untreated Control - This treatment will demonstrate the penalty for not controlling weeds during the seedling phase.

Results

There was very little to no injury to the alfalfa with the Roundup treatments. At some sites there were very slight injury symptoms but they were insignificant and short-lived. Alfalfa at the Kearney Agricultural Center site showed an initial reduction in plant height when treated with Roundup at the 6-9 trifoliate stage compared with other timings, but the injury was no longer evident by the time of first cutting. The Raptor and the Pursuit plus Buctril tank mix treatments resulted in more injury. However, the injury was generally less than 20 percent at most locations. Alfalfa crop mortality occurred in all Roundup treatments. The Roundup Ready alfalfa planted for the trials was a blend of experimental varieties and contained a small percentage of plants without Roundup resistance.

Better than 95 percent control of nearly all weeds was achieved with Roundup at all sites. These weeds included prickly lettuce, wild radish, shepherd's purse, volunteer wheat, volunteer oats, common groundsel, annual bluegrass, swinecress, chickweed, purslane, nightshade, and kochia. Roundup was less effective on henbit. While the 2.0 pounds active ingredient per acre rate (1.5 lbs. ae/A) of Roundup resulted in more rapid weed kill, it was generally not needed. A 0.5 pound active ingredient per acre rate was sufficient to control the summer annual weeds in the spring-seeded trial in the intermountain area.

The importance of the timing of Roundup application varied depending on weed species, location, and time of the year. At the intermountain site an application made at the unifoliate to first trifoliate timing resulted in subsequent invasion of prickly lettuce and henbit, but shepherd's purse was completely controlled, as there was no subsequent emergence of this weed after the initial application. A second application (3/28/02) was needed to control all the weeds that could infest first cutting. Similarly, a second application of Roundup was needed at one of the San Joaquin Valley sites (West Side Research and Extension Center) when the first Roundup application occurred when the alfalfa was at the cotyledon to unifoliate stage.

All of the Roundup timings resulted in excellent weed control in other trials. This was the case in the spring trial in the intermountain area and the trial on the east side of the San Joaquin Valley (Kearney Research and Extension Center). The situation was similar in the San Joaquin County trial, where all Roundup timings performed well. However, a second flush of annual bluegrass and canarygrass germinated in all treatments by early December. None of the herbicide treatments controlled this second flush of weeds.

Raptor and the Pursuit combinations controlled most weeds, but not as complete control as with Roundup. Weeds not adequately controlled with Pursuit alone were purslane, prickly lettuce, henbit, kochia and the grasses. Raptor was more effective than Pursuit for the control of the grasses and was generally slightly more effective on some of the broadleaf weeds.

The Roundup Ready system of weed management shows significant promise for use in seedling alfalfa. It resulted in the best overall weed control of the treatments evaluated and there was considerable flexibility in treatment timing. One of the major causes for weed control failures with conventional herbicides is late application—the weeds become too large for complete control. It appears that this will not be nearly as critical with glyphosate as it is with standard herbicides. Extremely early applications, at the unifoliate to first trifoliate growth stage are ill advised because at some sites and under some conditions subsequent weed invasion can occur because open areas in the young stand facilitate weed encroachment. Crop injury from glyphosate appears to be less than with most conventional herbicides.

Concerns and Other Issues

While this new technology has many advantages, Roundup Ready alfalfa will not be a panacea. Even though glyphosate is an extremely effective broad spectrum herbicide, there are still weeds such as malva and filaree that it does not adequately control. Continued use of glyphosate can over time result in a weed shift. While glyphosate is not as prone to weed resistance as are other herbicides, it still is feasible. Glyphosate-resistant ryegrass has already been found in the Sacramento Valley. Uninterrupted use of Roundup in a perennial crop like alfalfa, especially if followed by other Roundup Ready crops, increases the likelihood of resistance. The key is to avoid continual reliance on a single herbicide for weed control—integrate several weed management strategies including cultural and chemical weed control and alternate herbicides with different modes of action.

There are other issues related to Roundup Ready alfalfa that warrant consideration. Glyphosate obviously will not control Roundup Ready alfalfa. Hence, volunteer alfalfa may become more of a dilemma in rotation crops such as tomatoes, peppers, beans, etc., as glyphosate is often used to kill alfalfa prior to plowing or disking out an alfalfa stand in some areas. Similarly, volunteer alfalfa will be especially problematic when it appears in other Roundup Ready crops such as cotton and corn. Feral alfalfa growing along roadsides and non-crop areas may cross with Roundup Ready alfalfa. This is a concern, as many government agencies rely on glyphosate for control. Public acceptance of genetically-altered crops is an issue with alfalfa as it is with any transgenic crop. Adoption of Roundup Ready alfalfa by California producers will depend largely on the amount of the technology fee and the performance (both yield and quality) of Roundup Ready alfalfa varieties compared with conventional alfalfa varieties.

Conclusion

These results clearly demonstrate that there is a fit for Roundup Ready alfalfa in California alfalfa production systems. The commercial availability of Roundup Ready alfalfa awaits regulatory approval and may depend on agreements with alfalfa importing countries such as Japan. The introduction of Roundup Ready alfalfa varieties into California would be a significant advancement and would likely become a landmark in alfalfa weed control practices.

Acknowledgement

The researchers would like to acknowledge the financial assistance provided by Mosanto Company and the technical assistance provided by Wayne Edwards, Barbara Kutzner, Carlos Reyes, and Henry Wu with Monsanto and Dan Putnam with the University of California, Davis.

Integrating Weed Management Tools in Cotton and Corn: GMO's and Conventional Herbicides

Steve Wright and Ron Vargas
University of California Cooperative Extension, Tulare and Madera

Integrating herbicide resistant crop technology and conventional herbicides makes sense for many reasons. One of the main concerns is preventing weed resistance. There is a high probability of developing resistant weed species and/or weed shifts when solely relying on one type of herbicide. For example, we have Roundup resistant annual ryegrass and marestail in California. Growers have also reported poor control of barnyardgrass and lambsquarter in some cases. Some of this reduction in control could also be due to applying glyphosate to drought stressed weeds. There are many reports of reduced control of barnyardgrass with continual use dinitroanilines in cotton in the San Joaquin Valley. Some California growers have observed reduced nutsedge control with continuous use of thiocarbamate herbicides in corn.

Herbicide tolerant crop acreage has increased dramatically in the United States and amounts to approximately 30 percent of the California cotton and corn acreage (Table 1.) The herbicide tolerant acreage of both cotton and corn should continue to increase as higher yielding varieties receive these traits. Fig. 1. and Fig. 2 shows the dramatic increase in herbicide tolerant acreage in just a few years.

Crop	U.S. Percent	California Percent
Cotton	69	29
Corn	*26*	*30*
Soybeans	*68*	
Canola	*55*	

Table 1. Herbicide Tolerant Crop Percent of Total Acreage 2002.

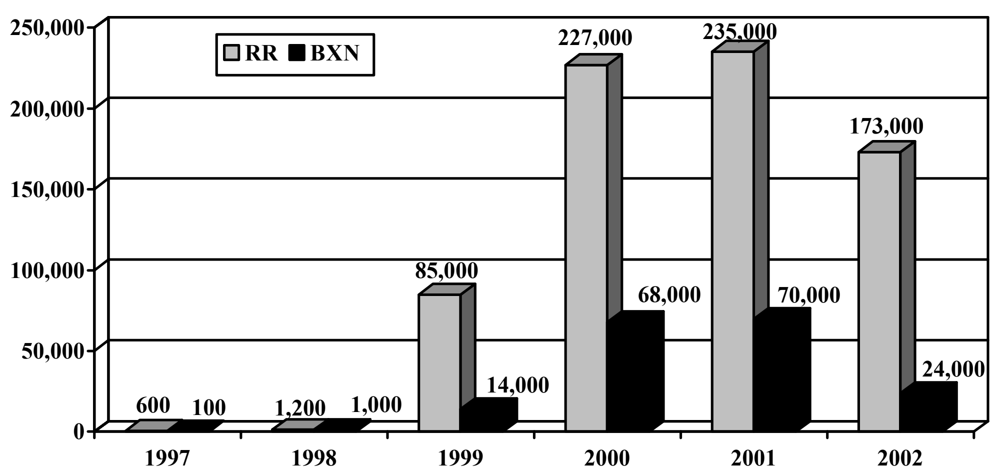

Fig. 1. Progression of Herbicide Tolerant Cotton in San Joaquin Valley.

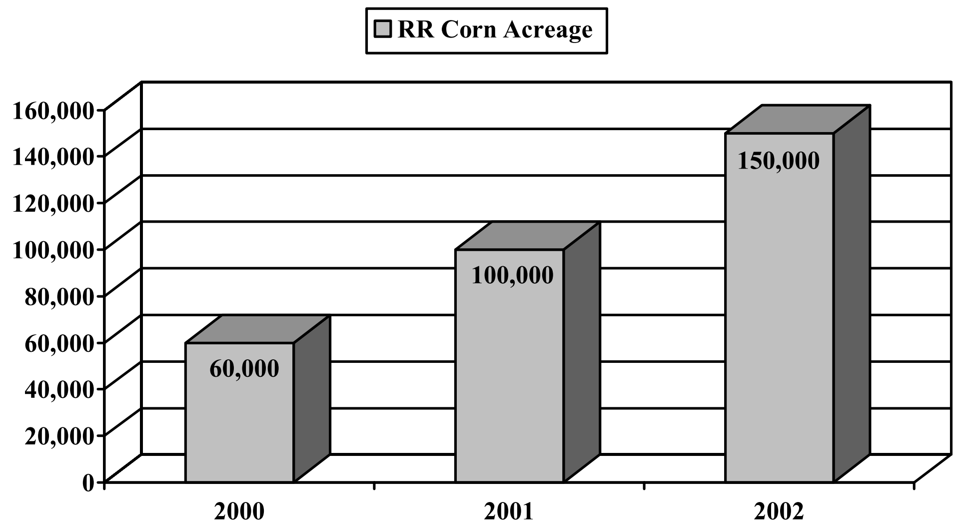

Fig. 2. Progression of Roundup Ready Corn in California.

The decision to use herbicide tolerant crops is largely based on the following criteria: 1) Can the crop be marketed? 2) Does the acreage of the weed infestation justify this use? 3) Is the weed pressure enough to impact yield? 4) Is hand weeding or cultivation eliminated or reduced? 5) How does this compare to the cost of alternative herbicides? 6) Cost of technology fee? 7) Are there well-suited transgenic varieties with favorable agronomic characteristics for both yield and quality?

Roundup Ready Technology in Cotton

The Roundup Ready technology has provided growers with an excellent tool for managing many annual and perennial grasses, broadleaves such as nightshades and annual morningglory, and nutsedge in cotton. Some of the advantages to this system include the following: 1) Glyphosate can be applied post emergence so growers can wait and see the weeds present. 2) There are no plant back restrictions. 3) Glyphosate has a wide spectrum of weed control controlling or suppressing many annuals and perennials.

Some of the problems associated with this system include the following: 1) There is a narrow window of application. 2) It must be applied before cotton has 5 leaves. 3) Hooded sprayers are needed to safely apply later directed applications. 4) Nutsedge and annual morningglory are still a challenge. 5) Variety selection can be limited in that the technology is somewhat behind. The highest yielding varieties often do not have this trait. Even with the herbicide tolerant technology weeds like annual morningglory are increasing especially when growers are only relying on glyphosate.

BXN System

The advantages of the BXN system or Buctril (bromoxynil) tolerant cotton is that there is not a concern about crop safety since it has a wide application window. With this system only broadleaf weeds are controlled. Only plant BXN cotton back if more than 1 pt. is used. Reduced grass control is sometimes observed if tank mixed with grass herbicides. Buctril controls many small broadleaf weeds like black and hairy nightshade, lambsquarter, Chinese thornapple, and annual morningglory. Annual morningglory control with Buctril is still a challenge. Treat before the 3-leaf stage. Best control (80-90%) is achieved at the 2-leaf stage. Studies in Madera County showed control dropping to (20-60%) at 4 to 6 leaf weeds. Layby preemergent herbicides like Caparol or Goal are usually needed even with either the Roundup Ready or BXN systems because annual morningglory comes up in different flushes (Fig. 3). Annual morningglory can be controlled by other herbicides and the best control is sometimes achieved using tank mixes. Table 2. lists herbicide options for annual morningglory control in cotton.

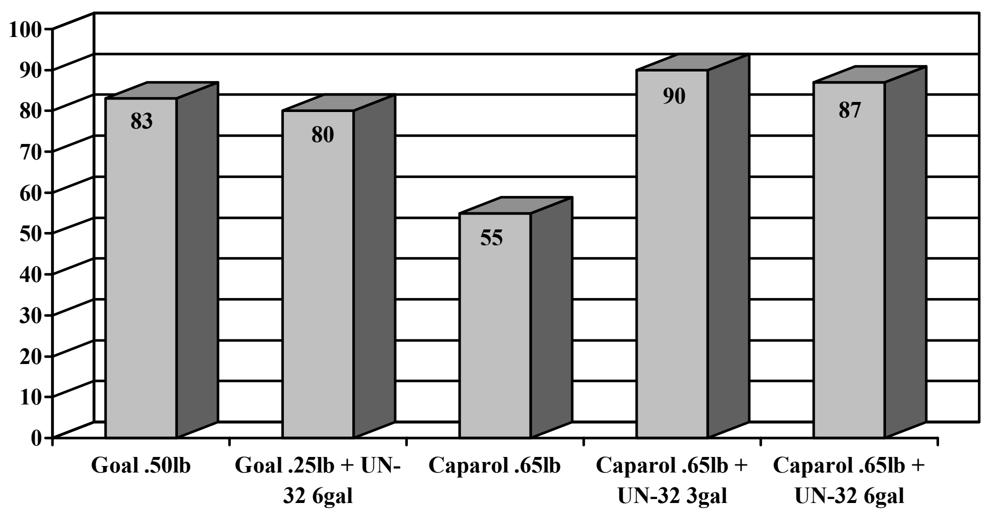

Fig. 3. Postemergent Annual Morningglory Control in Cotton-Tulare Co. 1999.

<u>Current</u>	<u>Future</u>
Glyphosate	Shark
BXN-Buctril	Harvade
Caparol	CGA 362622
Goal	MON 78270
Staple plus MSMA	Valor

Table 2. Annual Morningglory Control Tools in Cotton.

Integrated Nutsedge Control

An integrated approach is required especially for purple and yellow nutsedge by using herbicides associated with different crops and using tillage. The following preemergent herbicides are available in field crops for nutsedge control and also control other weeds: Vapam in cotton; Sutan and Eradicane in corn for both purple and yellow nutsedge, grasses, and some broadleaves; Lasso and Dual in corn for control of yellow nutsedge, grasses, and some broadleaves. Postemergence nutsedge herbicides include: MSMA in cotton for nutsedge; glyphosate and Touchdown for nutsedges, grasses and broadleaves; and Sempra (Halsulfuron) in corn for nutsedges, and some broadleaves.

Integrated Control of Nutsedge in Cotton

When used alone, the foliar-applied herbicide MSMA can suppress nutsedge in the seed row after cotton has emerged. MSMA is more effective on yellow than purple nutsedge. It is safest to use on cotton in the cotyledon stage however it is not registered to use until cotton plants have two or more true leaves. Make a second application 1 to 3 weeks later using a directed spray aimed at the base of the cotton. Apply before first cotton bloom. MSMA will often cause a purplish discoloration and may retard cotton growth. Injury to cotton can be severe when plants are stressed for water. Don't use MSMA more than twice per season as it may leave a soil residue that can damage some rotation crops.

Glyphosate is applied in two applications over the top of glyphosate-tolerant cotton before the fourth leaf stage of cotton. A 3rd application is often needed as a directed spray. Other generic glyphosates have shown similar results in a couple University studies. More consistent control is obtained when ammonium sulfate at 5 to 15 lbs/A is mixed with Roundup. Careful cultivation is essential for early season control even when using herbicides. After cotton has emerged, use precision equipment to cultivate as closely as possible to the crop row. Use sweep type cultivators (Alloways). Rolling cultivators are ineffective for nutsedge suppression and spread nutsedge tubers creating larger areas of infestation.

Integrated Control of Nutsedge in Corn

Nutsedge is very competitive with corn in the early stages of growth. Running a sweep four inches below the top of the bed or power tilling the beds with L-shaped knives 3 to 4 inches deep before planting is effective in inhibiting nutsedge that has already sprouted. It is important to cultivate a second time for nutsedge after the crop has emerged. In the second cultivation, throw soil to the corn plants to suppress nutsedge growth and allow corn growth to shade the furrow. Keep at least 4 inches from corn plants to avoid pruning fibrous roots and use sweep type cultivators.

Metolachlor (Dual) and alachlor (Lasso) herbicides can give effective preemergence yellow nutsedge control. EPTC (Sutan, Eradicane) applied preplant incorporated provides good control of both yellow and purple nutsedge in corn. Use the higher labeled rates for the most effective control. Disturb nutsedge by using sweeps or power mulchers before planting. Plant immediately after the herbicide application to achieve the longest control.

Halsulfuron (Sempra) gives excellent control applied postemergent to purple or yellow nutsedge. Two applications are preferable. Make the applications when nutsedge is less than 5 leaves. Do not cultivate within 7 days following application. Halsulfuron can be applied over the top of corn or with drop nozzles from the spike stage through layby. Glyphosate applied to Roundup Ready corn varieties will provide partial control. Two applications are most effective. Tank mix combinations of Sempra and glyphosate should enhance control.

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Summer Fallow Programs

Purple nutsedge tubers are susceptible to drying and can be destroyed with repeated summer tillage. Spring-tooth harrows are usually the best tools for this purpose; discing is often ineffective. Work conducted by Paul Keely at Shafter Research Station showed 95 percent control by listing and splitting the beds in summer. The remaining 5 percent still remains a problem the next season. Tillage is not likely to be successful in soils that form large clods or in fields where a high water table keeps soil near the surface moist. Tillage is not as practical for control of yellow nutsedge, because the tubers can survive up to 4 years in dry soil. Reports on the effectiveness of tillage are variable and often contradictory partly because of a general failure to distinguish between the species of nutsedge.

Integrated Weed Management Costs

The herbicide tolerant cotton and corn systems have allowed growers to effectively control most annual and perennial weeds, to reduce or eliminate hand hoeing, and reduce the number of cultivations. Cost savings range from $25 to $120/acre is achieved. Even if growers use an herbicide tolerant system it is still advisable to use one of the following preplant incorporated herbicides in cotton: Prowl, Treflan, Caparol, or Caparol + Treflan/Prowl. The cost is low ($6-$8/A) and controls most annual grasses and many broadleaves. Ultimately the decision to use one herbicide tool over and how to integrate different herbicides will depend on costs and effectiveness (Fig. 4 and Fig.5).

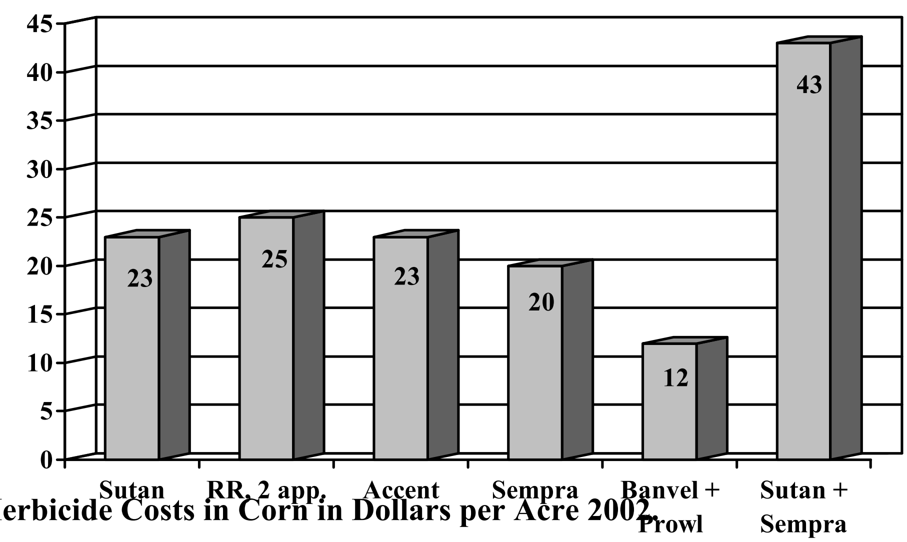

Fig. 4. Herbicide Costs in Corn in Dollars per Acre 2002.

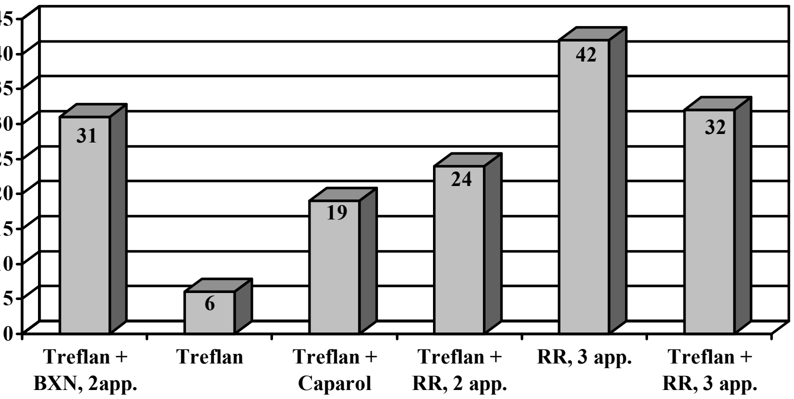

Fig. 5. Herbicide Costs in Cotton in Dollars per Acre 2002.

Summary

The herbicide tolerant systems in cotton and corn has reduced weed control costs and given growers greater flexibility. This has allowed growers and researchers to explore alternative production systems such as conservation or reduced tillage, double row configurations, and ultra narrow row systems. In the future we look forward to enhanced Roundup Ready varieties that have more crop safety with a greater application window; Liberty Link Cotton by Bayer, Sulfonyureas by Dupont, and more Stacked Genes/Multiple Genes with both herbicide tolerance and insecticidal properties together. A resistance management approach must incorporate crop/herbicide rotation and control of weed escapes by tillage or hand. An integrated weed management system supplements an existing transgenic or conventional weed control program and uses a variety of the available pre-plant, selective over-the-top and layby herbicides along with tillage.

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Session E: Forestry, Range and Wildlands
Santa Ynez Room
Moderator: Nelroy Jackson, Monsanto

Survival And Growth Of Three Conifer Species Following Three Types Of Site Preparation And Three Levels of Subsequent Shrub Control: 21 Years After Planting

W. Thomas Lanini, University of California, Davis

Disturbance such as fire or logging, often lead to a forest site being occupied by commercially undesirable vegetation. On the west side of the Sierra Nevada mountains, weedy trees such as black oak (*Quercus Kelloggii*), and shrubs, such as manzanita's (*Arctostaphylos sp*.) and Ceanothus *spp*., are common invaders after disturbance, particularly on harsh (hot, dry) sites. Efforts to re-establish conifers on harsh sites have often led to failure. In order to determine the best type of site preparation for conifer planting on harsh sites, an experiment was established in the fall of 1978. The objectives of the experiment were to compare the survival and growth of transplanted white fir, sugar pine, and ponderosa pine following site preparation by the use of fire, a rotary masticator (Hydro ax), and a brush rake. We also examined three levels of subsequent weed control, a single herbicide treatment at one year after planting, two herbicide treatments at one and two years after planting, and no subsequent treatment after planting.

Methods: A seven-acre area on Humbug ridge road in Tahoe National Forest (Foresthill Ranger District) was used for the study. The area chosen for the study had been occupied by shrubs and weedy trees for at least 18 years since the Volcano fire, and possibly much longer. A split plot design was used with three replications. Main plots were site preparation method (150 ft. X 200 ft.), and sub-plots were number of herbicide release treatments (150 ft. X 66 ft.). Site preparation was done in September 1978. A rotary masticator cut shrubs off close to ground level, with no disturbance to the soil. A brush rake pushed all the shrubs and trees into a pile in the center of each plot, also removing large roots in the process and causing disturbance in the top 12- to 18- inches of soil. Brush piles were later burned, but no effort was made to redistribute the ashes prior to planting. The brush rake also drove over the fire plots (no blade) to crush the shrubs to aid in shrub drying and allow a hotter fire. Several weeks later, the fire plots were burned, with only a few random, charred-branches still standing after the burn. Soil disturbance on the fire plot was limited to heating of the top layer and the addition of ash to the surface.

In early May 1979, 1-0 ponderosa pine, sugar pine, and white fir seedlings, were transplanted into every plot. A forest service crew used a power auger to prepare each planting hole. Trees were planted in a 6 ft. X 6 ft. grid, with 11 trees per row and 24 rows in each subplot. Each 11-tree row consisted of a single species, with 8 rows of each species being randomly arranged in each sub-plot. The untreated subplot did not receive any further management. The single release plots received a directed herbicide treatment in the spring of 1980, and the two-release plot received a directed herbicide treatment in the spring of 1980 and 1981. In September 2000, 21 years after conifer planting, conifer survival, diameter at breast height, and height were measured on each surviving tree.

Results: Ponderosa pine survival was affected by the site preparation method and the level of subsequent weed control following site preparation (Table 1). Survival was best where shrubs were brush raked and least on the hydroax plots. This was similar to what was observed in 1982, however, the difference among treatments was much greater in 2000. Ponderosa pine survival declined about 17% on the brush rake plots between the 1982 and the 2000 evaluations, while survival declined by 25% on the fire and hydroax plots. Survival of ponderosa pine was also greater with herbicide release treatments, compared to not treating (Table 1). This is the reverse of what was observed in 1982, where survival was poorest on plots that had two release treatments. The herbicide release treatments injured and killed some trees, however, surviving trees were able to grow quickly due to increases in resources and quickly dominated the site. Where shrubs were not controlled, ponderosa pine growth was slower and eventually some of the trees died. This is especially true on the fire and hydroax plots where survival declined by over 40% when no herbicides were applied. In general, the greater the level of soil disturbance and subsequent shrub control, the better the ponderosa pine survival.

Sugar pine survival was extremely poor in all plots (Table 1). Disease has killed most of the sugar pine found in these plots. There was better survival with two herbicide release treatments compared to the other treatments, and also the brush rake plots compared to the hydroax treatment. The reduction in weeds on these plots may have reduced alternative host plants for the disease, which killed the sugar pine. Sugar pine survival on the fire plots with two release treatments and the brush rake plots with one or two release treatments was greater than survival on other plots. Again, these plots had less competing weeds, which could have reduced the alternative host plants for the disease, which killed the sugar pine.

White fir survival was affected by the level of subsequent weed control following site preparation, but not by the site preparation method (Table 1). The first release treatment appeared to have decreased white fir survival to only 15 %. Two release treatments improved white fir survival about 10 % over the single release treatment, but still less survived than the average survival on the untreated plots. Similar to what was observed with ponderosa pine, white fir survival in 1982 declined between 1982 and 2000, by over 15% on plots that received 0 or 1 release treatment, but only 5% where two release treatments were applied.

Ponderosa pine diameter at breast height (dbh) was not affected by site preparation method but increased substantially with a single release treatment (Table 2). Two release treatments increased dbh growth only slightly compared to a single treatment. As with survival, dbh growth was best where shrubs were suppressed more effectively or for a longer period of time.

Sugar pine dbh was also not affected by site preparation method but increased substantially with a single release treatment and even more with two release treatments (Table 2). Maximum dbh was observed on the brush rake and hydroax plots that received two release treatments, but the single release treatment was best on the fire plots. The very low number of surviving trees makes data interpretation difficult with sugar pine.

White fir dbh was also increased substantially with a single release treatment and even more with two release treatments (Table 2). Unlike the other two conifers, white fir dbh was also affected by site preparation method, with trees on the fire plots having the smallest dbh and brush rake having the largest dbh.

Ponderosa pine height (ht) was least when no weed control was used after planting (Table 3). A growth increase (approx. 6 ft. in ht) in ponderosa pine was observed when a single herbicide treatment was used. Ponderosa pine ht was greatest when two yearly weed control treatments were used, with the increase over a single treatment of over 9 ft. Although site preparation method did not significantly affect ponderosa pine ht, there was a 10 ft. difference between the brush rake and hydroax plot, with trees on brush rake plots being much larger, particularly where no or only one release treatment was used.

Sugar pine ht data should be regarded as less reliable than the other two species, due to the small number of surviving trees (Tables 1 and 3). Sugar pine ht was greatest when one or two herbicide release treatments were used. Height was also greater on brush rake plots compared to hydroax plots. Since the trends in the sugar data parallel the other two conifer species, with the exception of the fire plots that received one or two release treatments, it seems that these are an accurate representation of tree height growth response to the treatments.

White fir ht was least when no weed control or a single release treatment was used after planting (Table 3). A small height increase (1 ft) in white fir was observed when a single herbicide treatment was used. White fir ht was greatest when two yearly weed control treatments were used, with an increase over the single treatment of 4.6 ft. in height. Site preparation method did not statistically affect ht of white fir, but like the other conifer species, was best on the brush rake plots.

Conclusions: At 21 years after transplanting, ponderosa pine survival was about 55%, white fir about 24%, and sugar pine less than 5%, of the original number of planted trees. On many of the plots, which received two herbicide treatments, conifers had achieved canopy closure and shrub growth was minimal. However, if tree survival was poor, the shrubs continued to significantly compete with the remaining conifers. It appears that the brush rake treatments reduced shrub re-growth better than fire and hydro ax treatments, which has improved survival and growth. Although there were consistent conifer growth benefits associated with herbicide treatments, there also appeared to be some conifer injury, based on the reduction in white fir survival. Where survival is high, trees are competing more with each other than other vegetation, as they are planted on a 6 ft X 6 ft grid.

Table 1. Survival (%) of conifer species (Sept. 2000), in relation to site preparation method and number of herbicide applications made after planting. Survival in 1982 is indicated in parenthesis following the 2000 value.

Treatment	# Herb. Treat.	Ponderosa	Sugar Pine	White Fir
		(%)		
Brush rake	0	66 (85)	3 (50)	40 (52)
	1	65 (84)	4 (48)	13 (36)
	2	71 (83)	4 (47)	35 (45)
Fire	0	34 (80)	2 (34)	26 (45)
	1	57 (84)	2 (45)	19 (39)
	2	69 (72)	7 (46)	27 (36)
Hydroax	0	26 (74)	0 (27)	24 (41)
	1	43 (75)	0 (23)	12 (33)
	2	62 (59)	1 (11)	15 (11)
Brush rake		67 (84)	4 (48)	29 (44)
Fire		53 (79)	3 (42)	24 (40)
Hydroax		44 (69)	0.3 (20)	17 (28)
		*	**	NS
O releases		42 (80)	2 (37)	30 (46)
1 release		55 (81)	2 (39)	15 (33)
2 releases		67 (71)	4 (35)	26 (31)
		**	**	*

Table 2. Diameter at breast height (cm) in September 2000, of conifer species in relation to site preparation method and number of yearly herbicide applications made after planting. Diameter at breast height (cm) in 1982 is indicated in parenthesis following the 2000 value.

Treatment	# Herb. Treat.	Ponderosa	Sugar Pine	White Fir
		-----------------------(cm)	-----------------------	-----------------------
Brush rake	0	15.4	9.6	6.7
	1	18.6	8.5	7.1
	2	22.5	12.7	9.2
Fire	0	9.0	3.0	3.5
	1	18.9	9.9	4.9
	2	20.9	7.2	5.8
Hydroax	0	10.6	3.4	3.9
	1	20.6	7.0	5.8
	2	20.6	10.6	8.8
Brush rake		18.8	10.3	7.7
Fire		16.3	6.7	4.7
Hydroax		17.3	7.0	6.2
		NS	NS	*
O releases		11.7 (0.9)	5.3 (0.5)	4.7 (0.9)
1 release		19.4 (1.7)	8.5 (0.8)	6.0 (1.0)
2 releases		21.4 (2.6)	10.2 (1.2)	7.9 (1.4)
		***	**	**

Table 3. Height (ft.) in September 2000, of conifer species in relation to site preparation method and number of yearly herbicide applications made after planting. Height (ft.) in 1982 is indicated in parenthesis following the 2000 value.

Treatment	# Herb. Treat.	Ponderosa	Sugar Pine	White Fir
		------------------------(feet)	------------------------	
Brush rake	0	24.2	17.2	13.6
	1	30.8	15.6	14.3
	2	37.2	23.9	19.2
Fire	0	17.7	8.6	9.5
	1	27.2	26.5	11.7
	2	32.8	14.5	13.0
Hydroax	0	14.6	8.5	8.6
	1	15.9	13.4	8.7
	2	31.2	18.4	16.5
Brush rake		30.7	18.9	15.7
Fire		25.9	16.5	11.4
Hydroax		20.6	13.4	11.3
		NS	NS	NS
O releases		18.8 (1.1)	11.4 (0.7)	10.6 (1.0)
1 release		24.6 (1.6)	18.5 (0.9)	11.6 (1.0)
2 releases		33.7 (2.0)	18.9 (1.1)	16.2 (1.2)
		***	**	**

Session F. Vegetable Crops
San Rafael Room
Moderator: Richard Smith, Farm Advisor-University of California Cooperative Extension and Oleg Daugovish, Farm Advisor-University of California Cooperative Extension

Precision Cultivation to Improve Cultural Weed Control Practices in Vegetable Production

John W. Inman P.E.
Farm Advisor emeritus, University of California Cooperative Extension Service
Agricultural Consultant

A major limitation of mechanical cultivation for weed control in vegetable production has been the ability of tractor drivers to keep cultivating equipment accurately centered on the crop rows. Very close cultivation can lead to serious crop damage when the cultivator operator gets the cultivator off the crop row. Damage to vegetable crops due to close cultivation is often referred to as cultivator blight or iron disease. In Europe some cultivators have actually had an operator on the cultivator trying to steer the cultivator using a steering system built into the cultivator. These systems have been suited to relatively small farms and have not been widely accepted.

A variety of automatic tractor steering systems for tractors have been developed over the years but none have been particularly successful. Most of these systems used some sort of feelers or a device in the furrow to control the tractor steering and were difficult to adjust and maintain and in most cases were not accurate enough to cultivate with.

In the 1980's Dr. David Slaughter at the University of California, Davis developed a system which used a video camera to observe the row and then fed the picture into a computer where it was compared with images of weeds and crop plants. The system guided on the plant row successfully and was demonstrated in several crops including tomatoes and lettuce.

The lettuce demonstrations were in Salinas and were arranged by the author who at that time was with the University of California Agricultural Extension service. Unfortunately Dr. Slaughter's system never reached the private sector and the technology was not available to growers.

In 2000 high accuracy GPS automatic tractor steering systems were introduced by several manufacturers and were a highlight of that year's World Ag Expo in Tulare, California. These systems use RTK technology with a secondary base station to automatically steer tractors with sub inch accuracy. Although cultivation is not a primary use of these systems, they have a memory system which allows the tractor to follow the same path through a field time after time. If a grower plants or transplants using a tractor equipped with one of these systems he can then cultivate using the system since the tractor will follow the exact same path through the field as it did when the field was planted. At least one manufacturer has a kit for the GPS steering system which allows the system to be easily moved from tractor to tractor thus allowing additional use of the basic system. The limitations are the initial cost of the system and that the system must be used for both planting and cultivating.

The best steering system for cultivating is one in which the system observes the plant row and then controls the cultivator so it follows the row accurately. A Danish company, ECO-DAN introduced such a system into the United States market in 2002 at World AG Expo. The system works on the same principles as Dr. Slaughter's system but is more sophisticated and utilizes digital information processing technology. It consists of two different elements; a plant camera and a laser camera. The system is operated through a monitor panel mounted in the tractor cab. The monitor is multilingual and user friendly.

For cultivating, the plant camera is mounted on the cultivator and looks at the plant row in two dimensions, height and width, identifying the vegetation as it moves through the field. The vision computer then analyzes the picture and uses a mathematical algorithm to distinguish the living plants from the soil or plant residue. The quantity of green is estimated and the vision computer analyzes the information to see if the plants appear to be in a row structure. If so a "valid signal " message is displayed on the control panel. If the camera is looking at bare soil or the weed density is so high that a row structure is not visible the picture is then classified as "invalid" and the operator must reset the camera.

If the camera moves off the row as it goes through the field an electrical signal is generated which moves the camera and therefore the cultivator back on the row using a hydraulic side shift on the cultivator or a steering coulter which can move the cultivator from side to side. The side shift on the cultivator can be a simple three point hitch A frame with a hydraulic sideshift on which the cultivator is mounted or a pivoting toolbar on which the cultivating tools are mounted which is connected to a fixed toolbar and is pivoted back and forth with a hydraulic cylinder.

The system operates under a wide range of conditions at speeds of up to 11 miles per hour. The minimum row spacing is 9 inches and the maximum plant distance in the row is 12 inches. Since the system senses color it does not work in crops such as red lettuce. With plants over 8 inches tall, movement of the plants in windy conditions can cause the plant camera to offset the row. This can be corrected by adjusting the offset on the monitor panel. Since the camera is looking down on the row dust and foggy conditions do not affect the operation of the system. Operation is limited to a half an hour after sunrise to one half hour before sunset since the system uses natural light. For nighttime operation special artificial light is needed.

The second element of the system is the laser camera. A laser is located in the camera housing and when the beam runs across a furrow made in the field, the laser line is deflected and the camera can see this deflection and generates an electrical signal which is used to control the same type of side shift mechanisms as used with the plant camera. A good example of the use of this system would be the application of a premergence herbicide. When the crop is planted a furrow is made by a marker attached to the planter. By following the furrow the laser camera can keep the spray nozzles centered over the seed lines allowing the width of the spray bands to be narrowed reducing the amount of herbicide needed and at the same time providing better weed control since the spray band is always centered over the crop row. The furrow must be at least two inches wide and two inches deep to be detectable by the laser camera and must have these dimensions at the time the camera is being used.

This system has the potential to make highly accurate cultivating and band spraying both faster and easier than current technology. It may allow growers to reduce herbicide use and reduce the amount of chemicals being released to the environment. The system has been proven in Europe and the manufacturer has received numerous awards including being the grand prize winner in the European IST competition in 2002.

A dealer network is being established throughout the country with initial emphasis being placed on the Southwestern vegetable industry.

Timing Kerb Applications in Lettuce

Barry Tickes, University of Arizona Cooperative Extension

Introduction

Kerb (Pronamide) is one of the three main herbicides used in lettuce. Results of the Arizona Agricultural Statistics Service's 1998 chemical use survey indicated that 29 percent of the lettuce acreage in Arizona was treated with Kerb, followed by Balan (Benefin - 21%) and Prefar (Pronamide - 11%). Lettuce is grown in the low desert from September to April and growers must contend with winter annual, summer annual and perennial weeds. No herbicide will control all of these weeds all of the time but increasing complaints of poor weed control with Kerb occurred over the last 10 years.

Tests conducted over the past two years have demonstrated that the cause for many of the cases of poor weed control was the leaching of Kerb below germinating weed seeds with sprinkler irrigation. Kerb works by inhibiting root growth of developing seedlings. It has postemergence activity on some very small weeds but it is important that roots and shoots absorb a lethal dose of the herbicide before they are well developed. The location of the herbicide at the time of weed seed germination and early development will greatly affect the level of control that results.

Most weed seeds that emerge with the crop are located within the top ½ inch of soil. It is a challenge to keep the herbicide in this region while applying enough water with sprinklers to germinate the crop and cool the soil. Kerb has commonly been applied after planting and prior to starting the sprinklers. One strategy to maintain the herbicide in the top ½ inch of soil has been to delay the application until after the sprinklers have been started but prior to the germination and early development of the weed seeds. The purpose of this project has been to determine the best time of application.

Application Timing

The most effective weed control will be achieved when the herbicide is in the right place (the top ½ of soil on the bed top) at the right time (when the weed seeds are germinating). Several factors will effect when weed seeds germinate after sufficient moisture is present. The most important of these are soil temperature and the temperatures at which the weeds that are present, germinate. As soil temperatures change from late summer, through the fall and winter and into the spring, the most effective time to apply Kerb will likely also change.

A test was conducted to evaluate how long it takes for certain common weeds to germinate after moisture is present. This test involved burying tea bags containing weed seeds in the seed row of eight commercial lettuce fields from August to February in Roll, the Gila Valley, the Yuma Valley and Bard, California. The test contained a winter annual grass, summer annual grass, two winter annual broadleaf weeds and three summer annual broadleaf weeds. The bags were buried 1/4 inch below the surface and checked every 24 hours. The time to germination appear in Table 1. The time to germination will vary considerably even within the same field due to variations in soil and micro climatology. Every year could be different and this test was intended to provide a general indication of germination times for various common weed seeds. The summer annual grass (barnyardgrass) took 24 hours to germinate in August and September, becoming longer in October (48 hours) to December (96 hours) with no germination in January. The winter annual grass (canarygrass) took 168 hours to germinate in September and dropped to 96 hours in December. The summer annual broadleaves took from 24 hours (purslane) to 96 hours (pigweed and nightshade) to germinate. The winter annual broadleaf weeds (lambsquarters and shepardspurse) took from 72 to 168 hours to germinate.

The weed seed germination test indicated that the best time to apply Kerb to minimize leaching and maximize the amount of herbicide in the zone where weed seed was germinating could be from 24 to 168 hours after the sprinklers had started.

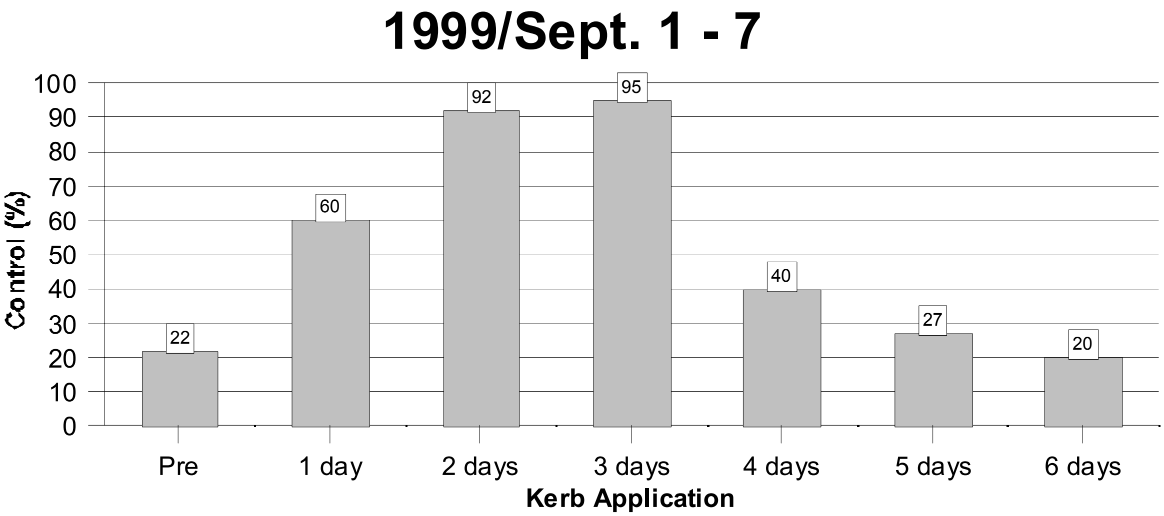
Chart Hours of germination

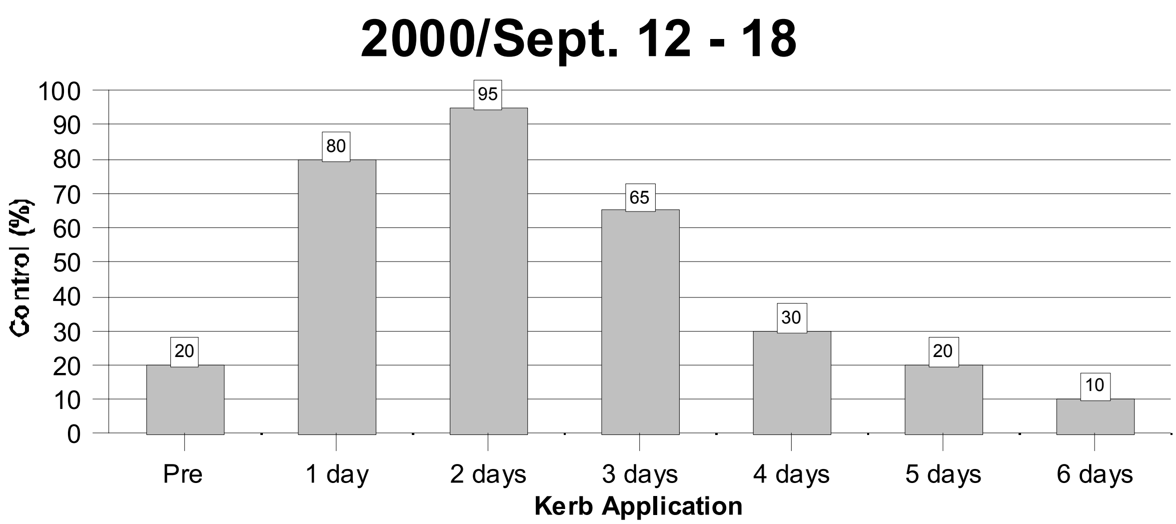
		Month					
		Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Weeds	Barnyardgrass	24	24	48	72	96	NG
	Canarygrass	NG	168	96	96	96	NG
	Lambsquarters	72	96	96	72	168	NG
	Silverleaf Nightshade	96	96	72	96	NG	NG
	Pigweed	48	72	48	72	96	NG
	Purslane	24	24	24	48	96	168
	Shepardspurse	NG	NG	168	96	168	NG

Tests were conducted to determine the best time to apply Kerb after sprinkler irrigation had started. Two tests were conducted during the early season (Aug. - Sept.), two tests during the mid-season (Oct. - Nov.), and one during the late season (Jan. - Feb.). All five tests were small plot tests (8 rows x 50 ft.) conducted at the University of Arizona Yuma Valley Agriculture Center. Treatments were applied manually with a backpack sprayer to simulate aerial application. Two pounds per acre of Kerb were applied either prior to starting the sprinklers or one to six days after they had been started. Each treatment was applied in a 20 gallon per acre spray volume and replicated four times. For the early season tests, common purslane was planted into the plots to insure a uniform infestation of weeds. Wild mustard was planted for the mid and late-season tests. Evaluations were made by visually estimating percent weed control.

Early season (Aug. - Sept.)

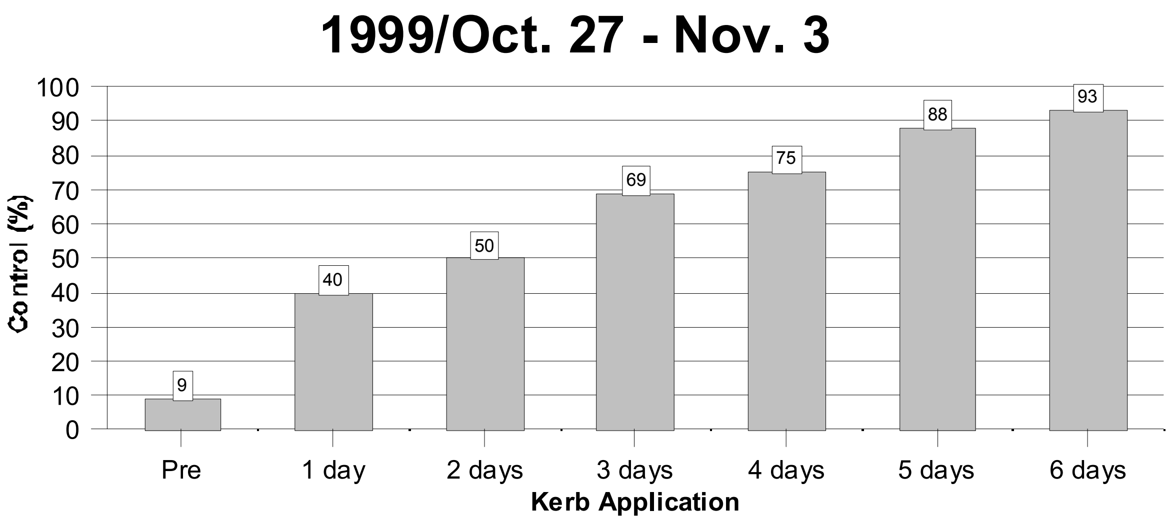
Soil temperatures (Top 4")	Yuma Valley, 2000: 87 to 100°F
Common weeds during this time period	Summer annual grasses Pigweed Purslane Sunflower Groundcherry Spurge
Likely time from irrigation to germination	24 to 96 hours



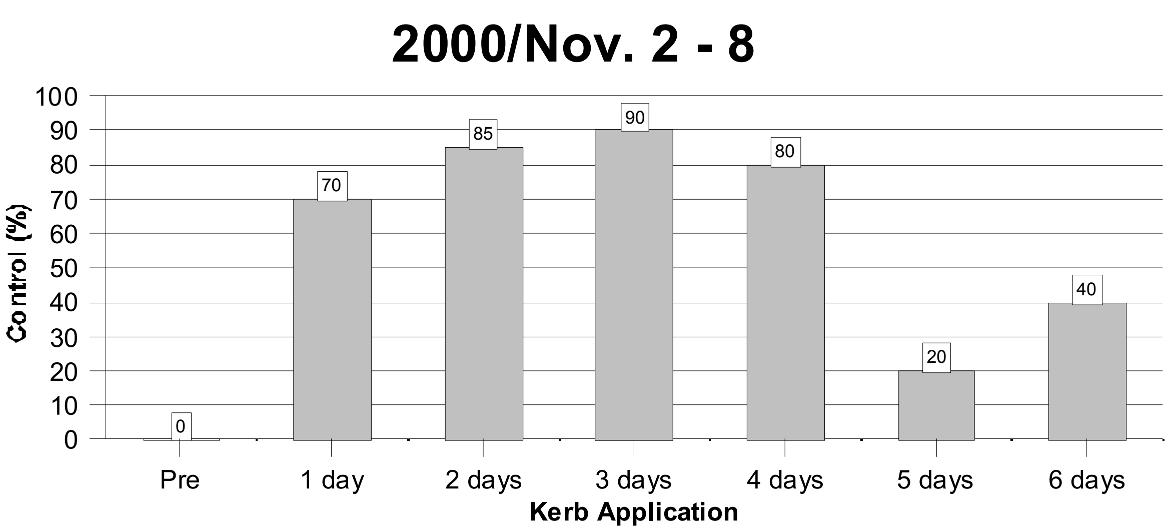


Mid-Season (Oct. - Nov.)

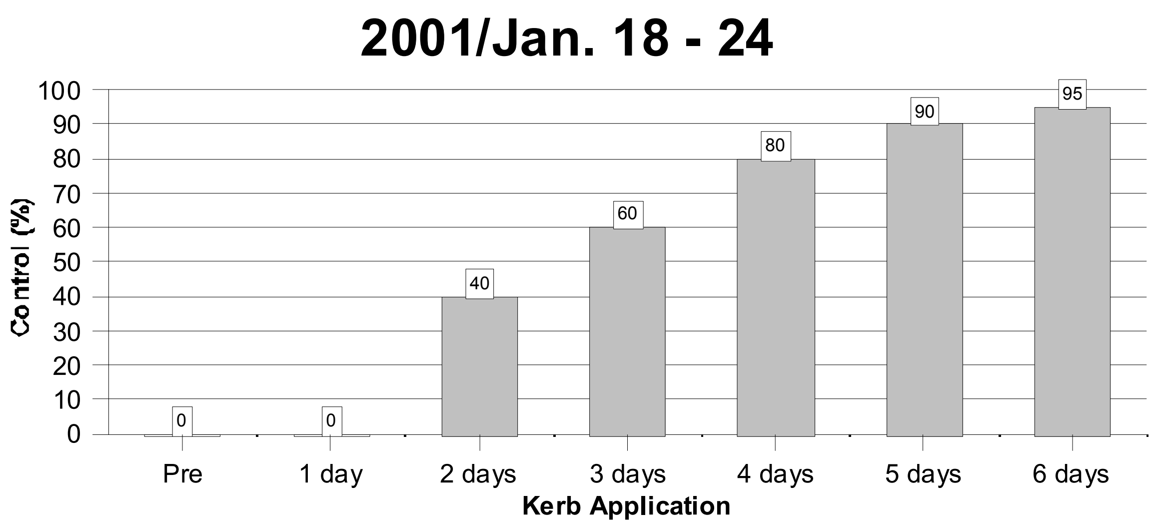
Soil temperatures (Top 4")	Yuma Valley, 2000: 58 to 87°F
Common weeds during this time period	Lambsquarters Goosefoot London Rocket Shepardspurse Prickly Lettuce Knotweed Sowthistle Wild Mustard * Summer annual weeds possible in October
Likely time from irrigation to germination	72 to 168 hours



Late Season (Jan. - Feb.)



<u>Soil Temperatures</u> (Top 4") Yuma Valley, 2000: 55 to 67^{o}F
<u>Common weeds during this time period</u> Mainly winter annuals, summer annual weeds possible in Feb.
<u>Likely time from irrigation to germination</u> unclear



Crop Injury

The delayed application of Kerb is a method of concentrating the herbicide in the area where the lettuce seed is germinating. Any method that concentrates the herbicide in this region will increase the possibility of crop injury. Crop injury sometimes occurs with all three of the preemergent herbicides used in lettuce.

Lettuce can tolerate Kerb and other herbicides when growing conditions are favorable. Anything that puts the crop under stress during stand establishment lowers this tolerance. This includes heat, cold, salts, disease, insects, poor nutrition and weak or inappropriate varieties. Primed and unprimed seed were compared in this year's test to evaluate this as a potential cause of crop injury. Priming did not cause increased injury in these tests. The only injury that has been observed has been from the treatments that were applied after the lettuce had emerged and when conditions were not favorable for rapid growth.

Delaying Kerb applications requires that aerial application be made. Aerial applications are generally less precise than ground applications and overlaps and skips are more likely. Where overlaps occur, a 2x rate is applied and injury more likely.

Conclusions

Lettuce is grown from August to April in the low desert and subject to varied and interrelated environmental conditions. The effects of delaying Kerb applications to improve weed control will vary from season to season, year to year and field to field. It is possible, however, to draw some general conclusions:

1. Kerb is ineffective when applied prior to starting sprinklers except on some of the most sensitive weeds.
2. Kerb should be applied 1 to 3 days after starting sprinklers in early-season plantings (Aug. - Sept.).
3. The most effective time to apply Kerb during mid-season (Oct. - Nov.) varied from 3 to 6 days after the sprinklers were started.
4. The most effective time to apply Kerb in the late season (Jan.) was 5 to 6 days after the sprinklers had started.

Tomato Weed Control: Historical Overview (1970-Present) and Current Research

Robert J. Mullen, Farm Advisor, University of California Cooperative Extension, San Joaquin County

Introduction

In 2002, California produced 93 percent of the processing tomatoes in the United States with a farm gate value of nearly $550 million; average per acre yields were nearly 38 tons. In 1970, the California industry was the dominant U.S. producer but the farm gate value was only $84.8 million and yields only averaged 23.8 tons per acre. The dramatic increase in production per acre and crop value can be attributed to a number of factors: varietal improvement, better cultural practices and certainly the development of Integrated Pest Management, with weed control a major component of this success.

As with most crops, tomatoes have been plagued with a number of weed problems that affect production including black nightshade (*Solanum nigrum*), hairy nightshade (*Solanum sarrachoides*), yellow nutsedge (*Cyperus esculentus*), dodder (*Cuscuta sp*.), field bindweed (*Convolvulus arvensis*), barnyardgrass (*Echinochloa crus-galli*) and other annual and perennial weed species. This paper will attempt to provide an historical overview of tomato weed control efforts since 1970, highlighting the major herbicides evaluated, the techniques employed and the changes that have occurred in the number of chemical companies and public sector researchers involved. The paper will be summarized with a brief presentation of current research and a look at some of the challenges to successful weed management that remain.

Tomato Weed Control (1970-1980)

Most of the tomato weed control effort concentrated on evaluation of preemergence herbicides, including Devrinol (napropamide), which attained a registration on tomatoes in the early 1970's. Deep shank injection of 1,3D into tall beds well in advance of crop planting was employed as well as the development of plug planting, using a dry mixture of peat moss, vermiculite, carbon and (tomato) seed put into beds that had marginally selective herbicides like Dual (metolachlor), Furloe (CIPC), Sonalan (ethafluralin), etc., shallow incorporated into the beds before planting. Growers began to go to fall bedding in an effort to plant earlier in the spring and this necessitated the fallow bed evaluation of Gramoxone (paraquat), Enide (diphenamed), Roundup (glyphosate) and Sencor (metribuzin). Also work started on postemergence use, over the tomato crop and emerged weeds, of Sencor and Basagran (bentazone).

During this decade, 18 preemergence and 3 postemergence herbicides were evaluated on tomatoes. Representatives of 14 chemical companies and 16 University of California academic personnel were involved in this research.

Tomato Weed Control (1981-1990)

During this period, preemergence efforts concentrated on the development of application methods of preplant application of Vapam (metham), including the use of a subsurface blade with soil cap sealing, high water volume soil drenches and mechanical incorporation. Perlka (calcium cyanamide) was also evaluated preplant either as mechanically or rainfall incorporated treatments. Postemergence treatments, over the tomato crop and emerged weeds (primarily hairy and black nightshade, involved evaluation of Sencor and Tackle (acifluorfen) and Basagran for yellow nutsedge management. Also postemergence evaluation of Poast (sethoxydin), Fusilade (fluosifop) and Select (clethodim) was done for grass control during the tomato cropping season. Fallow bed herbicide evaluation continued with standard materials and the addition of Goal (oxyfluorfen) and Ignite (glufosinate).

Sixteen preemergence and 10 postemergence herbicides were evaluated during the period with representatives of 17 chemical companies and eleven University of California academic personnel involved in tomato weed management research.

Tomato Weed Control (1991-2000)

Preemergence weed control efforts during these years continued the evaluation of Vapam and Perlka for preplant weed control as well as preplant incorporated and layby evaluation of Dual Magnum (metolachlor), Frontier (dimethonamid) and Prowl (pendimethalin). With the advent of the sulfonylurea family of herbicides, an intense research effort was conducted on the preemergence/postemergence examination of Shadeout/Matrix (rimsulfuron) for management of black and hairy nightshade, dodder and other annual broadleaved and grass weed species. The work was successful in obtaining a registration for Shadeout/Matrix in 1997, the first preemergence/postemergence herbicide registration on tomatoes in nearly 25 years. Sencor was also evaluated as single or sequential low rate postemergence applications during the early growth stage for the tomato crop. In the late 1990's, concentrated preemergence and postemergence evaluation of Permit/Sandea (halosulfuron) occurred with an abundance of work done on postemergence management of yellow nutsedge during the tomato cropping season.

Twelve preemergence and 9 postemergence materials were tested on tomatoes during the 1990's and representatives of 12 chemical companies and nine University of California academic personnel cooperated on tomato weed control research.

Tomato Weed Control – Current Research

For the past two years, weed control research in tomatoes has concentrated on preemergence evaluation of Prowl, Dual Magnum, Shadeout/Matrix, Sandea, Devrinol and Authority (sulfentrazone) alone or as combination treatments to maximize weed control efficacy and manage any potential problem of weed resistance with Shadeout/Matrix by using other preemergence herbicides having different modes of action. Postemergence research efforts have focused on Shadeout/Matrix and Sandea alone or in combination treatments, particularly in situations where nightshade and yellow nutsedge occur in the same field. Sencor is also included for control of both nightshade and other annual broadleaved weeds, as well as for weed resistance management where sulfonylurea herbicides may be used. Only 7 preemergence and 4 postemergence herbicides are currently being examined with representatives of only 7 chemical companies and 5 University of California academic personnel taking part in the tomato weed control research effort. Consolidation of companies into a few large entities, combined with the retirement of many University of California weed scientists has led to the current situation.

There are still many challenges to a truly successful tomato weed management program:

1 The development of only a limited number of herbicides for vegetable crop use
2 The need for vigilance in weed resistance management
3 The fact that problem weeds like dodder, field bindweed and velvetleaf *(Abutilon theophrasti)* are still not adequately controlled on tomatoes.
4 The current program of nightshade and yellow nutsedge management must be better defined to maximize weed control and reduce cost.

Weed Control with Methyl Bromide Alternatives

Husein Ajwa, Milt Haar, Steve Fennimore, and Mark Bolda
University of California-Davis

Possible alternative fumigants to methyl bromide (MB) include 1,3-dichloropropene (1,3-D), chloropicrin (Pic), methyl isothiocyanate (MITC), iodomethane (IM), and propargyl bromide (PrBr). Application of these fumigants through drip irrigation systems may provide a more uniform distribution of chemicals in soil (Ajwa et al. 2002) and greater weed control than shank injection (Fennimore et al., 2003). Our studies found that higher amounts of irrigation water would result in greater fumigant concentration in the gas phase across the soil profile. Factors affecting water distribution around a drip line include soil hydraulics, water application rate, drip system specification (emitter spacing and distance between the drip lines), and soil bed configuration (Ajwa et al., 2003). The objective of this research was to evaluate the weed control efficacy of alternative fumigants applied through drip irrigation systems in strawberry fruiting fields in California.

Methods

Several studies were established to evaluate weed control by fumigants applied through the drip irrigation systems. Soil gas concentrations of Pic, 1,3-D, MITC, IM, and PrBr (applied as Pic EC, InLine, metam sodium, IM/Pic mixture, and PrBr/toluene) in the soil profile were monitored following drip fumigation for 7 days. The effects of fumigants on weed seed viability were determined by burying weed seed samples at 5 cm deep in each plot prior to fumigation. Weed species tested were common chickweed (*Stellaria media*), common purslane (*Portulaca oleracea*), little mallow (*Malva parviflora*), and prostrate knotweed (*Polygonum aviculare*). About 7 days after fumigation, weed seeds were removed and viability was tested in the lab using tetrazolium. Native weed biomass (fresh weight) in all plots was determined at least twice during the crop growing season.

Results

Fumigant (1,3-D, Pic, and MITC) movement and distribution in soil depends largely on the amount of irrigation water used to deliver the fumigant. Figure 1 shows 1,3-D distribution in a Watsonville sandy loam soil approximately 24 hours following drip fumigation with InLine (393 L ha^{-1} or 476 kg ha^{-1}) using three amounts of irrigation water (26, 43, and 61 mm). These figures show that the concentration of 1,3-D in the soil air space was highest when applied with the largest amount (61 mm) of irrigation water, even though the concentration of 1,3-D in the applied water was the least (450 mg L^{-1}). The highest concentrations of fumigants in the soil air with large amounts of application water suggest that water reduces fumigant volatilization losses, possibly by reducing the total air space in soil and/or by forming a water seal. Our studies indicated that a minimum of 40 mm of water is needed to move the fumigant horizontally 30 cm in a sandy loam soil beds.

Application of these fumigants through the drip irrigation systems provided equal or better weed control than equivalent rates applied by shank injection (Table 1). InLine and Pic efficacy on little mallow or prostrate knotweed seed buried at the center of the bed did not differ from MB:Pic (Table 2). However, the percentage of weed seed survival at the edge of the bed was often higher in the shank treatments than in the drip-applied treatments, possibly due to the close proximity of the shank-injected fumigant to the edge of the bed. Weed seed sensitivity was in the order: Common purslane > prostrate knotweed > little mallow. Seed coat hardness thought to be responsible for differences. Drip applied InLine was often more active on weeds than shank applied Telone C35. Metam sodium was less effective than MB:Pic on the native weed population or on buried weed seeds.

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Fennimore, S.A., M.J. Haar and H.A. Ajwa. 2003. Weed control in strawberry provided by shank- and drip-applied methyl bromide alternative fumigants. HortScience. 38 (In press).

Table 1. Effect of MB:Pic and alternative fumigants on weed fresh weight. Total mean weed fresh weight $g \cdot m^{-2}$ of shank-applied MB:CP was compared to Pic, Inline, Telone C35 or metam sodium applied through the drip irrigation system or by shank injection at Salinas and Watsonville.

Treatment	Rate ha^{-1}	Application method	*Salinas 1999*	*Watsonville 2000*
			---------------- $g \cdot m^{-2}$ -------------------	
MB:Pic standard	425 kg	shank	39.0	20.3
Telone C35	374 L	shank	48.3 (0.81)[a]	50.0 (0.17)[a]
Inline (60%)	236 L	drip	25.5 (0.98)	14.9 (0.80)
Inline (100%)	393 L	drip	17.3 (0.55)	7.1 (0.44)
Pic EC	130 L	drip	31.3 (0.78)	10.8 (0.65)
Metam sodium (60%)	420 L	drip	98.9 (<0.01)	15.6 (0.82)
Metam sodium (100%)	700 L	drip	89.2 (<0.01)	4.8 (0.40)
Untreated	0	--	516.6 (<0.01)	186.7 (<0.01)

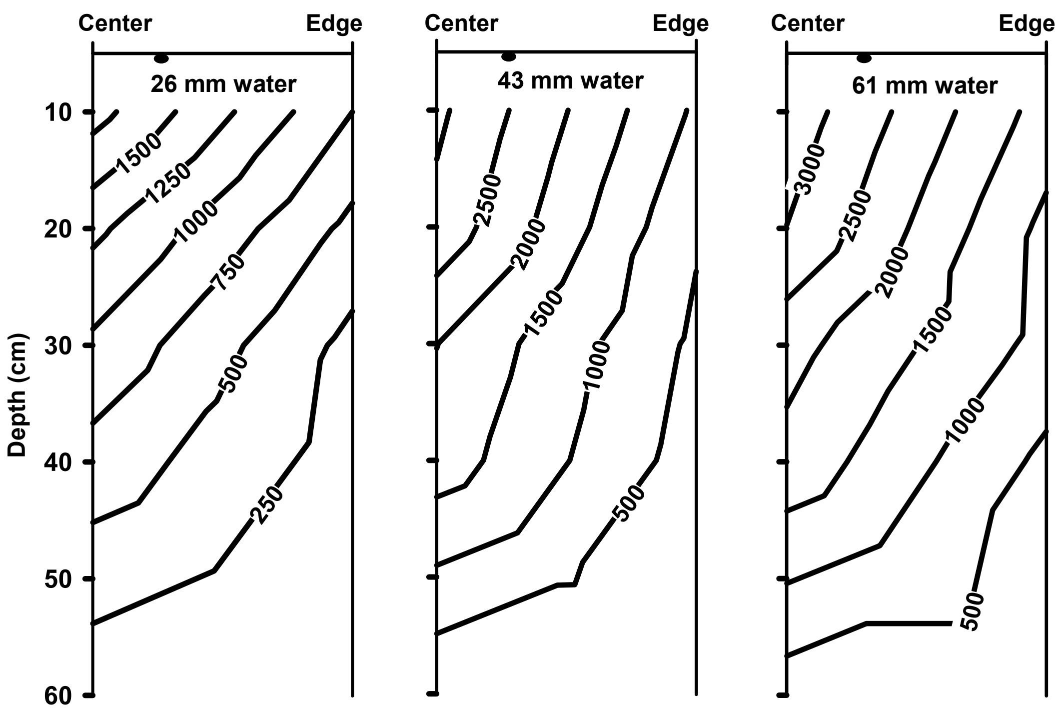
[a] P values of single degree of freedom contrasts comparing weed biomass with MB:Pic treatment.

Table 2. Efficacy of Pic, Inline, Telone C35 and metam sodium on prostrate knotweed seed viability compared to MB:Pic at Watsonville in 2000. The data are percentage viable seed buried
in the center and edge of a 1 m bed.

Treatment	Rate ha^{-1}	Application method	Prostrate knotweed		
			Center	Edge	
			---------- % viable ----------		*P* value
MB:Pic standard	425 kg	shank	0.13	1.77	0.73
Telone C35	374 L	shank	0.25 (0.92)[a]	26.82 (0.26)[a]	0.08
Inline (60%)	236 L	drip	0.06 (0.95)	88.63 (<0.01)	<0.01
Inline (100%)	393 L	drip	0.07 (0.95)	49.38 (0.04)	<0.01
Pic EC	130 L	drip	1.83 (0.52)	89.27 (0.03)	<0.01
Metam sodium (60%)	420 L	drip	5.45 (0.20)	91.70 (<0.01)	<0.01
Metam sodium (100%)	700 L	drip	3.17 (0.29)	90.48 (<0.01)	<0.01
Untreated	0	--	98.3 (<0.01)	79.80 (<0.01)	0.28

[a] P values of single degree of freedom contrasts comparing weed biomass with MB:Pic treatment

Figure 1. The concentration of 1,3-dichloropropene (µg 1,3-D L^{-1} air) in the gaseous phase of a Watsonville sandy loam soil 24 h after drip application of InLine at 393 L ha^{-1} (58% 1,3-D) in three amounts of irrigation water.



Integrated Weed Management Practices at Teixeira Farms Inc.

Vincent Ferrante, Crop Protection Manager, Teixeira Farm Inc., Santa Maria, CA

Lettuce, broccoli, cauliflower, cabbage celery and romaine are the main vegetable crops at he 4800 acre Teixeira Farm near Santa Maria, CA. Weed control for a new cropping season starts with field preparation after harvest. Repeated use of 'Sundance' type cultivator to break and incorporate the foliage of the previous crop also ensures weed and residue-free soil surface. Shallow tillage does not disturb and bring to the surface the weeds from the seed bank at greater depths. Fertilizer application is timed to disturb emerging weeds before they establish true leaves. Ammonium nitrate is applied in the areas of weed germination in the seed line as a foliar application on cole crops to suppress weed growth. Herbicides are sprayed on small germinating weeds in non-crop areas, which allows to lower the application rate. Crop maintenance also includes hoeing and weeding during thinning (for example for lettuce). Cover crops such as barley or oats are planted between production seasons to occupy the fields and provide competition with weeds and surface cover.

Weed control is not limited to the crop-growing area in the field. Field edges, roadsides, ditches or canal banks may become reservoir for weed seed production and spread, and therefore, are kept weed free. Besides herbicidal sprays, weed management is accomplished by planting trailing ice-plant on steep banks. Trailing ice-plant colonizes these sites, provides weed competition, dust and erosion control, while its flowers have aesthetic value. Weeds are hoed near the water edges in canals and in areas where ice-plant did not establish. Careful management of these artificial riparian zones improves water quality and is supported by the Fish and Game Department.

Area-wide approach to weed control is accomplished by communicating with neighbors about problem areas and cooperating to destroy weeds on the property borders, along fences and other areas that may become distribution sources for weed populations.

Borders and non-crop areas are subject of constant monitoring for weed emergence, weed species and growth stages, to ensure that escape weeds do no produce seed and re-infest the area.

Tuesday, January 21, 2003
What's New In Weed Science?
Moderator: Carlos Reyes, Monsanto

All GPS Receivers Are Not Created Equal

John W. Jarnagin, Electronic Data Solutions, Exeter CA

GPS, we all know what it is, right? The acronym stands for Geoprocessing Software, I mean Geoid Positioning Style, er, uh Global Positioning System, that's it. Let's face it; the acronym has been around for quite some time. Choices abound as to what brand of GPS receiver to purchase. Just as there are different companies that make GPS systems, there are different grades of GPS receivers to choose from, as well. I will present the three different grades of GPS receivers and the different functionality offered by each grade.

Navigational Grade: This kind of GPS receiver is readily available in many stores. It is the least expensive of the other grades and ranges in price from one hundred fifty to five hundred dollars. This kind of GPS unit is used for navigation and can collect x-y coordinates. Usually you only can collect point data. This grade of receiver is not recommended if you want to incorporate the GPS data collected into GIS/mapping software as the finished product. Horizontal accuracy that can be achieved on this grade of GPS unit ranges in the five-meter area, if you are running in real time.

Mapping/GIS Grade (specifically Trimble brand): This type of receiver is more expensive than the navigational grade receivers but in return offers better horizontal accuracy and increased functionality. This grade of GPS unit ranges in price from four hundred ninety five to twelve thousand dollars. A Mapping/GIS grade receiver has data dictionary capability. This means that detailed information about a feature can be entered directly into the GPS receiver, thus skipping the tedious task of data-entry back in the office. Data collection for points, lines and areas can be accomplished using this grade of GPS system. Horizontal accuracy ranges from sub-meter to five meters, when running in real-time or after correcting the data using a base station. Mapping/GIS grade receivers allow for external sensor interface input from equipment such as water quality instrumentation, laser rangefinders, bar-code wands, etc. An example of this grade of receiver is the brand new Trimble GeoExplorer CE system that offers a Windows CE platform, color touch screen and horizontal sub-meter accuracy in a handheld GPS unit.

Survey Grade: This grade of GPS receiver is extremely accurate (around two centimeters or better in regards to horizontal accuracy) and with that said, costs more than the other grade of receivers. Survey grade GPS systems range in price from third five thousand to seventy five thousand dollars (that's right, I said thousand, not hundred).

Just as there are many grades of receivers available there are many applications, which require different functionality and accuracy. So with that said, the choosing will be up to you, the end-user. Consider price, horizontal accuracy and functionality before making that GPS purchase. Ask your GPS vendor for an on-site demonstration.

Wednesday, January 22, 2003
Session A: Insert Weed of the Year: Nutsedge
Moderator: Kurt Hembree, Farm Advisor
University of California Cooperative Extension

History and Biology of Yellow and Purple Nutsedge

Dave Cudney
Extension Weed Scientist, U.C. Riverside

The nutsedges are members of the genus *Cyperus*. Cyperus is the "type genus" for the sedge or Cyperaceae family. Sedge family members are annuals or perennials, often found in wet habitats. They have three-sided stems and leaves that come off the stem on each of the three sides (three ranked). There are about 110 genera in the family and about 3600 species. Although there are 16 members of the genus in California which are known to be weedy, purple nutsedge (*C. rotundus*) and yellow nutsedge (*C. esculentus*) are by far the most troublesome. The genus name Cyperus is from Cypeiros which was the ancient Greek name for the genus. Rotundus is Latin for round and refers to the tuber and esculentus is from the Latin referring to the tuber as "edible". Yellow nutsedge is also known as Chufa, ground almond, earth almond or rush nut. Purple nutsedge is known as coco-sedge or coco-grass. Both species are often incorrectly referred to as "nutgrass"

Purple nutsedge has bracts or leaves which subtend the inflorescence and are shorter than the inflorescence. The bracts of yellow nutsedge are longer than the inflorescence.

Purple nutsedge is found in the warmer parts of southern California, Arizona, and 11 southeastern states. In the northern hemisphere it is seldom found above the 35th parallel or where the average mid-winter air temperatures drop below 28 F. Purple nutsedge is favored by high light, warm temperature, sandy soils and moist soil conditions. Worldwide it is rated as the world's worst weed. Purple nutsedge is thought to have originated in India and now can be found as a serious or problem weed in more than 70 countries. It is a severe problem in most irrigated summer crops throughout the tropical and semitropical regions. It has been reported to infest cotton, rice, cowpea, beans, soybeans, tomatoes, melons, carrots, tree and vine crops, turf and ornamentals. The tubers of purple nutsedge have a very strong and unpleasant taste and are not usually used for food, as are the tubers of yellow nutsedge. One reference did tout a medicinal use for the tuber.

Yellow nutsedge is found throughout most of California and in all fifty states except North Dakota and Alaska. In the northern hemisphere it is found up to about the 50th parallel. World-wide yellow nutsedge has been listed as a serious or problem weed in over 18 countries and is found many places where the average mid-winter air temperature does not drop below 0 F. Yellow nutsedge's favored habitats include sites with high light, sandy soils, and high soil moisture. Worldwide, it is rated in the top 20 of the world's worst weeds, most often as number 16 or 12. It is most commonly found in subtropical regions. In California it probably ranks above purple nutsedge as a serious weed due to its wider distribution in the state and would easily be in the top ten of our worst weeds. Yellow nutsedge is also a problem in cotton, rice, beans, soybeans, tomatoes, melons, carrots, tree and vine crops, turf and ornamentals.

Yellow nutsedge has been cultivated as a food crop. It has been grown for hog pastures in southeast U.S. and in the Mediterranean Region as "chufa", a food and beverage crop. The tubers are often eaten raw, cooked, ground to make a beverage after soaking, or scorched and ground to make an "instant coffee". One recipe calls fore roasting until dark brown, grinding, and brewing with a tablespoon per cup. Toasted tubers are eaten as "earth almonds". Many people consider them to be quite good. The tubers are also touted to have some medicinal uses in the treatment of boils, colds, colic, stomachache, ulcers, bladder ailments, etc.

The nutsedges cause serious economic losses. In crops that they infest it is common to have reports of up to 50% yield losses. Most of the damage that nutsedges do to annual crops is done early in the growing season, where heavy infestations, sometimes exceeding 2,000 plants per square meter, compete with crop seedlings for light, moisture and nutrients. If nutsedge can be reduced early with herbicides, cultivation or hand weeding, the crop gains a height advantage then crop shading reduces the competition effects of nutsedge. Heavy infestations of nutsedge often prohibit the production of summer crops. This necessitates summer fallow and rotation to other less profitable crops. Where practical in high value vegetable production, nutsedge infested land has been fumigated. Fumigation is often used for disease and nematode infestation as well as nutsedge control. Fumigation is very expensive, sometimes exceeding $1000 per acre. Fumigation, reduces nutsedge, but may not eradicate it form the site. Nutsedge is an example of a weed that can reduce land values. If heavy infestations are present on agricultural land, value can be reduced by as much as $200. per acre.

In turf nutsedge has a differe3nt and unsightly texture than desirable turf species. Nutsedge grows more rapidly than turf, extending its shiny leaves above the turf canopy. It is readily apparent two to three days after mowing. In addition the sod strength of nutsedge is much weaker than normal turf species; providing poorer footing for athletic events. Ornamental areas that become overgrown with nutsedge grow poorly and are of inferior quality. Hand removal of nutsedge from theses areas is extremely expensive; and due to the regrowth of buried tubers, is usually on successful. Often the only solution for nutsedge is to remove infested soil down to a depth of three feet and replace the soil with tuber-free soil. This operation can cost thousands of dollars per acre. The nutsedges are examples of weeds where the economic damage that they do is not only due to the cost in lost production of crops and ornamentals but also in costs of waging and ongoing war on this serious pest.

Few weeds have had as much research as the nutsedges. Many researchers have spent significant portions of their careers studying these pests. Bendixen in Ohio spent years studying the anatomy and sprouting of tubers. Dave Bayer at UC Davis studied germination, apical dominance, and translocation of herbicides in yellow and purple nutsedge. Day at UC Riverside studied the effects of drying on tuber survival. UC Farm Advisors Bill Fisher, Harold Kempen, Harry Agamalian, Tim Prather, Carl Bell, Cheryl Wilen, Ron Vargas, Steve Wright, Kurt Hembree, and Robert Kasllenbach have dealt with the biology, cultural and chemical control of these pests. UC Specialists including Clyde Elmore, Milt McGiffen and Art Lange have worked extensively with nutsedges and their management.

Many herbicides have been studied for their effects on the nutsedges. Early reports were published in the 1950's about control with a new miracle herbicide, 2,4-D. Later reports dealt with the use of MSMA, bentazon, thiocarbamates (EPTC, cycloate, etc.) the acid amides (alachlor, metolchlor, etc.), traizines (atrazine, metribuzin, etc.) uracils (bromacil) and fumigants (methyl bromide and metham), glyphosate, and finally the imidazolinone (imazaquin and imazethapyr) and the sulfonylurea (halosulfuron) herbicides. We have coma a long way in the last 50 years. I can remember crawling around on my hands and knees to place a drop of 2,4-D from an eyedropper into the central whorl of nutsedge plants in my lawn (with little success). Now with one or two applications of halosulfuron either yellow or purple nutsedge can be controlled in turf for a whole season. It is true that we now have many chemical tools that can be useful in a nutsedge management program, yet no one herbicide can completely control nutsedge. It requires a combination of chemical and cultural methods and a lot of patience.

Nutsedge management continues to be an elusive goal, one that may take several more research careers and years to solve.

Alternatives for Purple and Yellow Nutsedge Management

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Purple and yellow nutsedge are two of the world's worst weeds. The nutsedges are problem weeds throughout California, with purple nutsedge predominating in the southern half of the state. These perennials have a remarkable ability to survive adverse conditions and then grow explosively when the land is planted to irrigated crops. Losses can result when nutsedges compete with crops to decrease yield or directly damage below-ground plant parts such as onion bulbs. Nutsedge can even decrease property values, because potential tenants know that it is nearly impossible to eradicate the weed once established.

The nutsedges produce both seeds and tubers, but most reproduction is by tubers. The tubers may be thought of as a resting stage that allows the weeds to survive adverse conditions. Many people say tubers can survive almost anything. In fact, a large percentage of tubers are often killed during dormancy, but even only one percent of the tubers from a previous infestation are more than enough to bring back the population of these prolific weeds.

Understanding nutsedge control begins with the realization that tubers are the key to the weed's survival. Prevent tuber production, and you eliminate the weed. But the tubers can remain dormant and impervious to pesticides for years. Control programs should be aimed at preventing the formation of tubers through prevention of growth of nutsedge plants. If no new tubers are formed, tuber mortality will eventually eliminate nutsedge problems.

The best control of nutsedge is often obtained by growing competitive crops. Nutsedge is susceptible to shading, and crops that quickly form a dense canopy can outcompete the weed. Sudangrass, corn, and wheat are crops that have been suggested as able to shade out nutsedge. Conversely, melons and other warm season crops that do not shade the ground may be overrun by nutsedge infestations. Sudangrass is a rotational crop that could be grown during the summer to shade out nutsedge, and then followed with winter vegetables. A field so heavily infested it looked like a purple nutsedge lawn was planted with sudangrass. By midsummer, the dense sudangrass canopy had killed emerged nutsedge. Several growers have eliminated nutsedge as a pest by using summer rotations of competitive crops over several field seasons.

Tillage can be effective at reducing nutsedge populations, but it must be done thoroughly and often. Tillage should not be so deep as to bring additional tubers close enough to the soil surface that they germinate. To prevent tuber formation, cultivation must be done frequently, before the plants are have more than three leaves.
The order of field operations should be:

1) Form the beds.
2) Irrigate to germinate the tubers.
3) Cultivate to kill plants before they emerge.
4) Plant the crop to moisture.
5) Continue cultivation throughout the growing season.

Approaches that integrate several control methods have the best chance of effectively managing nutsedge. Irrigation and tillage can break tuber dormancy, encourage sprouting, and make nutsedge susceptible to fumigants and other herbicides. A control program recommended by the University of Arizona starts by fallowing the ground during July, when nutsedge is actively growing. Begin with a pre-irrigation to end dormancy and cause the nutlets to sprout. This initial flush of nutsedge is allowed to grow until soil moisture is depleted, generally about 3 weeks after nutsedge emerges. Shallow tillage such as disking will kill emerged nutsedge and help desiccate shallow tubers. EPTC is applied to the dry soil at 3.5 pints per acre and immediately incorporated. Make two applications of EPTC to heavily infested soils. The ground is then prepared to establish the crop, and irrigation water applied. Consult the EPTC label for how long to wait before planting the crop, as EPTC injures many crops.

Rotating with crops that are fumigated or can use linuron, halosulfuron, and other nutsedge herbicides helps to reduce nutsedge. Halosulfuron is becoming available for use in sweet corn, tomatoes, melons, and other warm season vegetables under the trade name Sandea, and can be applied both pre- and post-emergent. Halosulfuron can persist in the soil to injure subsequent crops. Most cool season vegetables are susceptible to halosulfuron injury.

Biological control has also been tried for nutsedge, but has generally been ineffective. Many insects and diseases infest nutsedge, but none has been shown to kill enough plants to be an effective control. Work with nutsedge diseases continues in Florida and other places, but our arid climate makes it unlikely that a bioherbicide will be an effective weed control in California.

Fumigants are the principal weed control method in some vegetables and other high value crops. Fumigation will not kill dormant tubers. Efficacy can be improved if tillage and irrigation are used prior to fumigation to sprout dormant tubers. Tarping the field and applying Vapam through drip systems will also help kill tubers that are actively growing but buried deeper in the soil. Incorporating metham sodium as it is applied also helps to evenly distribute it throughout the soil.

Solarization is a nonchemical soil sterilization method. A clear plastic tarp is used to cover the soil and raise temperatures high enough for pastuerization. Solarization is often reported as ineffective in controlling nutsedge. However, we observed significant control of emerged purple nutsedge in our Coachella Valley experiments, and other inland locations. It may be possible that by carefully timing when solarization is initiated will make it somewhat effective for nutsedge control.

In summary, yellow and purple nutsedge have earned the right to be considered among the world's worst weeds. The key to nutsedge control is to prevent tuber production, and stimulate dormant tubers so that they will be susceptible to control. Eptam and fumigation treatments can give some control, but can only be used when no crop is present. The best cultural control is to grow a crop that forms a dense canopy during the summer when nutsedge is active. Halosulfuron, linuron, and other herbicides have some nutsedge activity. The weed susceptibility chart on the Weed Research and Information Center website lists how well nutsedge and other weeds are controlled by herbicides, and can be downloaded at: http://wric.ucdavis.edu/information/weedchart.html.

Nutsedge Control in Field Crops

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Introduction

Nutsedge is commonly described as the world's worst weed. Yellow nutsedge (*Cyperus esculentus*) and purple nutsedge (*Cyperus rotundus*) are troublesome perennial weeds in California. The most common species in most areas is yellow nutsedge, but purple nutsedge, is more common in desert areas and southern San Joaquin Valley. Left uncontrolled, they can significantly reduce stand establishment, yield, and quality in cotton and other field crops. Infestations often begin in poorly drained parts of a field or along irrigation ditches. Tubers are commonly spread by tillage equipment. Cleaning equipment before moving between fields will keep nutsedge from infesting new fields.

Nutsedge can reduce yield substantially if allowed to compete with the crop during the first few weeks after planting, especially if the competition is great enough to cause moisture stress in crop seedlings. To prevent losses, prevent nutsedge from emerging ahead of the crop. To give the crop a head start on nutsedge, use sweeps to dislodge early nutsedge shoots before planting in row crops. In preirrigated fields, the use of sweeps may result in a small loss of soil moisture, but the moisture savings gained from slowing nutsedge growth compensates this loss.

Summer Fallow Programs

Purple nutsedge tubers are susceptible to drying and can be destroyed with repeated summer tillage. Spring-tooth harrows are usually the best tools for this purpose; discing is often ineffective. Work conducted by Paul Keely at Shafter Research Station showed 95 percent control by listing and splitting the beds in summer. The remaining 5 percent still remains a problem the next season. Tillage is not likely to be successful in soils that form large clods or in fields where a high water table keeps soil near the surface moist. Tillage is not as practical for control of yellow nutsedge, because the tubers can survive up to 4 years in dry soil. Reports on the effectiveness of tillage are variable and often contradictory partly because of a general failure to distinguish between the species of nutsedge.

The use of EPTC (Eptam) during a fallow or idle summer season can suppress the growth of both yellow and purple nutsedges. Preirrigate the field in June or July to sprout tubers and allow nutsedge to emerge. Apply EPTC as a broadcast application and incorporate by discing at the same time. For best results, use a finishing disc in two directions with a heavy drag bar to seal the soil surface. Treat the nutsedge shoots that escape the EPTC treatment with spot applications of glyphosate. After application, leave the soil undisturbed for at least 60 days. To prepare the land for planting of a subsequent crop, preirrigate and disc the soil at least once before the beds are formed. Plant back restrictions vary for different crops.

The most effective control is obtained by preventing the production of new tubers. Prevent the nutsedge plants from developing beyond their 4 to 6-leaf stage. Repeat applications of glyphosate at 1.0 to 2.0 lb ai/A or with Halsulfuron (Sempra) gives excellent control applied postemergent to purple or yellow nutsedge. Treating at least twice but often three times a year at monthly intervals is essential to prevent new tuber formation. Halsulfuron is more effective but has plant back restrictions that will limit its use for most broadleaf crops. Repeated applications of MSMA may also provide some control. Postemergent applications of herbicides will not be effective if nutsedge is water stressed. Delaying the treatment beyond the 6-leaf stage of growth can reduce the effectiveness of earlier treatments because of the production of new tubers.

Deep Plowing

Nutsedges grow mainly from tubers or "nutlets" and can emerge from a depth of 20 inches. Plants are capable of producing up to 300 tubers each. Tubers can remain viable up to 4 years. The primary means of reproduction is through underground vegetative propagules (tubers) formed on rhizomes, mostly in the upper 1-foot (30 cm) of soil. As these tubers mature, they become impervious to most herbicides and require alternative methods for control.

Burying nutsedge tubers can result in high tuber mortality (80% or more) through decomposition, but it is difficult to bury them with most conventional equipment. A modified moldboard plow (Kverneland plow) was designed to invert the upper soil profile to a plowing depth. It has been used with some success to bury weed seeds such as black nightshade as well as disease pathogens (sclerotinia in lettuce).

Kurt Hembree, Tim Prather, and Michelle Lestrange conducted studies to contrast the effectiveness of a moldboard and Kverneland plow at burying yellow and purple nutsedge tubers deep into the soil profile. The Kverneland plow reduced the number of yellow nutsedge tubers to a depth of 8 inches, while purple nutsedge tubers were reduced in numbers to a depth of 10 inches. Since a significant number of yellow nutsedge tubers died after burial at a depth of 12 inches or more, using the Kverneland plow for deep burial can be an effective tool in a yellow nutsedge control program. However, in order to prevent bringing up remaining viable tubers, the field should not be plowed again for at least two years.

Purple nutsedge tubers were also distributed at higher numbers deep in the soil profile than yellow nutsedge, making it more difficult to obtain control since many tubers at the middle depth remain at that depth and can produce plants during the growing season. The five-bottom Kverneland plow used in one study did not invert the soil as effectively as the two-bottom plow. The horsepower requirements of the larger plow may have taxed the 240 HP tractor sufficiently so that the tractor could not pull the plow at a speed necessary for proper soil inversion. A tractor equipped with front-wheel-assist would have benefited the operation of the plow. While there appeared to be no difference in cotton stand establishment between the two plow treatments, purple nutsedge plants emerged at least two weeks earlier in the moldboard than in the Kverneland treated plots.

Metham Herbicide Applications

A preplant application of metham in cotton or vegetable crops can help suppress severe infestations of both purple and yellow nutsedge. Apply metham to preirrigated, preformed beds with an 8-inch (20-cm) spray blade 4 to 6 inches (10 to 15 cm) below the soil surface and then cover the treated soil with a 2- to 3-inch (5- to 7.5-cm) layer cap of soil. The soil must be in seedbed condition, with no clods or trash, and with soil moisture at least 50 percent of field capacity. On a well-drained soil of light to medium texture (sandy loam to loam) that is not excessively wet or cold following application, planting may take place 14 to 21 days after treatment. If the soil has high clay content, is high in organic matter, or remains wet and cold, allow at least 21 days before planting. To determine if it is safe to plant following a metham treatment, transplant a potted pant, such as a succulent annual, into the field. If the plant is growing within 1 to 2 days of transplanting, it is safe to plant. At planting, avoid mixing untreated soil with treated soil. Control will be lost in the seed row if treated soil is pushed into the furrow or untreated soil is moved into the planted row. Metham can cause yield reductions in some fields due to loss of soil mycorrhizae resulting in reduced phosphorus uptake by the young cotton seedling.

Crop Rotation

In addition to summer fallow, several combinations of rotation crops, herbicides, and tillage can improve long-term management of nutsedge. An established crop effectively competes with nutsedges, which have little tolerance for shade. With effective early season nutsedge control there is sometimes little need for special control measures later as long as a good crop stand exists. Crops such as corn, sorghum, and alfalfa are effective rotation crops because of their ability to shade nutsedge and herbicides in those crops can be used to reduce nutsedge populations.

Nutsedge Control in Cotton

When used alone, the foliar-applied herbicide MSMA can suppress nutsedge in the seed row after cotton has emerged. MSMA is more effective on yellow than purple nutsedge. It is safest to use on cotton in the cotyledon stage, however it is not registered to use until cotton plants have two or more true leaves. Temperatures need to be at least 80 degrees F. to be effective. Make a second application 1 to 3 weeks later using a directed spray aimed at the base of the cotton. All applications must go on before first cotton bloom. MSMA will often cause a purplish discoloration and may retard cotton growth. Injury to cotton can be severe when plants are stressed for water. Don't use MSMA more than twice per season as it may leave a soil residue that can damage some rotation crops.

More growers have shifted to herbicide-resistant cotton to avoid injury associated with MSMA. Approximately 30 percent of cotton acreage in California is planted to Roundup Ready cotton and will likely increase as new varieties are developed. Glyphosate is applied in two applications over the top of glyphosate-tolerant cotton before the fourth leaf stage of cotton. A third application is often required using a hooded sprayer after the 5^{th} leaf stage. Generic glyphosates have shown similar control in a couple University studies. More consistent control is obtained when ammonium sulfate at 5 to 15 lbs/A is mixed with Roundup. In the future we look forward to enhanced Roundup Ready varieties that have more crops safety with a greater application window.

Careful cultivation is essential for early season control even when using herbicides. After cotton has emerged, use precision equipment to cultivate as closely as possible to the crop row. Use sweep type cultivators (Alloways). Rolling cultivators are ineffective for nutsedge suppression and spread nutsedge tubers creating larger areas of infestation.

Nutsedge Control in Alfalfa

Another partially successful rotation in the San Joaquin Valley includes alfalfa treated with EPTC (Eptam).Two applications are needed before July. Eptam is more effective on lighter soils. This rotation has not been as effective at reducing nutsedge in Southern California desert valleys and in Arizona. Zorial (norflurazon) applied postemergent has given short-term (about 4 weeks) suppression of nutsedge. Crop phytotoxicity is a concern and the long soil residue restricts rotations.

Nutsedge Control in Corn

Nutsedge is very competitive with corn in the early stages of growth. Running a sweep four inches below the top of the bed or power tilling the beds with L-shaped knives 3 to 4 inches deep before planting is effective in inhibiting nutsedge that has already sprouted. It is important to cultivate a second time for nutsedge after the crop has emerged. In the second cultivation, throw soil to the corn plants to suppress nutsedge growth and allow corn growth to shade the furrow. Keep at least 4 inches from corn plants to avoid pruning fibrous roots and use sweep type cultivators.

Metolachlor (Dual) and alachlor (Lasso) herbicides can give effective preemergence yellow nutsedge control. EPTC (Sutan, Eradicane) applied preplant incorporated provides good control of both yellow and purple nutsedge in corn. Use the higher labeled rates for the most effective control. To maximize the performance of preplant incorporated herbicides, the following is important: 1. Preirrigate where feasible. 2. Disc in manures before incorporating the herbicide. 3. Incorporate to the proper depth: 4 to 6 inches for EPTC and 2 to 3 inches for alachlor or metolachlor. 4. When using a rotary hoe, incorporate two times, in opposite directions. 5. Broadcast applications of EPTC require cross discing for maximum incorporation and effective weed control. 6. Time incorporation according to the manufacturer's label: EPTC immediately; alachlor and metolachlor, 7-14 hours. 7. Use proper incorporation speed. 8. Disturb nutsedge by using sweeps or power mulchers before planting. 9. Plant immediately after herbicide application.

Halsulfuron (Sempra) gives excellent control applied postemergent to purple or yellow nutsedge. Two applications are preferable. Make the applications when nutsedge is less than 5 leaves. Do not cultivate within 7 days following application. Halsulfuron can be applied over the top of corn or with drop nozzles from the spike stage through layby. Glyphosate applied to Roundup Ready corn varieties will provide good control. Two applications are most effective. Tank mix combinations of Sempra and glyphosate should enhance control in Roundup Ready corn.

Conclusion

Because nutsedge is nearly impossible to eradicate and will quickly reinvade the field if control measures are relaxed, a vigorous control program must be maintained indefinitely. Persistence in pursuing proper control measures including all possible cultural and chemical control methods, results in considerably reducing nutsedge populations.

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Nutsedge Management in Landscaped Areas

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Nutsedge management in turf and landscaped areas require different strategies than those used for field crops. While field crops are often grown as monoculture, landscaped areas usually have a number of different species planted at the site and crop/weed selectivity becomes an issue when selecting a herbicide. Additionally, since most landscaped sites are planted with mixture of annual and perennial crops cultivation is not usually an option for control. Alternatively, since the sites may be small areas, hand weeding or fabric mulches can be employed. In turf, which is a monoculture, selective herbicides may be applied for successful control of nutsedge but care must be taken regarding the tolerance to the turf species to the herbicide.

While there are cultural and chemical controls for nutsedge, the most important part of a control strategy is prevention. In many cases, nutsedge is introduced into turf and landscaped areas from soil that is contaminated by nutsedge tubers. Since nutsedge prefers wetter areas, it is often found in sandy stream banks. When that sand is used as a soil amendment or as filler for holes in an area, there is a good chance that the nutsedge will establish in those sites. Choose clean and screened sand for those uses. Soil from contaminated fields also has the same risks so it is imperative that the distributor supplies only clean soil.

Non-chemical control of nutsedge in landscapes is obtained by using a combination of shading out the nutsdege plants, use of heavyweight fabric mulch, and diligent hand removal of sprouts. Since tubers will generally only survive two to three years in the soil, removal of plants before they produce new tubers (the five-leaf stage) will effectively control the population in two to three years. Fabric mulches have been shown to suppress the growth of nutsedge but care must be taken that the fabric is not torn or otherwise have holes in it or else the nutsedge can grow through the holes. The most common source or holes in fabric mulches is from pulling out plants that have rooted into the mulch from the top, such as groundcovers or weeds that have blown in by seeds and grown into the mulch. Covering the fabric mulch with bark will make it easier to remove those blown in weeds and will also protect the fabric from degrading in sunlight.

Non-chemical control in turf areas is somewhat more difficult. In turf, nutsedge is less likely to be found in small clumps and therefore is harder to remove by digging or hand removal. Also, since nutsedge tends to grow faster than most turf species it is difficult to control by shading. Reducing irrigation to minimal levels and irrigating deeply may help but once nutsedge is established it can tolerate low soil moisture.

There are few *effective* herbicides registered for use in California. Although some postemergence herbicides list nutsedge on their label, they will not be successful for long-term control unless they translocate to the basal bulb at the base of the stem or move into the rhizomes. Products that kill only the aboveground portion of the plant are not effective unless applied repeatedly to deplete reserves in the plant. Postemergence herbicides that have been shown to be effective in controlling nutsedge include:

Common name	Commercial name	Comments
2,4-D		
2,4-DP		
bentazon	Basagran	
dicamba		
glyphosate	Roundup	
halosulfuron	Manage	Add non-ionic surfactant
MCPP		
MSMA		

Regardless of the choice of product, control of nutsedge is maximized when the product is applied prior to the 5-leaf stage. The site should be monitored for later sprouting plants and a second application made if the label allows. One should also be aware that these products can injure nearby desirable plants if the spray contacts them so extreme care should be used if using the herbicide in landscape beds. Using a nozzle that sprays larger droplets can reduce drift.

Use of preemergence herbicides for control of nutsedge is best done prior to planting any desirable plants. Preemergent herbicides used of nutsedge control must be moved to the soil depth where the tubers are found. Consequently, they are usually incorporated mechanically or by irrigation. These products are highly soluble and may cause injury to nearby plants via root uptake. Therefore, these herbicides should only be used in an area under renovation and the area should not be planted until there has been sufficient time for the herbicide to degrade. Preemergence herbicides that have been shown to be effective in controlling nutsedge include:

Common name	Commercial name	Comments
dazomet	Basamid	Fumigant-like. Incorporate mechanically 8" deep. Works best in sandy soils.
dichlobenil	Casoron	Use with caution, very soluble, may cause injury to nearby by plants by root uptake.
EPTC	Eptam	Use with caution, very soluble, may cause injury to nearby by plants by root uptake.
metolachlor	Pennant Magnum	Use with caution, very soluble, may cause injury to nearby by plants by root uptake. Yellow nutsedge control only.

Nutsedge Management in Trees and Vines

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Introduction

Yellow and purple nutsedge (*Cyperus esculentus* and *C. rotundus*) are troublesome perennial weeds in orchards and vineyards. Yellow nutsedge is found throughout California, while purple nutsedge is found generally south of Fresno County, particularly in Tulare County and the southern desert regions. Nutsedge does not normally affect production directly, but does highly compete for water and nutrients, especially in new plantings when root systems are not fully developed. It thrives in moist, light textured soils and impedes with the distribution of water, particularly in low-volume irrigation systems. Although seed are produced, it spreads primarily through the production of underground rhizomes and tubers. Nutsedge is moved into and spread throughout fields mainly by cultivation equipment.

There is no easy way to control nutsedge in tree and vine crops. Even diligent management efforts often go unnoticed. Several options are available, however, that can help provide some level of control, including field selection, preplant control, prevention, and pre- and post-emergence herbicides after planting. Since no one option or program will work in all situations, the combined use of available tools is usually required for adequate control.

Field selection

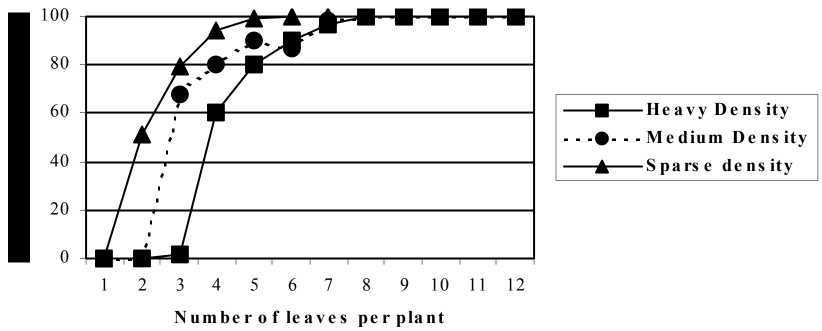
Planting in fields that do not have a history of nutsedge is the best method of control. Conduct routine weed surveys well before planting to help determine if nutsedge is present and at what population levels. Knowing the history of the field ahead of time will make it easier to develop a plan of attack in the advent you plant into a field that is infested.

Preplant control

Repeated applications of post-emergence herbicides (like glyphosate) can help to reduce nutsedge levels, especially in fields where the initial population is low. This method requires irrigating the field and allowing the nutsedge to emerge. Once growing, apply the herbicide directly to the plants when they have fewer than 4 to 5 leaves. This will help prevent the formation of new tubers and plants (see figure 1). It is important to repeat applications as often as needed (usually every 2 to 3 weeks) to prevent nutsedge from reinvading the area.

Repeated tillage operations, while the field is fallow or idle, can be used to bring tubers to the surface so they can dehydrate during the hot summer months. The soil should be dry and free of large clods to be effective. Purple nutsedge tubers are sensitive to drying under these conditions and can dehydrate in as few as three weeks. A spring-tooth harrow is usually the best tillage tool for this method, while disking is often ineffective. Studies conducted by Paul Keeley at the University of California Shafter Field Station showed 95% control using this method by listing and splitting the beds during the summer. Yellow nutsedge tubers will not be controlled in this manner, since they can survive in warm, dry soils for up to four years. It is, therefore, important that you determine which type of nutsedge you have before attempting this technique.

Figure 1. Tuber production of yellow nutsedge
Fischer, 1986



Nutsedge tubers buried for more than a year can result in high tuber mortality (80% or more) through decomposition, but it is difficult to bury them with most conventional equipment. Modified flip-over plows (like the Kverneland or Wilcox plow) can invert the upper soil profile to a plowing depth, effectively burying tubers. These plows have been used successfully to bury weeds like nightshade and others as well as disease pathogens (sclerotinia in lettuce). Studies by Tim Prather and others have shown significant reductions in purple and yellow nutsedge emergence and increased tuber mortality when buried more than 12" deep before planting annual crops like cotton. This procedure can also be effective prior to planting an orchard or vineyard. It works best when the majority of the tubers are distributed in the upper four to eight inches of the soil profile prior to turning the soil. Tubers spread evenly throughout the profile will not be buried effectively.

Prevention

Closely monitoring fields for new nutsedge outbreaks is the cheapest and easiest way to prevent its spread. New nutsedge infestations typically appear as small patches, limited in size and distribution. Studies by Dr. Theodore Webster in Tifton, GA have shown that a single nutsedge tuber can give rise to significantly large areas of new nutsedge plants in a short period of time. A single yellow nutsedge tuber may yield an infestation patch of up to 1 m^2 within six months, while a purple nutsedge tuber can spread to an area of more than 7 m^2 in the same period of time. To help prevent its spread, inspect cultivation equipment entering the field from infested fields and control nutsedge growing along field edges and other nearby locations. Once identified in the field, pay special attention to those areas and dedicate labor and resources to eradicating it. Use timely post-emergence herbicide sprays to control them and prevent new tubers from forming. Do not skip treatments or use cultivation as the sole means of control, since this can lead to an increase in the size and distribution of the infested patches. Be diligent in your efforts.

Pre- and post-emergence herbicides

There are several pre- and post-emergence herbicides registered in a number of tree and vine crops that can provide control of nutsedge (see table 1). While none of these herbicides will completely eradicate nutsedge with a single application, they can significantly reduce populations over time if applied accordingly. In fact, it may take several years to get nutsedge under control if the initial population is high and distributed throughout the field. No one approach will work for every field, so select the herbicide or combination of herbicides that best suits your situation. Factors like tree or vine age, soil texture, irrigation type, scope of infestation, equipment availability, field access, and others will influence the approach you take. Prior to using herbicides, read the label carefully and follow all recommendations.

Table 1. Herbicides registered in trees and vines for nutsedge control

Pre-emergence	Purple	Yellow	Post-emergence	Purple	Yellow
Casoron®	C	C	DSMA®	P	C
Eptam®	P	C	Gramoxone®	C	C
Hyvar X®	C	C	MSMA®	P	C
Krovar®	C	C	Reglone®	P	P
Solicam®	N	P	Rely®	P	P
Visor®	P	C	Roundup®	C	C
			Sempra CA®	C	C
			Touchdown®	C	C

C = control P = partial control or suppression N = no control

Refer to the appropriate label for the herbicide registration on specific crops. Control assumes proper rate, application, and timing according to label recommendations.

Pre-emergence herbicides need to be applied prior to the tubers sprouting or emerging. In California, the majority of nutsedge grows from March to September, but can differ, depending on each growing region in the state. Pre-emergent sprays should be timed to meet periods of nutsedge emergence and receive adequate rainfall or irrigation to incorporate and activate the chemical. In some cases, it may mean making more than one application to achieve adequate residual control. Some of the common pre-emergence herbicides are listed on the following page, along with factors that can influence their performance and crop safety.

Solicam®: Crop is 1.5 to 2+ years old • the population is low • symptoms first appear after emergence as leaf bleaching, followed by death • it can leach and cause crop injury in sandy soils with low-volume irrigation.

Hyvar X®: Used in citrus >4 years old • runoff water containing the herbicide can cause injury to nearby trees and vines.

Krovar®: Used in citrus >4 years old • runoff water containing the herbicide can cause injury to nearby trees and vines.

Visor®: Used in bearing and non-bearing citrus and non-bearing tree nuts • applied at 2 pt/A in the fall and again in the spring • mixed with Goal® for broader weed spectrum.

Post-emergence herbicides should be applied after nutsedge plants have emerged. These herbicides must be applied before nutsedge has more than four to five leaves. Applications are generally made every two to three weeks, or as often as necessary to meet new periods of emergence. Since nutsedge is nearly impossible to fully eradicate once it is distributed throughout the field, and will quickly reinvade the field if control measures are relaxed, a vigorous control program must be maintained indefinitely. Some of the common post-emergence herbicides are listed below, along with factors that can influence their performance.

Roundup®: Plants have <4-5 leaves • treated every 2-3 weeks • don't skip treatments if needed • generics give similar control • ammonium sulfate improves control slightly.

Touchdown®: Plants have <4-5 leaves • treated every 2-3 weeks • don't skip treatments if needed • ammonium sulfate improves control slightly.

Sempra CA®: Tree nuts are >1 year old • plants have <4-5 leaves • used at 2/3 to 1 2/3 oz/A • add a crop oil concentrate, non-ionic surfactant, or ammonium sulfate • also controls pigweed, cocklebur, mustard, and lambsquarters • it has many cautions on the label regarding its use.

MSMA® or DSMA®: Primarily used in non-bearing crops • better yellow nutsedge control • air temperature is warm during and following treatment • burn-down control only.

Gramoxone®: Plants have <4-5 leaves • burn-down control only • Category I, restricted use.

Conclusion

Persistence is the key to nutsedge management in orchard and vineyard settings. While no one measure will provide complete nutsedge control, the proper selection of combinations of options can help to significantly reduce its presence in the field.

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Session B: Laws and Regulations
Moderator: Regina Sarracino, California Dept. of Pesticide Regulation and Dave Haskell, California Dept. of Pesticide Regulation

Clopyralid in Compost

David E. Haskell
California Department of Pesticide Regulation

Introduction

The observation that clopyralid residues could survive the composting process in trace amounts first came to light in Washington State. During 2000 and 2001, residues of clopyralid were detected in commercial compost. Compost made at a municipal site damaged tomatoes and other garden plants planted in it. The lawn clippings feedstock was tested and found to contain clopyralid residues up to 1.5 ppm. As news of this condition became public knowledge, California compost producers and municipalities with green waste recycling programs became concerned the possible presence of clopyralid residues in finished compost may damage consumer confidence in compost products. In a few locations, the demand for compost has fallen off and some compost has been hauled off to landfill sites. Organic growers are particularly sensitive to the possibility the compost they are using may have trace amounts of clopyralid. Their industry dictates they must grow crops using only natural occurring pesticides like copper and sulfur. The composting industry and the California Integrated Waste Management Board (CIWMB) view this condition as a threat to the successful recycling programs for municipal green waste that were initiated in response to Assembly Bill 939. Many communities have green waste recycling programs that collect lawn clippings as part of the program. The urban pesticide applicator needs to determine whether green waste from treated turf sites is being recycled before clopyralid is used for weed control.

Clopyralid Properties & Products

Clopyralid is a selective herbicide used to control weeds in agronomic crops (asparagus, hay, small grains, sugar beets), lawns, pasture and rangeland, and rights-of-way. Clopyralid is a growth regulator-type herbicide with activity on a relatively narrow range of broad-leaf weeds. It is relatively stable in the environment.

I. Physical-chemical properties:
- Soluble in water
- Does not degrade readily in water
- Low volatility
- Field conditions- average half-life in soil 25 days (range 8-66)
- Low soil absorption rate

II. Clopyralid activity:

- Auxin type herbicide- disrupts plant growth processes
- Enters plant through leaves & roots
- Systemic- moves rapidly through plant, collects in meristems
- Symptoms- thickened & twisted leaves, stems; cupped leaves
- Has contact & pre-emergent activity

III. Sensitive plant families

- Asteraceae (Composites)- asters, dandelions, prickly lettuce, sowthistle, yellow starthistle
- Fabaceace (Legumes)- beans, clovers, peas, vetch
- Solanceae- nightshades, jimsonweed, potato, tomato
- Polygonaceae- curly dock, knotweed

IV. Clopyralid toxicity:

Clopyralid has low acute toxicity to humans via the dermal, inhalation and oral routes of exposure and has been designated as a category III pesticide. Similarly, wildlife studies indicate that clopyralid is slightly toxic to birds and relatively non toxic to aquatic life.

Clopyralid is marketed as a concentrate product or sold in combinations with fertilizer as "weed and feed" products for turf care. Currently there are 14 clopyralid products registered in California with Dow AgroSciences as the primary registrant. In the year 2000, the majority of the clopyralid use reported to the California Department of Pesticide Regulation (DPR) was from products registered for agronomic and rangeland-rights-of-way uses. Products registered for lawn and turf uses accounted for about 33% of the reported use for that year. Commercial lawn maintenance companies, golf course operators and growers value clopyralid for its safety and ability to control some problem weed species with only one to two applications per season. Golf courses in particular value its ability to control clover in the fairways and rough areas.

The Dow AgroSciences concentrate product labels with turf uses advise the user not to use treated grass clippings for mulch or to make compost from the treated grass clippings during that season of use. The Riverdale Chemical concentrate products advise the user to wait 10 or more weeks after treatment before using treated grass clippings for compost or mulch. Most "weed & feed" products do not have any compost or mulching restrictions for treated grass clippings.

Clopyralid and Compost in California

Municipal and private compost producers in California have tested their compost for trace amounts of clopyralid. At a City of San Diego site, residues were detected at 11 ppb. and at one site in Los Angeles at 3-4 ppb. The preliminary results from a voluntary survey conducted by compost industry indicate 13 out of 20 samples tested positive for clopyralid with residue levels ranging from 2-13 ppb. Research by Dow AgroSciences indicates that clopyralid levels as low as 3 ppb. can be phytotoxic to garden vegetables like beans, peas and tomatoes grown in pure compost. At this time, DPR is not aware of any reports of phytotoxicity in California due to compost with clopyralid residues in it.

DPR is working with the CIWMB, Dow AgroSciences, and commercial composters to assess the scope of the problem and to propose mitigation measures. A workgroup has been formed to gather information and coordinate activities between the two agencies and stakeholders. This workgroup has sponsored a series of stakeholder meetings to gather more information on how clopyralid is used in California and which uses present a potential for contamination of feedstocks for compost. The workgroup has coordinated stakeholder efforts to provide public information on the problem and to promote a compost testing program to generate clopyralid residue data.

Current Research

Dow AgroSciences is currently conducting research to better understand the interaction between clopyralid, turf and compost. These studies include exploring the following relationships:
a. the impact of product formulation and mowing regimes on residues of clopyralid.
b. factors that influence the degradation of clopyralid in compost.
c. Dissipation in turf and how it breaks down.
As part of these studies, the half-life of clopyralid in compost will be assessed. Dow AgroSciences has indicated the studies are largely completed and they intend to publish the results.

Mitigation Actions Taken by Registrants

In the summer of 2002, Dow AgroSciences petitioned the U.S. EPA to delete residential turf uses from their manufacturing use labels and their clopyralid product labels. The company has also requested that text be added to their manufacturing use and their clopyralid product labels requiring applicators making nonresidential lawn and turf treatments to notify property managers about the label requirements regarding compost. The request to delete residential turf uses from their labels was published in the Federal Register August 28, 2002. Other registrants that formulate and sell clopyralid products will have to make these changes to their product labels when they purchase new technical material from Dow AgroSciences.

Dow AgroSciences has initiated a product stewardship program to educate chemical suppliers and users about the persistent nature of clopyralid and the importance of following label restrictions regarding mulching or composting treated lawn clippings. Dow AgroSciences has asked commercial pesticide applicators not to make clopyralid applications to residential turf. The company has held a series of product meetings to reiterate the composting and mulching restrictions on the clopyralid labels. These meetings will also serve to educate users on the potential for trace amounts of clopyralid to enter the composting process through feedstocks. Dow AgroSciences is recommending that site managers wait one year before recycling grass clippings from a clopyralid treated site.

Regulatory Actions Taken

Some regulatory actions have been taken to keep clopyralid residues out of compost. DPR has initiated a cancellation action on all registered clopyralid products which permit use on residential lawns. Use on residential lawns is considered the least controllable use in relation to keeping clopyralid from entering composting feedstocks. The cancellation action does not include clopyralid products registered for agricultural or rights-of-way, rangeland uses. DPR is currently negotiating with the registrants of clopyralid products regarding possible label changes to protect compost. The use of products affected by the cancellation notice can continue until some final regulatory action is taken. A voluntary recall of clopyralid products with residential lawn uses is not occurring at this time.

The assembly bill (AB 2356 Keeley), sponsored by the composting industry, was passed in September and became effective January 1, 2003. This bill contains limitations on the sale of clopyralid products and requires DPR to take certain actions. The bill requires pesticides that contain clopyralid may only be sold by licensed pest control dealers. It will also require pest control dealers to only sell pesticides with clopyralid labeled for use on lawn and turf including golf courses, to applicators holding a Qualified Applicator Certificate (QAC) or a Qualified Applicator License (QAL). The lawn and turf restrictions do not include use of clopyralid-containing products on lawn and turf located on turf farms, uncultivated open space, agricultural rangeland or cultivated farm land. By April 1, 2003, DPR must make a determination on which lawn and turf uses are likely to cause persistent residues in compost and which uses will not. For those uses that are likely to cause persistent residues in compost, DPR must either impose restrictions on those uses or cancel products allowing those uses.

Suggested Actions for Applicators

There are actions that applicators can take to reduce the risk of compost becoming contaminated with clopyralid. Applicators can contact their local distributors for pesticides to obtain current information regarding the use of clopyralid products. Applicators should contact turf site managers to determine if green waste recycling is taking place before applying a clopyralid product. If grass clippings, leaves are being recycled into compost and moved off-site and the site manager cannot wait one year, the applicator should use another herbicide.

POTENTIAL LOSS OF HERBICIDE REGISTRATIONS

Tobi Jones, Ph.D., California Department of Pesticide Regulation

This paper will review a variety of factors influencing the registration status of herbicide products. Potential loss of herbicide registrations is a concern to the user community, but regulatory decisions at the federal and state level as well as lawsuits may affect how and where products can be used over the next several years.

The Food Quality Protection Act of 1996 (FQPA) is one of the recent factors that may influence availability and use of herbicides. FQPA amended the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) and the Federal Food Drug and Cosmetic Act, and created a new food safety standard by which food residue tolerances were to be judged. U.S. Environmental Protection Agency (USEPA) must review existing and new tolerances for the aggregate exposure to pesticides from nonoccupational, dietary and drinking water sources. USEPA also must assess cumulative exposures for pesticides that share a common mechanism of toxicity, and the potential for pesticides to act as endocrine disruptors. Three triazines (atrazine, simazine and propazine) and their common metabolites have been grouped for cumulative assessment, as have certain of the chloroacetanilide herbicides. Dietary exposure will likely play less of a role for these herbicides in cumulative assessment, unlike the organophosphate insecticides.

Reregistration under FIFRA is another factor that may influence use and availability of herbicides. Reregistration is the more generic review of pesticides' risks, and includes worker and ecological risks. The timetable for USEPA's reregistration review has been merged with the tolerance review under FQPA. Depending on the toxicity profile, degree of user exposure, and potential for ecological risks, USEPA's reregistration decision on individual herbicides may influence use and availability. Registrants' decisions on continued marketing of herbicides in the United States may arise from reregistration, FQPA or other factors.

The federal Clean Water Act (CWA) has arisen in the last few years as a factor outside of traditional pesticide regulatory channels to potentially influence the use of herbicides, and pesticides in general. Section 303(d) of CWA requires states to identify impaired water bodies, develop a maximum allowed level (Total Maximum Daily Load or TMDL) for each identified contaminant, and develop a plan to achieve the TMDL. While pesticides are not the primary challenge for many states addressing their impaired water bodies, they do represent a challenge in some states. The National Pollutant Discharge Elimination System (NPDES) of CWA has more recently appeared as an influencing factor for herbicide/pesticide use as the result of several lawsuits and conflicting federal court decisions. The conflict between FIFRA approval of pesticides and the CWA standards will receive considerable attention in the next couple of years. Other sections of CWA administered at the state level may influence use patterns of some pesticides.

Other factors that may affect herbicide use and availability are lawsuits under the Endangered Species Act, federal and state efforts to manage drift, state efforts to manage groundwater contamination, and state efforts to address the contribution of certain pesticides, including herbicides, as volatile organic compounds contributing to ozone formation in nonattainment areas of the state.

Preventing the Entry and Spread of Noxious Weeds in California

J Robert Leavitt and Courtney Albrecht
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The California Department of Food and Agriculture's (CDFA) Division of Plant Health and Pest Prevention Services is charged with the responsibility of preventing the entry and spread of noxious weeds in California. The primary enabling legislation is Section 401 to 405 of the California Food and Agriculture Code (FAC). FAC Section 403 states, "The department shall prevent the introduction and spread of … noxious weeds." FAC Section 5004 defines a noxious weed as "any species of plant that is, or is liable to be, troublesome, aggressive, intrusive, detrimental, or destructive to agriculture, silviculture, or important native species, and difficult to control or eradicate." FAC Section 52256 defines noxious weed seed as "the seed or propagule of any species of noxious weed, as defined in Section 5004."

Noxious weed pests are harmful to agriculture and the environment in many ways, including: invading native plant habitats and outcompeting native plants for resources, becoming troublesome to ornamental plants in nursery settings, interfering with agricultural equipment, invading water transport systems (such as irrigation canals) and impeding the flow of water (this is especially detrimental to agriculture since much of the agricultural production in the state occurs in areas that are essentially deserts (Imperial Valley) and relies on the unimpeded flow of water).

California's noxious weeds are listed in Section 4005 of the California Code of Regulations (CCR). The noxious weed list includes such weeds as Scotch thistle (*Onopordum acanthium*), musk thistle (*Carduus nutans*), spotted knapweed (*Centaurea maculosa*), leafy spurge (*Euphorbia esula*), yellow starthistle (*Centaurea solstitialis*), and hydrilla (*Hydrilla verticillata*). California also includes all the federal noxious weeds (Title 7, Code of Federal Regulations, Part 360) as state noxious weeds, by reference (FAC Section 6301 and CCR Section 3161). The federal list includes such weeds as red rice (*Oryza rufipogon*) and giant salvinia (*Salvinia molesta* complex).

The CDFA also classifies noxious weeds as to the extent of their distribution in the state, and to the possibility of successful eradication. A-rated noxious weeds are prohibited from entry into the state, sale within the state, and are subject to eradication. B-rated noxious weeds are prohibited from nurseries and sale by nurseries, and can be prohibited and eradicated at the county level at the discretion of the county Agricultural Commissioner. C-rated noxious weeds can also be prohibited from sale and eradicated at the discretion of the County Agricultural Commissioner. Q-rated noxious weeds are those weeds that are prohibited until more information as to their invasiveness can be determined (further information on CDFA's A, B, C, and Q-rated noxious weeds can be found in CDFA's Plant Quarantine Manual, on the internet at www.cdfa.ca.gov/pqm/manual, then follow the link "Go to *The CDFA Plant Quarantine Manual,*" then "Special Handling" and then "Weed Policy").

Once a noxious weed pest becomes established in the environment, it can be difficult and costly to remove. The characteristics that make weeds "noxious" mean they tend to grow and reproduce rapidly, tolerate a wide variety of habitats and climates, and in some cases have the ability to spread seeds or propagules via wind, water, or other uncontrollable means. Therefore, it is important to prevent the entry of noxious weeds into California in order to prevent the need for costly eradication efforts. Preventing the entry of weeds can be considered “the first line of defense” in the control of invasive weeds in California. It is the responsibility of the Division of Plant Health and Pest Prevention Services’ Pest Exclusion Branch to prevent pests from entering California through various pathways, such as through commerce and travel. For this purpose, agricultural inspection stations are maintained at entry points along California’s borders, and mail and common carrier distribution centers within the state (FAC Sections 6401 to 6403, 6441 to 6442, 5341 to 5350).

Quarantine efforts are equally as important as is preventing the entry of noxious weeds into California to prevent the further spread of infestations within the state. It is the responsibility of the Division of Plant Health and Pest Prevention Services’ Pest Exclusion Branch, with the help of the county agricultural commissioners, to inspect businesses within the state for infested commodities (FAC Section 408).

If a noxious weed enters the state and begins to establish itself, control and eradication efforts are necessary to eradicate the weed from the state, or to contain its spread, or to suppress its population. It is the responsibility of the Division of Plant Health and Pest Prevention Services’ Integrated Pest Control Branch to protect rangelands, crops, waterways, and urban areas from noxious weeds through various weed survey and detection, control and eradication (including biological control), and weed education programs (FAC Sections 403, 5321, 6048, 6049). The Integrated Pest Control Branch also supports the Weed Management Areas in their noxious weed control efforts (FAC Sections 7270 to 7274).

Anti-Drift Labeling Requirements

Roy E. Rutz, California Department of Pesticide Regulation

A significant event in the history of the Department of Pesticide Regulation (DPR) occurred on September 25, 2000. On that day DPR stated in Enforcement Branch letter 2000-34 (*www.cdpr.ca.gov/docs/enfcmpli/penfltrs/penf2000/2000034.pdf*) "Some pesticide drift is expected from aerial and other above ground pesticide applications". In other words, drift, like life and other stuff, happens, routinely, like always. Drift per se is not a violation. However, substantial drift is a violation of Food and Agricultural Code (FAC) section 12972 and must be prevented. When does drift become substantial you ask? The shade tree lawyers in the audience will understand when I say that illegal drift is based on a negligence standard rather than a strict liability standard. In other words, substantial drift occurs not when a specific amount is found off target but when the amount found off target is greater than what would have occurred had the applicator used due care.

There are two groups of things that an applicator must consider. First there are controllable things like selection of equipment for optimal droplet size. Nozzle type, size, orientation, pressure, buffer zones, height, things like that.

The other group (no surprise) is composed of uncontrollable factors like weather, (inversions, wind, humidity, temperature, fog) and sites surrounding the treatment area.

`The drift section in law is not the only requirement impacting what must be considered. There are sections in Title 3, California Code of Regulations (3CCR) also.

Some of these are general provisions that are used if something goes wrong and it can't be tied to another specific section. But others are more specific.

On of the most commonly used sections of the regulations is 6614. It is in between the general and specific. Basically, section 6614 is a recognition that failure to use due care can be mental as well as physical. It requires that thought be given to three specific areas. Contaminating people will not be tolerated. Damaging off-target property must be avoided. Contaminating off-target property to the extent that it cannot be used for its normal purpose must also be avoided. These three things must be avoided at all costs. Even if it means that you do not make the application! This is as close as we come to a strict liability standard when it comes to drift.

The most specific drift requirements are in the restricted materials regulations. They apply to certain herbicides and cotton harvest aids. These requirements have been in place with only minor changes since 1950. They are prescriptive standards as opposed to performance standards. Prescriptive standards describe the equipment or procedures that must be used. Performance standards describe the outcome desired and leave it up to the person how to achieve that result. About three years ago, DPR decided it was time for an update of the drift regulations in 3CCR.

Issuing the revised drift investigation policy in September 2000 was the first step. The plan also included regulation changes based on the following:

- Rely, to the extent possible, on the data developed by the Spray Drift Task Force.

- Move the drift regulations from the restricted materials portion of the regulations to a more general area so they would apply to both restricted and non-restricted pesticides.

- Limit application of the nozzle specifications to herbicides and cotton harvest aids for the time being. Later we will develop more appropriate specifications for other kinds of pesticides.

- Clean up some of the other sections that use these basic drift control provisions to avoid duplication.

What's the hold-up you ask? Why haven't these changes been made? Well, the USEPA has also embarked on a comprehensive project to issue standards for how pesticide labeling addresses drift. Theirs is a much more comprehensive project, so, to avoid being caught going in the wrong direction, DPR decided to put our project on hold until USEPA played their hand. This is consistent with most regulatory actions. DPR's strong preference is for pesticide labeling to contain instructions and precautions necessary to use the pesticide. When labeling is deficient and does not address all of our concerns, regulations are adopted to fill the gaps, so to speak. That is what we are waiting to do here.

The U.S. EPA draft Pesticide Registration Notice generated a modest amount of comment, to say the least. The comment period was extended a couple of times. USEPA is still working on review of the comments received. We understand that the re-registration process is forcing their hand and we expect some indication shortly.

Cruising the DPR Website
www.cdpr.ca.gov

John B. Stutz, Department of Pesticide Regulation, Sacramento, California

The Department of Pesticide Regulation has provided web-based public access to regulatory and other relative materials since 1995. These initial offerings came during the early days of the internet when "mosaic" was still the browser of choice (and not just a plant virus), Microsoft domination of all things "PC" was a distant reality, and access via a 9600 baud modem was really "flying".

DPR was the first pesticide regulatory agency in the United States to provide real time database access to registered product and chemical data. In addition, DPR developed the programming to access the USEPA's Pesticide Product Information System (PPIS), an application made available to the public in 1996. The EPA product data access has been recently updated to include a link to multi-page "tiff" images of the labels, making the application even more useful. The DPR also instituted the use of "list serving" in 1996 to reduce costs, and increase distribution of notices, regulatory changes, press releases, etc. It is estimated that the Pesticide Registration Branch alone saves nearly $40,000 per year in production and mailing costs and reaches a much larger audience of stakeholders.

Access by the public of DPR's website has grown by leaps and bounds over the years despite the esoteric nature of the data. Today the website registers upwards of 500,000 hits per month and is accessed by users from every country in the world.

DPR's website (www.cdpr.ca.gov) contains a significant number of documents and access to a number of real time databases not all of which may be relevant or of interest to the weed science profession. Throughout the rest of this document, I will try to prioritize those areas of content that I think will be of most use or interest to Weed Science Society members and include the internet links to those resources.

Product/Label and Chemical Information
(www.cdpr.ca.gov/dprdatabase.htm)

There are 12,043 pesticide products currently registered in California with 1,438 categorized as herbicides. Products registered with the US Environmental Protection Agency number approximately 28,000.

Users can access product information by a number of different criteria; product name, registration number, chemical ingredient, pesticide type, formulation, signal word, etc. These searches require some practice to master and in most instances searches on partial names or numbers will compensate for a misspelling or incorrect number. There are several hints when searching both the DPR and USEPA data; i.e. the federal product name and state registered name often are completely different, or; chemical trade names and the common or technical names vary widely. HINT 2: it is better to start your search at a high level, like "company name"(i.e. Du Pont) and then narrow the search as you go along.

The EPA's PPIS database is located at www.cdpr.ca.gov/docs/epa/epamenu.htm. This database is also searchable by several criteria. The product reports found via this application contain links to images of the federally registered label information. HINT: you will need to have a multi-page "tiff" viewer configured on your PC to view these labels. Kodak or Wang viewers are both free and generally provided with your windows software.

A new application, developed in conjunction with the National Pesticide Information Retrieval System (NPIRS), utilizes a combination of California and Federal label information. The unique feature of this application is that you can access products by target pests, including specific weed names. This link can be found on DPR's database page, but can also be accessed directly at: http://state.ceris.purdue.edu/doc/ca/stateca.html.

Once you have identified a specific product or products, the most likely online source for an up-to-date label is at the Crop Data Management Systems (CDMS) website: www.cdms.net/manuf/default.asp. While CDMS is not linked to DPR's site, most major and minor agricultural and turf/ornamental products can be found here. HINT: you will need a PDF reader (free at www.adobe.com/products/acrobat/readstep.html) installed on your PC in order to view the labels or MSDS's.

It is unfortunate that all product and chemical information are not aggregate on one website, neatly linked together, and easily accessible by any criteria. It will require substantial resources, prioritization, and a lot of cooperation to make that happen.

Licensing, Certification and Continuing Education
(www.cdpr.ca.gov/docs/license/liccert.htm)

Many members of the Weed Science Society and attendees of this conference are licensed by the State of California as Pest Control Advisors, Qualified Applicators, Dealers, or Brokers. The DPR website has application forms, exam schedules, listings of approved continuing education classes, on-line county registration for pest control licensees, and much more.

Pesticide Use Information
(http://jolie.cdpr.ca.gov/cfdocs/calpip/prod/main.cfm)

New to the DPR website on January 1, 2003, is the California Pesticide Information Portal (CalPIP). This application provides access to the most extensive database of pesticide use information in the world. Complex queries can be developed in a top-down fashion using many different data criteria and output can be formatted as tabular raw data or summarized by category or subcategory. This is a complex application that requires practice and forethought to use effectively. HINT: you should carefully read the Introduction and Overview and the First Time Users sections before you start.

News, Notices, and Regulatory Changes
(www.cdpr.ca.gov/dprnews.htm)

If you need to keep on top of information regarding new products coming down the registration pipeline, news releases, and regulatory changes, you are in luck! All these items and many more are available via the DPR website. One of the best ways to receive specific information that you are interested in is by subscribing to a "list". DPR currently has 11 different lists that range from the Surface Water Protection Program updates to Materials Entering Evaluation (registration process).

Publications, Reports, Summaries, and Reviews
(www.cdpr.ca.gov/dprprograms.htm)

There are hundreds, if not thousands of scientific or regulatory documents on the DPR website pertaining to pesticide toxicity, environmental fate, monitoring, enforcement, etc. These reports may be found under the individual program web pages or by using the *search* or *advanced search* features found in the upper right corner of many of the top level pages on the DPR website (www.cdpr.ca.gov)

Conclusion

The DPR website is a constantly evolving product. What you currently see is the result of input from stakeholders, staff, industry groups, and the legislature. DPR is committed to provide the best source of pesticide information and to use internet technology for cost-saving efficiencies and to streamline the regulatory process. We encourage all of you to use the site to it's fullest capabilities and to provide us with your comments regarding content and navigation.