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2011 Proceedings of the California Weed Science Society

Volume 63

Papers Presented at the 63rd Annual Conference
January 19, 20, & 21, 2011
Portola Hotel & Spa
Two Portola Plaza
Monterey, California

2010/2011 Officers and Board of Directors:

Preface

The proceedings contain contributed summaries of papers presented at the annual conference as well as the minutes of the annual business meeting, year-end financial statement, award winners, sponsors, exhibitors, and names, addresses and phone numbers and email addresses given by permission of those attending the meeting.

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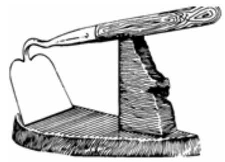
California Weed Science Society
and
The Story of the Short Handle Hoe



Norman D. Akesson
University of California, Davis

The California Weed Science Society Short Handled Integrated Tool (Short Handle Hoe) is a descendent of a long line of hand powered digging tools handed down through the millennia from generations of tillers of the soil. But unlike most of its genre, the short handle (overall about 18 inches) introduces an operational requirement, the stooped body position that could only have been developed in the chambers of the medieval torturers. However, it appears to have been a product of the culture of sugar beets in the irrigated fields of the Western United States, where it was thought that the untested laborer of the period (largely nationals from South of the border) couldn't aim the hoe and cut out the weeds accurately enough unless he stooped over and intimately selected the weed from the crop plant.

The CWSS hoe is a unique representative of this line. This particular tool was said to have been used by Dr. W.W. Robbins as a poignant reminder of the pest and an urgent reason for the further development and use of chemical weed control. He carried with it with him on his rounds of the farmer weed control meetings and punctuated his talks with references to this tool, the demon of the farm laborer and the lowest rung of the weed control ladder which was shortly to lead into the heady synthetic herbicide period of post WW II.

Today, it is difficult for us to relate to pre-chemical herbicide farming; we now accept these miracle materials (as they were dubbed in the 1940's) as a part of the arsenal (but certainly not the weapon) in the never-ending battle of crop plants versus weeds. However, to the farm laborer who had to assume the stooped, lock-kneed position and maintain this while swinging the little hoe for 8 to 10 hours per day "hell could have had no greater torture". Many California farm operators had, by the end of WW II, abandoned the short handle hoe in favor of the five-foot handle model and at some point during this period the California Assembly passed a resolution further condemning its use. This and the rapid development of the synthetic herbicides relegated this little torture tool to the museum.

The CWSS hoe probably started out as a work roughened model liberated from the tool shed at the University Farm by "Doc" Robbins and carried by him on his rounds of the farmer weed control meetings. In 1951 the hoe was spirited away, unbeknownst to Robbins by Walter Ball, a former student of Doc's when they were both at Colorado State. Walt had the hoe cleaned up (the blade and shank were cadmium plated) and polished to a mirror-like finish. At the 1951 California Weed Conference held in Fresno, CA, the hoe was presented by Walter to W.W. Robbins in honor of his many years of dedicated service to the science of weed control and to his key role in founding the California Weed Conference. Walt provided an old well-worn brown duffel bag to hold and protect the hoe. W.W. Robbins died in 1952 and his wife, Barbara, returned the hoe to Walter who then presented it to the California Weed Conference with the stipulation that it be passed on from the outgoing President to the incoming President in memory of W.W. Robbins. Thus over a period of about 10 years, a progression of Conference Presidents dutifully accepted the hoe and passed it on to their successors as a part of an installation ceremony at the annual conference.

In 1966 when I became President of the conference, several of the founding group looking to develop the image of the conference with a more polished symbol suggested we should “dress up the old hoe”, fit it with an identifying name plate and perhaps a mounting pedestal and give it rebirth as the conference symbol in honor of Doc Robbins.

On a holiday trip with my family to Fort Bragg I visited a local hobby shop and was shown some nice looking cuts from a redwood burl. I purchased a couple of these and brought them back to the wood working shop of the Agricultural Engineering Department at Davis where Paul Rutherford, our spray equipment mechanic and I fashioned the present mounting for the hoe. We polished up the hoe, handle and the burl and gave it a couple of coats of varnish. Walt Ball had a brass identification tab made which was installed on the base but we retained the “old brown duffel bag” which we felt maintained the proper aura as a fitting container for the venerable hoe. In its new reborn form it was first presented to Cecil Pratt, the incoming President of the 1967 Conference which was held in San Diego, California.

Today, some 30 years and as many Presidents later, the hoe is still being passed on in its little brown bag. To those of us who have watched and participated in the events which have resulted in a virtual revolution in weed control practices, the hoe is a practical reminder of the past. Perhaps a sobering thought or two may pass through our minds as we recall a long gone time when, for a brief period, the Short Handle Hoe was the tool of choice for weed control in California.

W.W. “Doc” Robbins, Bill Harvey, Walter Ball, Alden Crafts, Murray Pryor and the many others who have been honored by the California Weed Conference might look askance at the name change that was visited on the organization in the mid 90’s when the name was changed to the California Weed Science Society. I can hear Bill Harvey murmur to no one in particular “my, my, now ain’t that something fancy” while Walt Ball would likely have simply mumbled a “mild expletive” and Doc would have pontificated something to the effect that “progress does take strange and exotic forms”. They would have all agreed that the little hoe was and is a suitable reminder of the humble origins of weed control and that it matters not what the new name of the conference may be – its spirit will continue.

Odd as it may be, Doc Robbins never accepted the Presidency of the California Weed Conference. He retired from the University in 1951 after 29 years of service and lived with his wife, Barbara, in their little brown redwood house at the top of Oak Avenue in Davis until his death in 1952.

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Michelle Le Strange
Farm Advisor, Tulare & Kings County
UC Cooperative Extension
4437 S Laspina Street, Suite B
Tulare, CA 93274
Phone: (559) 685-3309 ext. 220
Cell: (559) 799-1250
Fax: (559) 685-3319
mlestrange@ucdavis.edu

Vice President
Chuck Synold
Vice President/Regional Manager
Target Specialty Products
2478 N. Sunnyside Avenue
Fresno, CA 93727
Phone: (559) 291-7740
Phone: (800) 827-4389
Fax: (559) 291-2433
chuck.synold@target-specialty.com

Secretary
Steve Fennimore
CE Weed Specialist, UC Davis
US Ag Research Station
1636 East Alisal St.
Salinas, CA 93905
Phone: (831) 755-2896
Cell: (831) 594-1333
Fax: (831) 755-2898
safennimore@ucdavis.edu

Past President
Dave Cheetham
R&D and Technical Marketing Manager
Helena Chemical Co.
3155 Southgate Lane
Chico, CA 95928
Phone: (530) 345-6140
Cell: (530) 570-4070
Fax: (530) 892-9259
dcheetham@helenaresearch.com

Director - Finance
Wes Croxen
Account Representative
Alligare LLC
20931 Rd. 31
Madera, CA 93638
Phone: (559) 661-1845
Cell: (559) 706-2460
Fax: (559) 674-4480
WCroxen@alligare.com

Director - Steering
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39962 Via Espana
Murrieta, CA 92562
Cell: (909) 226-0176
brucekidd9@yahoo.com

Director – Non-conference education
Richard Smith
Farm Advisor, Monterey County
1432 Abbott Street
Salinas, CA 93901
Phone: (831) 759-7357
Fax: (831) 758-3018
rifsmith@ucdavis.edu

Director - Membership
Rick Miller
Specialty Products
Dow AgroScienses
9854 Oakplace East
Folsom, CA 95630
Cell: (916) 212-8598
Fax: (916) 989-3654
rmiller@dow.com

Director – Student and commercial liaison
Rob Wilson
IREC Center Director/Farm Advisor
UC Cooperative Extension
2816 Havlina Rd.
Tulelake, CA 96134
Phone: (530) 667-5117
Fax: (530) 667-5265
rgwilson@ucdavis.edu

Director – Public relations
Milt McGiffen
UC Cooperative Extension Specialist
Botany & Plant Sciences
4101 Batchelor Hall
Riverside, CA 92521-0124
Cell: (909) 560-0839
Fax: 951-827-4437
milt@ucr.edu

Business Managers (non-voting)
Judy Letterman & Celeste Elliott
CWSS Business Office
P.O. Box 3073
Salinas, CA 93912
Phone: (831) 442-0883
Fax: (831) 442-2351
manager@cwss.org (Celeste)
judy@papaseminars.com (Judy)

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The California Weed Science Society wishes to thank the following companies for their generous support of the 63rd Annual Conference.

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*Helena Chemical Company
*Syngenta

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California Weed Science Society Honorary Member – 2011

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

Tom grew up in California. He graduated from Vallejo High School in 1967 and then went through a four year apprenticeship and worked as an electrician. In 1974 he started at CSU Sacramento in Wildlife Biology and earned a B.S. degree (1977). At UC Davis he completed his M.S. (1981) and Ph.D (1983) degrees in Weed Science. His first job in agriculture was on his grandparents' farm, hauling hay out of fields into barns. He also picked peaches in Suisun valley for 10 cents per lug - hard work!! During undergraduate summers, Tom worked for the forest service, building trails and fighting fires, hoping to land a position with the park or forest service.

Instead in 1983 he became an assistant weed science professor at Penn State University, working in agronomic crops. In 1986, he accepted his current position at UC Davis as Extension Weed Ecologist, where he works in vegetable crops, looking for chemical and cultural ways to improve weed control.

Tom has a long history with CWSS. His first CWSS Conference was in Monterey in 1980, as a student in the graduate student oral competition. In Tom's own words "This was the first talk I had ever given at a professional meeting and I was nervous. I placed third and was feeling pretty good about myself. I bought a copy of my talk on a cassette which were offered at the time. As I started driving back to Davis, I put the cassette tape in to listen to my talk. After listening to the first few minutes, I realized that this was the worst talk I had ever heard - I pulled the tape out and threw it out on the freeway!" Since 1986, Tom has attended all but perhaps two CWSS Conferences, when he was on sabbatical leaves. He has served as a Board Director and on the steering, student competition, and numerous program committees. Tom's speaking skills have certainly improved since his graduate school days and it is not unusual for Tom to educate and entertain us on a couple of topics at each Conference.

The Board of Directors would like to award Tom as an Honorary Member for his consistent participation in the CWSS, for his willingness to volunteer and present whenever a speaker is unable to attend, for his perpetual service on the student competition committee, and for his dedication to research and education in Weed Science in the areas of organic weed control, herbicide symptomology, and herbicide performance in vegetable crops.

California Weed Science Society Award of Excellence - 2011

Jennifer Malcolm
Caltrans Headquarters, Division of Maintenance

CWSS has presented the 2011 Award of Excellence to Jennifer Malcolm for her contributions and service to the society.

Jennifer recently became a Project Director 1 for the California Department of Corrections and Rehabilitation. She is the newest project team member on the state's largest ever design/build project, working on the new 900 million dollar California Health Care Facility in Stockton.

Until recently, Jennifer was the Acting Landscape Program Administrator at Caltrans, Headquarters, Division of Maintenance in the Office of Roadsides. During her past 11 years at Caltrans Headquarters as a Senior Landscape Architect, she was responsible for the maintenance stormwater program; the maintenance worker access program; and major maintenance for roadsides, along with pesticides. Jennifer developed an interest in hardscaping (or physical barriers, or structural vegetation control) as a permanent solution to many problems she noticed while doing her many field reviews. Jennifer dedicated her past 18 years working for Caltrans, starting with 7 years in District 3 (Marysville) and 'Acting' for the pesticide position four times.

Prior to becoming a state employee, she worked in private practice for 12 years in the development world with architects, engineers and contractors. She earned her Bachelor's Degree at Cal Poly, San Luis Obispo in Landscape Architecture. She also has a Master's Degree along with another Bachelor's Degree in Communication Studies from CSU, Sacramento.

Her leadership and enthusiasm are contagious, and she has served the society well over the years as both session co-chair and speaker. Although Jennifer will not be working with pesticides and weeds at her new position at CDCR, she is keeping her PCA license active and will be assisting PAPA in Sacramento as a volunteer.

California Weed Science Society Award of Excellence – 2011

Hugo T. Ramirez
Field Development Representative, DuPont Crop Protection

Hugo spent his early youth in Texas, but grew up in Kingsburg, CA where he graduated from high school. He attended CSU Fresno from 1988-93 and graduated with a B.S. degree in Ag Business and Economics and a M.S. degree in Plant Science.

Hugo has been employed with DuPont Crop Protection since 1993. His first jobs in agriculture and weed science were working on his father's and uncle's farms in east Texas and northeastern Mexico as a kid. In Hugo's words, "I ended up making more work for them. I cultivated corn and cotton on their farms and I actually left more weeds than corn and cotton." As a Field Development Representative for DuPont he conducts efficacy field trials with unregistered and registered compounds over multiple disciplines and on a broad range of crops. His training is actually in plant pathology with an emphasis in fungal pathogens of tree and nut crops, so weed science is not really his specialty. However, Hugo reports "he is getting better at using Joe DiTomaso's double-fisted weed handbook".

It was either 1995 or 1996 when Hugo attended his first CWSS Conference and he has attended every conference since then. He has been a co-chair and moderator for all of the sessions except aquatics citing two valid reasons for preferring to stay away from water: he is not a very good swimmer and where he grew up in east Texas, snakes always lived in water and tall grass. He has been a session speaker, poster presenter, and exhibitor at several Conferences. The topics included: Introducing new chemistry/products, weed susceptibility to herbicides and environmental conditions and the Use of adjuvants with different mode of action herbicides.

Hugo was pleasantly surprised to receive the Award of Excellence from CWSS and graciously recognized that it was a great honor to receive this award from his peers and feels it a privilege to be a part of the CWSS.

2011 Conference Student Awards

Pictured left to right: Kristen Weathers, Katrina Steinhauer, Annabel Rodriguez,
Nathalia Mourad, Marcelo Moretti with Rob Wilson, CWSS Director-Student and Commercial Liaison

Research Paper

1st place ($500) Marcelo Moretti, CSU Fresno

2nd place ($300) Kristen Weathers, UC Riverside

Poster

1st place ($500) Nathalia Mourad, CSU Fresno

2nd place ($300) Annabel Rodriguez, CSU Fresno

3rd place ($200) Katrina Steinhauer, CSU Fresno

2011 Student Scholarship Winners

Undergraduate Scholarship Awards

1st place - $2000 award	Stacey Haack, UC Davis
2nd place - $1000 award	Lennel Mendoza, Cal Poly, San Luis Obispo
3rd place - $500 award	Sarah Bell, Yuba College/CSU Fresno
4th place - $500 award	Sonia Rios, Cal Poly, Pomona

Graduate Scholarship Award

1st place - $2000 award	Rachel Brush, UC Davis

Claire Uke, CWSS Summer Intern
California Polytechnic State University, Pomona
Major: Plant Science
Estimated Graduation Year: Winter, 2012

Summer Intern Found Playing 'Where's Waldo'

My name is Claire Uke and last summer I participated in the California Weed Science Society Internship Program with director Carl Bell at the UC Cooperative Extension Office in San Diego. Compared to the summer heat of CalPoly Pomona, San Diego was a beautiful paradise and home-away-from-home since I am originally a San Diego native.

My stay at UCCE was fun and eventful. My starting work familiarized me with wildfire vegetation management, the Urban-Wildland Interface, and how each district in San Diego manages related problems. I conducted research, compiled spreadsheets, put together an index of vegetation management research publications, managed a database of fire departments by zip code, and made updates to their wildfirezone.org website. This work left me with an understanding of wildfire vegetation management, fire departments, and ordinance information. I also was introduced to ArcGIS software, which was pretty neat.

The research collection projects were very fun. My boss Carl was researching ways to control invasive grasses, and I was able to see how data was collected and used for this process. I was also given instructions to travel around San Diego to survey every retail plant nursery in the county for invasive species. I learned a lot in my visits and had a good time playing 'Where's Waldo' in other people's nurseries.

I feel very fortunate to have had such an enriching experience at UCCE. I received valuable exposure to the industry and experienced research in a tangible, hands-on way outside the classroom. I'd like to thank the California Weed Science Society for making opportunities like this available to students like me.

In Memoriam
John W. Inman
July 25, 1940 – June 28, 2010

John Inman, a professional engineer, consultant, and farm advisor emeritus with the University of California in Monterey County passed away unexpectedly after a stroke. He was 69. John grew up in northeastern Oregon where his family owned and operated a cattle ranch in Haines and a small grocery store in Baker City. In high school John was active in FFA. He graduated from Oregon State University with degrees in both Agriculture and Agricultural Engineering. At a university social he met Jody, his wife of 46 years.

In 1965, John began working with UC Cooperative Extension as a farm advisor in agricultural engineering for Monterey County, a career that would last 29 years. He conducted research studies and helped design and modify new farm machinery to meet the needs of vegetable, strawberry, grape, and field crop growers. His projects included equipment and techniques for seeding, transplanting, harvesting, weed, insect and disease control. He frequently attended the CWSS Conference and participated as a speaker. He was a regular contributor to American Vegetable Grower for more than 30 years, as the writer of the column “Into Gear.” In his columns, he covered everything from emission standard changes for tractor engines to the latest weeders and everything in between. He also wrote the monthly "Tool Tip" section.

In 1970, John started the Salinas Valley Chamber of Commerce Ag Business Day tours which showed many people the sophistication of agricultural production. He led Ag Business Day tours for 29 years. He was appointed to the Hartnell College Board of Trustees in 1984 and re-elected until he chose to retire in 1999. Board President for three years, he devoted many hours in the interest of the College, its faculty and students. He continued supporting local education as a member and officer of the Hartnell College Foundation Board until his death. Blending his interest in agriculture and education, he was a Founding Board member of Monterey County Agricultural Education and was actively involved in Ag Against Hunger, serving on their Board for nearly a decade.

In 1993, John retired from the University and became a full time private consultant. Working with manufacturers, dealers, importers, distributors and growers, he searched the world for equipment appropriate for California agriculture. He loved equipment shows and never missed a chance to see new products. John consulted, wrote, travelled and networked until the day of his stroke, always aware that he was one of the few who were truly passionate about their work.

John is survived by his wife, Joyce "Jody" Inman of Salinas and daughter, Janet Sutton and numerous extended family members.

3 Hours
Continuing
Education granted

Pre-Conference Weeds Tour

Tuesday, January 18, 2011 12:30 to 5:30 pm
Tour Fee was $30.00

This year the CWSS offered a pre-conference tour. We traveled by bus from the Portola Plaza Hotel and made three stops that highlighted weed control efforts along the Central Coast of California. Expert Tour Leaders guided us through their field sites and explained their particular weed control challenges and research projects. Below is the itinerary we followed.

Research on Weed Control in Perennial Artichokes

Location: Pezzini's Fruit Stand, Castroville

Guide: Mohammed Bari, Researcher, Artichoke Research Board

This stop highlighted weed control in perennial and seeded artichokes. We viewed and discuss recent efforts to control Bermuda Buttercup (Buttercup Oxalis), a perennial weed that spreads strictly by tubers. It is a troublesome weed invading wildlands and landscaped groundcovers along much of CA coast.

Eradication of Invasive Weeds on the Central Coast

Location: Point Lobos State Natural Reserve (*east side*)

Guides: Bruce Delgado, Bureau of Land Management Botanist and Amy Palkovic, Environmental Scientist, CA State Parks

This stop highlighted an ongoing 96-month project to eradicate French Broom from Pt. Lobos

Weed Management in Golf Courses

Location: Pebble Beach Golf Links

Guides: Mark Mahady, Turfgrass & Research Consultant and Greg Fernald, Target Specialty Products

Annual and perennial, cool and warm season, grass and broadleaf weeds challenge every golf course superintendent. We discussed some of the most difficult weed problems and learned about recent successes on a spectacular, well groomed golf course.

Mode of Action of the Growth Regulator Herbicides

Joseph M. DiTomaso, University of California, Davis, Dept of Plant Sciences, Davis, CA 95616, jmditomaso@ucdavis.edu

Early Discovery of IAA and 2,4-D

Although IAA (indole acetic acid) has been know to chemists as long ago as 1904, the first isolation of an active auxin occurred in 1931 by two Dutch biochemists. They isolated a compound called "auxin A" from 33 gallons of human urine. The first generally accepted report of IAA in a higher plant was published by A.J. Haagen-Smit and coworkers in 1946.

The discovery of 2,4-D, and related chemicals, occurred independently by four research groups in Britain and the U.S. during World War II. This discovery revolutionized modern agriculture.

Since the synthesis of 2,4-D, a number of other synthetic auxins have become commercially available. Although these products are referred to as growth regulators or phytohormones (previously known as plant hormones), they really represent only one group of growth regulators, the auxins. Auxins can be divided into six major groups; indole acids, naphthalene acids, phenoxy carboxylic acids, benzoic acids, picolinic acid derivatives (also called pyridine carboxylic acids) and the quinoline carboxylic acids. The first group contains the natural product IAA, and does not contain any herbicides. IAA is highly unstable in plants and metabolizes too fast to be an effective synthetic herbicide. The naphthalene acids (NAA) are used in research but are not commercially available as herbicides. The other groups contain many well known herbicides; phenoxy carboxylic acids (2,4-D, 2,4,5-T, 2,4-DB, dichlorprop, MCPA, MCPB, mecoprop), benzoic acids (dicamba, chloramben), picolinic acids (aminopyralid, clopyralid, picloram, triclopyr), quinoline carboxylic acids (quinclorac), and one yet to be named family (aminocyclopyrachlor). These compounds are often called auxinic herbicides. Quinclorac has also been shown to have growth regulator activity on broadleaf species, although it is not typically considered to be an auxinic herbicide on grasses.

Mode of Action of the Auxins

IAA influences nearly every aspect of plant growth and development, it is thought to act as a ‘master hormone’ in the complex network of interactions with other growth regulators. Shoot tips, including the young leaves, are the center of most abundant naturally occurring auxin synthesis in higher plants. Other rich sources are root tips, enlarging leaves, flowers, fruits and seeds. One of the difficulties in studying the mechanism of auxin action is the multitude of different kinds of physiological processes that they appear to control. Recent evidence indicated there are IAA receptor sites (auxin-binding proteins) which unleashes a cascade of events. Auxins seem to be involved in a number of developmental functions, including phototropism, apical dominance, senescence, cell growth and differentiation, and root formation.

The initial response of plants to auxin treatment can be categorized into three phases. First, there is a rapid response (within minutes), simulated by low pH and perhaps due to auxin stimulating the pumping of protons into the cell wall and loosening it. During this phase ethylene synthesis is also increased. The second phase of the response occurs 35-45 min after treatment, and involves the synthesis of nucleic acids. The third phase is when the plants senesce and tissue decay occurs. During this phase chloroplasts are damaged and chlorosis develops, membranes are destroyed and the plant loses its vascular system integrity which leads to wilting, necrosis and finally death.

Acid-growth hypothesis

According to the acid-growth hypothesis auxins initiate an acidification mechanism, possibly a membrane-bound H^+ pump (ATPase), with the result that proton efflux occurs and the pH of the solution in the matrix of the cell wall decreases. The resultant lowering of the pH of the solution bathing the cell walls has been suggested to activate enzymes, called expansins, capable of hydrolyzing wall polysaccharides, thereby softening the wall and allow cell extension. Movement of the sugar chains along the cellulose microfibrils occurred by a mechanism (enzymatic or non-enzymatic) which catalyzes breakage and reformation of the hydrogen bonds, allowing the glucan structures to creep inchworm-fashion along the cellulose microfibrils. The rate at which the sugar polymers moved increased at lower pH. This is due to a weakening of the hydrogen bonds. The loosening of the bonds decreased the resistance of the wall to turgor pressure. More water would move into the cell causing an increase in cell volume and irreversibly stretching the cell wall.

The acid-growth hypothesis was supported by evidence showing that an exogenous acid solution can induce short term growth, which could be stopped with the addition of more basic buffers. In addition, an inhibitor of acid-induced growth was also shown to inhibit auxin-induced growth. This suggests that the growth responses evoked by both auxin and acid involve some common step. It could also be argues that acidification is not just a result of growth, but is a necessary part of the growth phenomenon.

Cell elongation after 30 to 60 min does not involve acid-induced elongation, but is due to auxin turning on genes which help cells elongate by other mechanisms (i.e. synthesis of new cell wall material).

Nucleic acid metabolism

Plant tissues respond to auxin treatment by dramatically increasing nucleic acid and protein synthesis, and this effect is closely correlated to auxin-induced growth. However, this response may be independent of the cell wall loosening phenomenon, although this is by no means conclusive.

The action of auxin appears to involve specific gene activation at the transcriptional level. Auxin may interact with a binding protein and the auxin-protein complex then interacts with chromatin (filamentous complex of DNA, histones and other proteins constituting chromosomes) to cause an increase in DNA template available for transcription. The result of this action could be altered DNA transcription and quantitative and qualitative changes in RNA synthesis. These RNAs would then serve as templates for the synthesis of the proteins required for the observed physiological responses.

The changes in DNA transcription in auxin-treated chromatin were shown to cause a substantially higher RNA polymerase activity than control chromatin. It was subsequently shown that the major influence of auxin was to increase the endogenous RNA polymerase of chromatin. The DNA-directed RNA polymerase functions in mRNA synthesis. It was demonstrated that auxins increased a specific set (at least 10) of translatable messenger RNAs that encode for a variety of proteins.

Auxinic Herbicides

The auxinic herbicides are still the most widely used herbicides in the world. They are used to selectively control broadleaf weeds in grass crops, including corn, wheat, barley, oat, sorghum, rice, sugarcane, pasture, rangeland, and turf. These compounds are all weak acid herbicides (see chapter on herbicide absorption) that are primarily applied postemergence and translocate via the phloem to the growing points and other sink regions in the plant.

At low doses, the growth regulator herbicides have a stimulatory effect on plant and cell growth similar to that of IAA. However, phytotoxic concentrations of the auxinic herbicides elicit a variety of symptoms in plants. Among these include, leaf chlorosis, altered stomatal function, stem tissue proliferation, root initiation in stem tissue, disintegration of root tissues, leaf cupping, stunted leaves, and abnormal apical growth. Many of these are secondary effects. In addition, auxin herbicides cause plugging of the phloem, growth inhibition, and tip and stem swelling.

The mechanism of action of these herbicides is thought to be the same as that of naturally occurring auxins. The primary effect of low levels of growth regulator herbicides on nucleic acid synthesis appears to be a stimulation of RNA polymerase followed by stimulation in RNA and protein synthesis. However, in meristematic tissues, high levels of auxins (typical of herbicidal concentrations) inhibit RNA synthesis and growth. In contrast, high auxin levels stimulate RNA and protein synthesis is mature tissues. This stimulation in the more mature stem regions causes parenchyma cells to divide in mature tissues. This often leads to uncontrolled growth and the production of callus tissue. Volume expansion of mature tissues is somewhat restricted by the presence of secondary cell walls and thickened cells, such as collenchyma and fibers.

Consequently, excessive cell division in these tissues can cause stem swelling and eventually cellular collapse. This occurs because the newly developed callus tissues crush the phloem and cortex, eventually resulting in rupturing of the epidermis of stem tissues. Symptoms normally appear within a few hours or days although death may not occur for several weeks or months.

A characteristic twisting symptom known as epinasty occurs following treatment with all of the auxin-like herbicides. This response is the result of an auxin-induced stimulation in ethylene production. It is thought that these herbicides stimulate ethylene production by promoting the synthesis of RNA and the enzymes involved in ethylene synthesis. More specifically, auxin activates transcriptional genes that encode for the enzyme 1-aminocyclopropane-1carboxylic acid synthase (ACS). Although ethylene is induced in most broadleaf species after exposure to auxinic herbicides, some broadleaf species (i.e. chrysanthemum, chickweed, tobacco, yellow starthistle) are tolerant to exogenous ethylene itself and phytotoxic symptoms induced by the herbicide are unaltered in the presence of ethylene biosynthesis inhibitors, suggesting ethylene plays no role in plant death. There are other broadleaf species (i.e. tomato) where auxin-induced ethylene induces the production of ABA (abscisic acid) and ABA which results in stomatal closure.

The characteristic symptoms of auxinic herbicides include rapid internode and petiole expansion due to the cell wall loosening response, and epinasty caused by the stimulation in ethylene. In addition, the inhibition in cell division in meristematic regions occurs at the same time as abnormal stimulation of cell division in mature tissues. Auxin-induced ethylene production leads to stimulation in ABA biosynthesis by up to 70 times the normal level. Together with ethylene, ABA functions as a hormonal second messenger in the mode of action of auxin herbicides. Increased ABA causes stomatal closure which photosynthesis and sugar production. In addition, ABA directly inhibits cell division and elongation and promotes, together with ethylene, leaf senescence with chloroplast damage and destruction of membrane and vascular system integrity. Another byproduct of the ethylene synthesis pathway is cyanide which injures sensitive grasses. Growth inhibition, tissue desiccation and decay and finally plant death are the consequences.

Phenoxy Carboxylic Acids

Phenoxy herbicides are formulated as either salts or esters. Esters are more volatile than salts and are more susceptible to vapor drift, particularly under warmer ambient conditions. However, ester formulations are more readily absorbed through the leaf cuticle and therefore, tend to be more active than salt formulations. This is especially true for waxy-leaved broadleaf species.

The phenoxy herbicides are widely used in many grass crops and in forestry and other non-crop areas. In California, phenoxy herbicides registered for use include 2,4-D, 2,4-DB, dichlorprop, MCPA, and mecoprop. 2,4-D is the oldest and most widely used of these compounds. MCPA is similar to 2,4-D, but is considered somewhat safer on grain crops and legumes. It is less effective on many weeds, such as borages (Boraginaceae), but may be more effective on some thistles and members of the carrot (Apiaceae) and buttercup (Ranunculaceae) families. Dichlorprop is primarily used for controlling brush. Mecoprop is generally used in combination with other auxinic herbicides for control of broadleaf weeds in turf. It is more effective than 2,4-D on chickweeds and clovers, and is safer on bentgrass turf. 2,4-DB is selective in legumes. It must be metabolically converted, through a oxidation reaction, to 2,4-D within the plant in order to be active. Many legumes crops, such as soybeans, peanuts, and seedling forage legumes (clover, alfalfa, and trefoil), as well as mints, metabolize 2,4-DB very slowly and, thus, are fairly tolerant to the herbicide.

Benzoic Acids

Among the benzoic acid herbicides, only dicamba is registered for use in California. It acts in plants the same way as the phenoxy herbicides and other auxins. The selectivity of dicamba is similar to 2,4-D, but it is generally considered to the more active than 2,4-D on perennial broadleaf weeds, legumes, and members of the smartweed (Polygonaceae) and pink (Caryophyllaceae) families. In contrast, it is less effective on mustards (Brassicaceae) and borages. Although the soil activity of dicamba is short, it does persist longer than 2,4-D. Dicamba is often used in combination with other phenoxy herbicides for control of turf and brush weeds.

Picolinic Acids

Four major herbicides belong to the picolinic acid group; aminopyralid, clopyralid, picloram, and triclopyr. Picloram is the only one that is not registered in California. Another herbicide that is very similar to aminopyralid is the new compound called aminocyclopyrachlor. It has not been classified in a chemical family as of yet. The action of these herbicides is similar to other auxinic herbicides. Triclopyr is very active on most shrub species, but also provides excellent control of most broadleaf species. It is one of the most important herbicides in non-crop areas. It has very little soil activity and tends to be somewhat weak on members of the mustard family (Brassicaceae). Aminopyralid and clopyralid are registered for use in rangelands, pastures, and wildlands. Aminocyclopyrachlor will also be registered in the same areas, but is likely to only be available as a premix with other sulfonylurea herbicides. These compounds are effective both post- and preemergence on susceptible species, but have a relatively narrow spectrum of selectivity. They are highly effective against plants in the Asteraceae (sunflower family). Fabaceae (pea family), Solanaceae (potato family), many members of the Apiaceae (carrot family) and Polygonaceae (smartweed family), and have activity on teasel (*Dipsacus* spp.). They are particularly effective for the control of thistles, including yellow starthistle, purple starthistle, Canada thistle. Aminocyclopyrachlor seems to also have good activity on a number of invasive shrubs.

Quinoline Carboxylic Acid

Quinclorac can stimulate ethylene production and cause symptoms in sensitive broadleaf species very similar to that of other auxinic herbicides. However, it is also selective for control of many grasses by a mechanism that appears to involve inhibition in cell wall synthesis. Thus, it is possible that this herbicide possesses two different mechanisms of action in plants.

Auxinic Herbicide Selectivity between Broadleaf and Grass Species

It is thought that no single aspect of herbicide behavior could completely explain auxin herbicide selectivity between broadleaf (dicotyledon) and grass (monocotyledon) species. Although a number of factors may be involved in selectivity, there is no evidence for differences in the target auxin binding sites between monocotyledons and dicotyledons. This may account for resistance in some dicot species.
Some of the possible explanations include:

1. The arrangement of the vascular tissue in bundles surrounded by protective tissue in monocotyledons seems to prevent the destruction of the phloem by the disorganized

growth caused by the herbicides. Furthermore, there is no auxin-sensitive layer of cells capable of cell division in the vascular bundles of monocotyledons.

2. Translocation of foliar-applied auxins from the site of application is less in monocotyledons than in susceptible dicotyledons. Differences in translocation also exist among species of dicotyledons.
3. There are differences in metabolism between monocotyledons and dicotyledons that could also contribute to selectivity. Differences in metabolism can also account for selectivity among dicotyledons. It has even been suggested that cucumbers compartmentalize 2,4-D in the vacuoles and this affords the species a greater degree of tolerance.

Although grass crops are tolerant to auxinic herbicides, they can be injured if these herbicides are applied during rapid cell division (tillering or flowering) or during rapid growth (high temperatures and high soil moisture). Corn and sorghum stems may become brittle after auxinic herbicide application. Wheat and rice may exhibit buggy-whipping and malformed seed heads after 2,4-D treatment.

Herbicide Resistance

A total of 28 weed species in 15 countries have developed resistance to the auxinic herbicides, with the first case appearing in 1957. In the United States and Canada, the dicot species yellow starthistle (*Centaurea solstitialis*), spreading dayflower (*Commelina diffusa*), field bindweed (*Convolvulus arvensis*), wild carrot (*Daucus carota*), kochia (*Kochia scoparia*), prickly lettuce (*Lactuca serriola*), and wild mustard (*Sinapis arvensis*) have been reported to be resistant to one or more of the auxinic herbicides (weedscience.org). The mechanism of resistance has not been identified in most cases, but may to be due to either differential binding to the target receptor site, as appears to be the case with wild mustard, or enhanced metabolism of the herbicide to non-phytotoxic metabolites.

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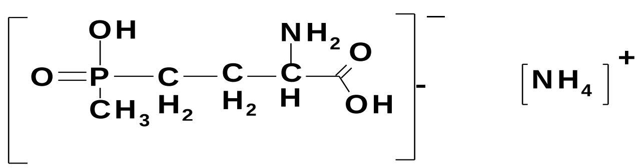
AMINO ACID BIOSYNTHESIS INHIBITING HERBICIDES

John Jachetta, Ph.D., Dow AgroSciences LLC, jjjachetta@dow.com

The identification of herbicide families that act through the inhibition of amino acid biosynthesis has resulted in revolutionary progress in agricultural practices. This review describes three herbicide classes which act through this mode-of-action; including glufosinate (also called phosphinothricin, Liberty®, Ignite®, or Finale®) which inhibits ammonia assimilation, glyphosate (Roundup®, Touchdown®, Glyphomax®) which blocks aromatic amino acid biosynthesis, and several chemical families of acetolactate synthase (ALS) inhibitors (sulfonylureas, imidazolinones, triazolopyrimidines, pyrimidinyl thiobenzoates and sulfonyl-aminocarbonyltriazolinones). These herbicide families share several characteristics including, a single plant-specific biochemical target site (with the exception of glufosinate) and low mammalian toxicity.

Inhibitors of Ammonia Assimilation and Glutamine Biosynthesis: Glufosinate:



Glufosinate-ammonium

Ammonia and Amino Acid Metabolism:

Ammonia is present in plant cells by direct uptake, photorespiration, and nitrate reduction or by the turnover of N-containing compounds in the cell. In all cases, glutamine synthetase (GS) is the essential enzyme employed in the incorporation of ammonia into glutamine. In this pathway (figure 1), glutamine is formed from glutamate by the addition of ammonia through the action of GS. Plant cell aminotransferases enable GS assimilated ammonia to move into many other amino acids and nitrogen-containing products.

The production of glutamine from glutamate is initiated with the binding of ATP to the catalytic domain of GS, followed by the binding of glutamate. Glutamate is subsequently phosphorylated within the active enzyme site to produce a glutamyl-phosphate intermediate. This intermediate reacts with ammonia to form a tetrahedral transition-state; release of PO_4 from this transition-state results in the formation of glutamine (Figure 3)(Lea and Ridley, 1989).

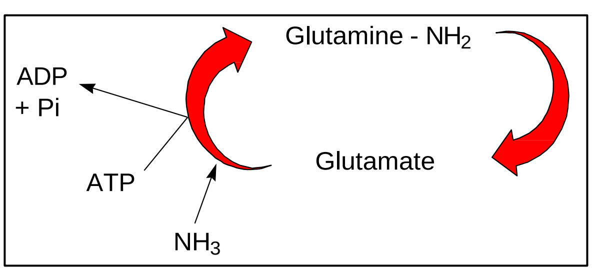


Figure 1. Reaction catalyzed by glutamine synthetase.

Glufosinate Mode-of Action:

Glufosinate (also known as phosphinothricin) is a non-selective ammonia assimilation inhibitor isolated from the bacteria *Streptomyces viridichromogenes.* This inhibitor is a phosphinic analog of glutmate and occurs naturally as one component of a small herbicidal tripeptide called bialaphos (Boger and Sandyman, 1990). The commercial product is the isolated herbicidal peptide component; this product is currently produced by chemical synthesis. Glufosinate is an inhibitor of the enzyme glutamine synthetase (GS) (reviewed by Ray, 1989, and Lea, 1991). At this site-of-action, glufosinate competes with glutamate binding at the GS catalytic domain (figure 2). Once bound to GS, glufosinate is phosphorylated to form a transition-state mimic. This mimic is then irreversibly bound to GS, resulting in deactivation of the enzyme (Lea and Ridley, 1989). The herbicidal result of GS inhibition is the rapid accumulation of ammonia in plant chloroplasts. Ammonia is a known uncoupler of photosynthetic electron transport in plant cells. Ammonia accumulation can occur within 1 hour of glufosinate treatment, with initiation of photosynthetic inhibition following in as little as 4 hours; complete photosynthetic inhibition can occur within 8 hours; free ammonia can increase within the treated cell by 10-fold within this period. This activity is light dependent, as are glufosinate induced visible symptoms of herbicide injury. Light dependency is likely the result of the inhibited ammonia reassimilation from photorespiration-produced ammonia or light-dependent nitrate reduction.

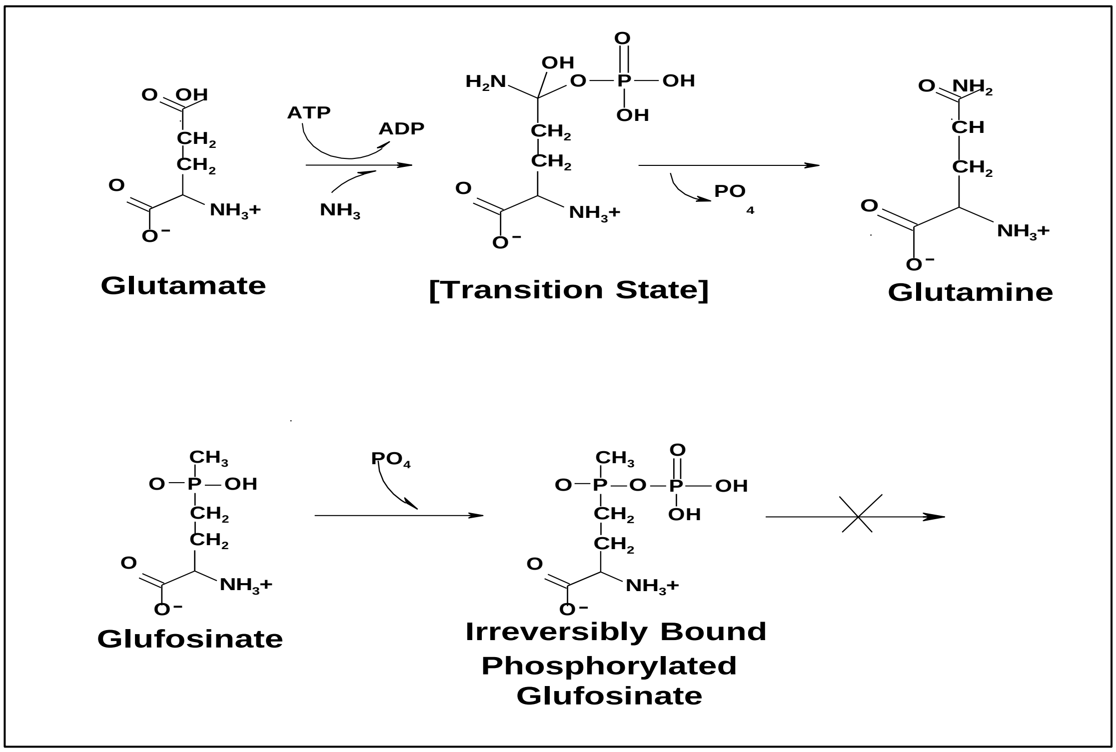


Figure 2: Incorporation of ammonia into glutamine by glutamine synthetase (GS). Glufosinate is a transition-state mimic of glutamate and binds irreversibly to GS

There is strong evidence that the inhibition of photosynthesis by glufosinate is not due to ammonia accumulation alone (Lea P.J. 1991; Gonzalex-Moro *et al.*, 1995). A second mechanism for photosynthetic inhibition results from the depletion of amino acids as a downstream effect of GS inhibition; this action may be the primary cause of glufosinate herbicidal activity (figure 3). In this scenario, amino acid depletion due to GS inhibition results in a depletion of amino (NH_2) donors for the glycolate pathway during photorespiration. The glycolate pathway mediates the oxidation of glycolate to produce glyoxylate for the ultimate production of the amino acid glycine. Since the conversion of glyoxylate to glycine is prevented by the depletion of amino donors, several metabolic intermediates accumulate, including phosphoglycolate, glycolate and glyoxylate. Several studies (most recently, Gonzalez-Moro *et al.*, 1995) have shown that glyoxylate inhibits photosynthesis by preventing the activation of RuBP, a key enzyme involved in photosynthetic CO_2 fixation. Inhibition of photosynthesis results in membrane damage, chlorophyll bleaching, and ultimately in tissue necrosis. Glufosinate induced plant necrosis normally occurs in 1 to 5 days.

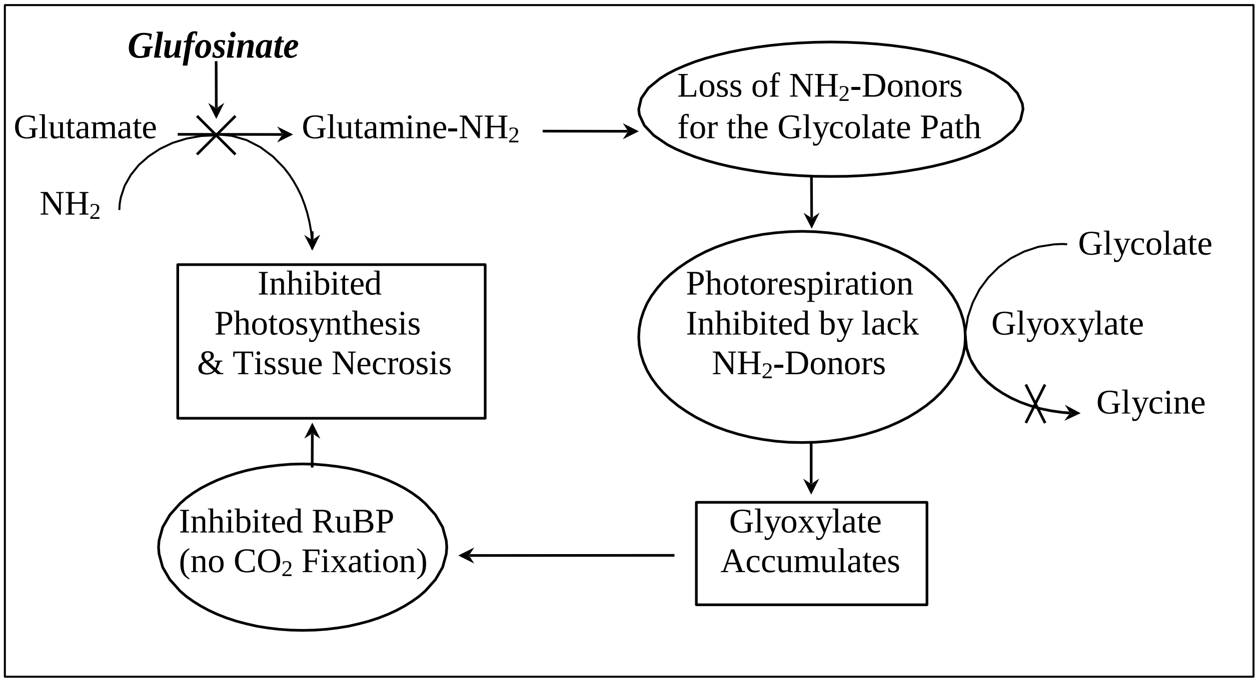


Figure 3: Glufosinate Mode-of-Action

Activity:

Glufosinate is a non-selective herbicide used at 1 to 1.5 lb./A. This inhibitor has non-systemic contact activity, is not active by root uptake, and has minimal translocation within the whole plant. Glufosinate is rapidly degraded in soil.

Glufosinate Resistant Crops:

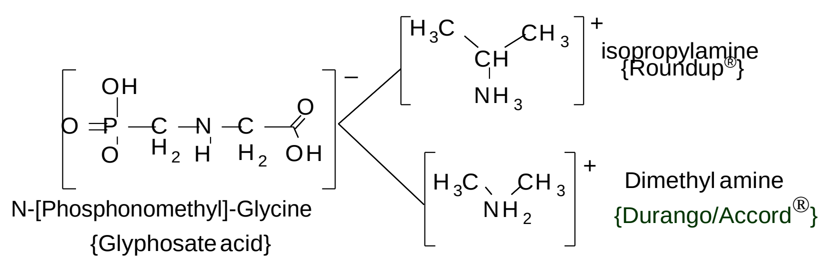
Several crops (corn, soybeans and canola) have been genetically engineered to possess resistance to glufosinate. The glufosinate resistance gene, (called *bar* for bialaphos resistance) was also isolated from *Streptomyces viridichromogenes* (Thompson *et al.*, 1987). This gene encodes a metabolizing enzyme (phosphinothricin acetyltransferase) that prevents autotoxicity in the bacteria. Plants transformed with the *bar*-gene are highly resistant to glufosinate (De Block *et al.*, 1987, De Greef *et al.*, 1989). Introduction of *bar*-transformed crop plants is proceeding quickly. Gene transfer through out-crossing is an issue for glufosinate resistant canola, as the *bar* gene appears to be able to pass to closely related plants, such as wild radish in as few as four generations (Brown *et al.*, 1996) .

Inhibition of Aromatic Amino Acid Biosynthesis: Glyphosate

Biosynthesis of Aromatic Amino Acids:

Phenylalanine, tyrosine and tryptophane are aromatic amino acids essential for protein synthesis. Biosynthesis of these amino acids (figure 2) is initiated with the condensation of a 4 carbon sugar, eythrose-4-PO_4, with a 3-carbon sugar, phosphoenylpyruvate, to form a 7-carbon sugar, deoxyarabino-heptulosonate-7-PO_4 (DAHP), via the enzyme 3-deoxy-D-arabino-heptulosonic-7-phosphate synthase (DAHP synthase). DAHP undergoes a series of reactions, including ring closure, dehydration and reduction to produce shikimic acid. Through the action of the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (ESPS), shikimic acid combines with a second phosphoenylpyruvate, followed by the loss of a PO_4 group, to produce chorismic acid (chorismic is Greek for "fork"). This pathway has two branches following chorismate formation: one into the formation of anthranilic acid leading to the amino acid tryptophane, and the other fork leading to the biosynthesis of phenylalanine and tyrosine. Tryptophane can also be formed from serine and indolglycerol.

Two primary glyphosate salts



Glyphosate Mode-of-Action:

Glyphosate was identified in the late 1960's in a Monsanto discovery program that initially produced the sugar cane ripener glyphosine (which was originally identified from a Monsanto program to identifying new water softening agents). This herbicide was introduced in 1971 at the North Central Weed Science Conference. Glyphosate is a biosynthesis inhibitor of the aromatic amino acids phenylalanine and tyrosine, and these amino acids can reverse glyphosate-induced plant growth inhibition (Gresshoff, 1979). Specifically, glyphosate inhibits the enzyme 3-phospho-5-enoylpyruvateshikimate (EPSP) synthase (figure 4), thus, preventing the conversion of shikimate to chorismic acid (reviewed by Duke, 1988, and Ray, 1989). Inhibition of this biosynthetic pathway results in an unregulated accumulation of shikimate. Following glyphosate treatment, as much as 10 to 20% of the plant's total soluble carbon can be found to accumulate in shikimate. Plant death is apparently the result of the unregulated accumulation of carbon in that intermediate. As the rate of plant death is dependent on the amount of stored carbon in plant tissues, small plants may die relatively quickly (1 to 4 weeks) whereas larger shrubs or small trees may require a year or more to be fully controlled.

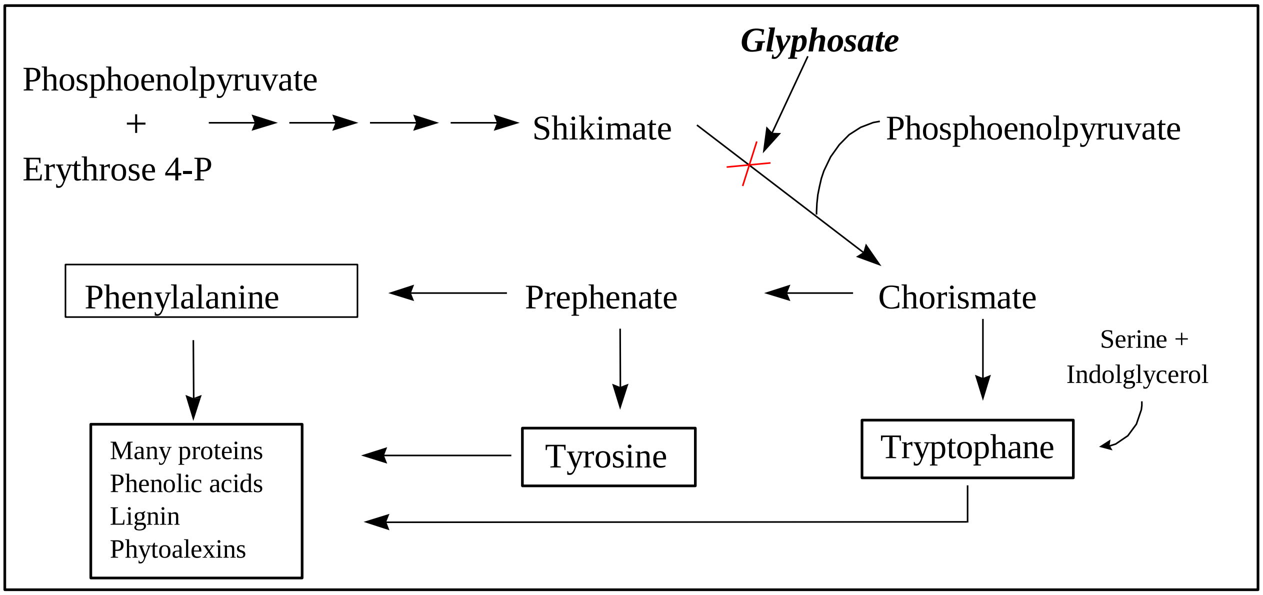


Figure 4: Aromatic amino acid biosynthesis and inhibition by glyphosate

The structure of the active site of EPSP synthase (EC-2.5.1.19) has been determined by co-crystallization of EPSP synthase from bacteria (*E. coli*) with its substrate shikimate- and glyphosate or with shikimate alone. This has allowed a determination of the structures of the enzyme-inhibitor complexes by X-ray crystallography at resolutions of 1.5 and 1.6 angstroms, respectively. Upon binding of shikimate, the two-domain enzyme closes to form an active site in the interdomain cleft. Glyphosate appears to occupy the site of the 2nd substrate, phosphoenyl pyruvate.

Two additional sites-of-action for glyphosate have been described; however, both are inhibited at far higher concentrations (mM) than required for EPSP. These sites include DAHP synthase, an earlier enzyme in the shikimate acid pathway, and the biosynthesis of 5-amino-levulinic acid (ALA), a chlorophyll precursor (reviewed by Duke, 1988). While glyphosate does inhibit chlorophyll synthesis and the whole-plant symptoms do include interveinal chlorosis, these affects appear as a result of the buildup of the shikimate (an organic acid) in the chloroplast. Accumulation of this organic acid destroys the pH balance of the plastid, causing membrane degradation and the bleaching symptomology. Young chloroplasts appear much more susceptible to glyphosate induced pH imbalance than mature plastids[1]. Fairly decisive evidence

[1] Personal communication, Dr. Douglas R. Sammons, Project Leader for Resistance Mechanisms, Monsanto Co.

that EPSP is the sole site of herbicide action can be inferred from the fact that plants genetically transformed with a glyphosate insensitive form of EPSP synthase have been shown to possess commercial levels of tolerance to the herbicide.

Activity:

Glyphosate is a non-selective broad-spectrum herbicide that is highly phloem mobile in plants. Use rates range between 0.25 and 2 lb./A. Glyphosate is not metabolized in treated plants and has no soil activity.

Glyphosate Resistant Crops

Table 1: Glyphosate Resistant Crops

CROP	STATUS
Soybeans	Commercial
Cotton	Commercial
Corn	Commercial
Sugarbeet	Commercial
Wheat	Target~?
Alfalfa	Commercial
Canola	Commercial

a number of crops (table 1). In these crops, glyphosate resistance is the result of plant transformation with a gene (*aroA*) coding for an insensitive form of EPSP synthase. Monsanto engaged in a significant, multi-year search to locate an EPSP synthase enzyme which both bound poorly with glyphosate, but was still

and bacteria EPSP synthases were characterized; a useful gene was ultimately isolated from an *Agrobacterium* bacteria. As aromatic amino acid biosynthesis occurs primarily in the plant chloroplast, it was critical to target the gene product, EPSP synthase, to that organelle. To accomplish this, the *aroA* gene was fused to a chloroplast transit peptide sequence derived from *Arabidopsis thaliana*. The protein produced from this gene fusion product liberates bacterial EPSP synthase upon processing in the plastid. This mechanism of resistance is employed in Roundup Ready soybeans.

A second gene for glyphosate resistance has also been developed, this time coding for glyphosate metabolism via glyphosate oxidoreductase (*GOX*). The *GOX* gene was isolated from an *Achromobacter* bacteria collected from a glyphosate waste stream treatment facility. In a manner similar to *aroA*, glyphosate oxidoreductase was targeted to the chloroplast by fusing the *GOX* sequence with an *Arabidopsis thaliana* chloroplast transit peptide sequence. This gene construct has also been introduced into crop plants. Plants transformed with both the *aroA* and *GOX* gene constructs show excellent vegetative and reproductive glyphosate tolerance with little impact on yield.

Transgenic crop plants expressing glyphosate resistance have had a significant impact on US agriculture. Ninety percent or more of US soybeans and 95 percent or more of the cotton in the Southeast are glyphosate-tolerant; glyphosate-tolerant corn is catching on fast with 60% of the US acreage expressing this trait[2]. In the first year of introduction, canola resistant to glyphosate was planted nearly 200,000 acres, or about 20% of the total canola crop. Much of these uses

[2] Service, R.F. 2007. Newsfocus: A growing threat down on the farm. Science 316; 1114-1117

were by growers who traditionally apply a soil treatment and then follow up with a post-emergence spray, with glyphosate now serving as the latter treatment. Glyphosate tolerant alfalfa was de-regulated by USDA in June, 2005, but use was halted under injunction ordered by the Ninth Circuit in September 2007 based on an appeal by non-GM alfalfa growers and environmentalist groups over fears that the GM alfalfa would cross-pollinate with conventional crops. Monsanto appealed to the Supreme Court after a divided three-judge panel on the 9th U.S. Circuit Court of Appeals upheld the ban for the second time on June 24, 2009. In its first ruling on genetically engineered crops, the Supreme Court on June 21, 2010, overturned the lower court's decision, stating that "An injunction is a drastic and extraordinary remedy, which should not be granted as a matter of course".

Monsanto had stated that the injunction was unfair to the 5,500 growers who chose to plant Roundup Ready alfalfa on some 263,000 acres (106,000 ha) of the approximately 23 million acres of alfalfa planted in the US. A very similar, if not identical situation has occurred with glyphosate-tolerance sugar beets. Sugar beets were deregulated by the Agriculture Department in 2005 following an environmental assessment and planted widely. However, in September, 2009, the Federal District Court in San Francisco ruled that the Agriculture Department should have done a more comprehensive environmental impact statement and assessed the consequences from the likely spread of the genetically engineered trait to other sugar beets or to the related crops of Swiss chard and red table beets[3]. However, in this case, the Federal District Court allowed plantings of glyphosate-tolerance sugar beets to continue in 2010, but warned of a potential block on the use in future seasons while an environmental review takes place. The June 21, 2010 decision for glyphosate-tolerant alfalfa may affect this case as well.

<u>Glyphosate Resistant Weeds:</u>

A significant number of examples of glyphosate resistance have been documented since 1996, including goosegrass (*Eleusine indica)* in Malaysia and rigid ryegrass (*Lolium rigidum*) in Australia and the United States (California)[4]. In resistant goosegrass, EPSP has been determined to be an altered enzyme with two apparent point mutations[5]. One is mutation (glycine 🎭alanine) is known to inhibit glyphosate binding, but also decreases binding of EPSP to the natural substrate, PEP; the second mutation is not yet fully characterized, but may compensate for the negative fitness effects of the first. Multiple sprays at high rates still appear to provide control of the resistant goosegrass biotype. In the case of Australian rigid ryegrass, a 3X increase in the enzyme EPSP appears to be the only observed difference between resistant and wild type plants (Gruys *et al.* 1999), glyphosate-resistant annual ryegrass populations have now been confirmed at 87 sites across Australia[6]. The resistance trait itself may be polygenic, as a full range of tolerant and sensitive plants are found in outcross breeding events. It has been speculated that these plants contain a mutation in a chloroplast PO_4-transporter that is putatively involved in glyphosate import into plastids. This hypothesis was developed from an observation of cross-

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[3] Judge Rejects Approval Of Biotech Sugar Beets; New York Times via NewsEdge Corporation, 24-Sep-2009
[4] http://www.weedscience.com
[5] Mintein Tran and Scot Baerson *et al.*1999, Southeast Asia Weed Science Society in Bangkok.
[6] Dr Chris Preston, Stock and Land Journal, July 2, 2009

resistance between glyphosate-resistant ryegrass and a Zeneca AG Product's phosphonate compound that inhibits histidine biosynthesis (IUPAC, 1999). While this may be possible, the exact mechanism of glyphosate import into chloroplasts in yet unknown[7]. More recently, marestail with tolerance to 10 quarts/A of Roundup has been identified in the Mid-Atlantic States of Delaware, New Jersey and Maryland; waterhemp in Missouri also has at least one, but probably more, biotypes with resistance to glyphosate[8]. In 2003, a highly resistant population of Buckhorn Plantain (*Plantago lanceolata*) was discovered in South African vineyards with a history of poor control with glyphosate[9]; no mechanism has yet been postulated for this resistance. A University of Missouri weed scientist (Reid Smeda) has documented a 20-acre field in which common ragweed (*Ambrosia artemisiifolia*) has shown itself to be resistant to 10 times the rate of glyphosate that normally controls it[10], this biotype is now widespread in the south. In West Tennessee, cotton producers have had to re-introduced residual herbicides into their weed control programs to combat glyphosate-resistant horseweed (*Conyza canadensis*), which now comprises between 80 percent of 90 percent of the horseweed infesting the region[11]. The difficulty in controlling glyphosate-resistant horseweed is exacerbated by its biology; horseweed has an extended period of germination and can emerge in all but the coldest months of the year. Glyphosate-resistant horseweed was first documented in the Mid-South in 2002 by University of Tennessee weed scientist, Bob Hayes, after it appeared in one field in west Tennessee in 2001; over the years, glyphosate-resistant horseweed has become widely distributed in Southern no-till cotton and soybeans where it has caused significant reductions in yield (Zelaya *et al*. 2007; Steckel & Gwathmey, 2009). Zelaya *et al*. (2007) has evaluated the possible occurrence of interspecies transfer of the glyphosate resistance within the genus *Conyza* and observed that hybridization and transfer of herbicide resistance can occur between C. *canadensis* and *C. ramosissima*. The researchers have determined that approximately 3% of ova were fertilized by pollen of the opposing species and produced viable seeds. The interspecific hybrids were found to have intermediate phenotype between the parents but exhibit superior resistance to glyphosate compared to the herbicide resistant *C. canadensis* parent. This fact may be responsible for the 2007 first occurrence of glyphosate resistance in the *Conyza bonariensis* that has recently been identified in California[12].

There have also been confirmed reports of "Palmer pigweed" (*Amaranths palmeri*) resistance in several states including Arkansas (Norsworthy *et al*., 2008), Georgia[13] and Tennessee[14]. Since pigweed species are know to hybridize, glyphosate resistance in the pigweed family is of especially serious concern for if resistance in this key agronomic weed family becomes broadly entrenched across the Unites States, it has potential to seriously affect entire weed management and cultural systems and necessitate wide-scale changes in farming practices. In *Amaranthus*

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[7] Personal communication, Dr. Douglas R. Sammons, Project Leader for Resistance Mechanisms, Monsanto Co.
[8] Soybean Digest via NewsEdge Corporation, January 11, 2002
[9] WSSA International Survey of Herbicide Resistant Weeds; http://www.weedscience.org/in.asp
[10] Personal communication, Dr. Reid Smeda, University of Missouri
[11] Delta Farm Press, July 18, 2005
[12] AGROW - World Crop Protection News - http://www.agrow.co.uk, (A00970440) , Filed 12 September 2007
[13] Monsanto Imagine (weedresistancemanagement.com/layout/press_releases/09-13-05.asp)
[14] The University of Tennessee Institute of Agriculture (agriculture.tennessee.edu/ news/releases/0509-pigweed.htm)

palmeri populations collected from Georgia, the molecular basis of resistance has been identified as EPSPS gene amplification where genomes of resistant plants contained from 5-fold to more than 160-fold more copies of the EPSPS gene than did genomes of susceptible plants (Gaines *et al.*, 2010). Interestingly, in this population, EPSPS genes were present on every chromosome; therefore, gene amplification was likely not caused by unequal chromosome crossing over.

Johnson grass resistance to glyphosate would be an agronomic problem of similar magnitude. Recently, a Johnson grass (*Sorghum halepense*) glyphosate resistant biotype has been noted in Argentina (Salta province), estimates of the effected area are 10,000 hectares and the area is increasing (De La Vega *et al.*, 2006); confirmed glyphosate resistant Johnson grass has been observed in the states of Arkansas and Mississippi; though in both cases, resistance was confined to individual farms[15]. Glyphosate resistance in barnyardgrass (*Echinochloa crusgalli*) is being investigated in the Lower Namoi area of Australia at the University of Adelaide where the summer fallow weed control program relied solely on glyphosate with 15 to 20 applications over a 5-year period; initial greenhouse test results have demonstrated resistance, confirmative testing is now underway[16]. The perennial weed, sourgrass (*Digitaria insularis*), has recently infested Paraguay's glyphosate-tolerant soybean crops and many farmers are considering a return to planting conventional seeds[17]. Most recently, Kansas State University scientists identified five Kochia weed populations in western Kansas with confirmed resistance to glyphosate[18]. Kochia, also called fireweed, is a drought-tolerant weed commonly found on land in the western United States and Canada where crops are grown and cattle are grazed.

Additionally, there have also been scattered reports of glyphosate "nonperformance" on lambs-quarters (C*henopodium album*), with the first reports appearing in South Dakota and Western Minnesota and moving east. If true, a potential mechanism of lambsquarters tolerance could be an alteration in emergence pattern in response to glyphosate-mediated selection of earlier germinating biotypes and encouragement of later germinating biotypes through reduced tillage.

A unique insect-mediated mechanism leading to reduced glyphosate performance has been reported for glyphosate in common ragweed, giant ragweed, and tall waterhemp via the disruption of vascular translocation pathways by feeding insect larva tunneling within the plant stem[19]. Researchers at the University of IL reported on the distribution and impact of insect tunneling on herbicidal control caused by *Lepidoptera*, *Coleoptera*, *Lixus*, and *Dectes* species. Researchers at Purdue, Michigan State and Ohio State Universities have also investigated a tunneling phenomenon in the weed species mentioned above as well as marestail. While not true resistance or tolerance, this phenomena may mimic either situation and result in misdiagnosis of the phenomena.

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[15] AGROW - World Crop Protection News - http://www.agrow.co.uk, (A00989414) Filed 17March 2008 Agrow News Update

[16] Glyphosate Resistance in Barnyardgrass, January 30, 2007. Cotton Tales. Vol. 6. www.dpinsw.gov.au

[17] AGROW News Update, Published Online: 07-May-2008

[18] Associated Press via NewsEdge Corporation 1-Mar-2010

[19] Notes from NCWSS Herbicide Resistance Committee Meeting – Monday, December 1, 2003

Weed or volunteer populations with increased herbicide resistance are also possible due to genetic contamination of non-GM crops by glyphosate-resistant and other herbicide-resistant GM-crops. Field studies of *Brassica* pollen dispersal have indicated that most pollen falls near the release point, but some has been found up to 120 m or more from the point of release. Cultivate rape pollen is capable of fertilizing the weeds *Raphanus raphanistrum* and *Hirschfeldia incana* (Champolivier, Messean and Prunier, 2001) and the transfer of glyphosate resistance to cultivated mustards has been observed in Canada and elsewhere.

While weed population shifts to more tolerant species due to herbicide selection pressure is not true resistance, shifts to indigenous weed species with a higher natural tolerance to glyphosate and/or later emerging species has been observed following continuous use of glyphosate in crop rotation schemes limited to glyphosate-resistant crops. The grower should consider the wisdom of this type of herbicide use pattern on the long-term composition of weed populations in any agroecosystem under continuous cultivation (Miller et al., 2003).

Inhibitors of Branched Chain Amino Acid Biosynthesis: Acetolactate Synthase Inhibitors

Acetolactate synthase (ALS) catalyzes the first committed step in branched-chain amino acid biosynthesis (figure 6, reviewed by Kishore and Shah, 1988). This enzyme facilitates the condensation of two molecules of pyruvate to form acetolactate, which is converted through a series of reaction steps into valine and leucine. ALS also catalyzes a similar reaction, producing acetohydroxybutyrate for the production of isoleucine, when 2-ketobuterate and pyruvate are used as substrates. Biosynthesis of branched-chain amino acids takes place in the chloroplasts.

<u>*Branched Chain Amino Acid Biosynthesis Inhibition:*</u>

Five families of herbicides with remarkable activity have been discovered over the last 25 years, including the sulfonylureas, imidazolinones, triazolopyrimidines, pyrimidinyl thiobenzoates, and sulfonylaminocarbonyltriazolinones (figure 5). These herbicides inhibit the production of branched chain amino acids by the inhibition of acetolactate synthase (ALS) (see reviews by Pesticide Science, 1990, and Stetter, 1994). Several commercial examples of these herbicide families are listed in table 2 with representative structures in figure 6.

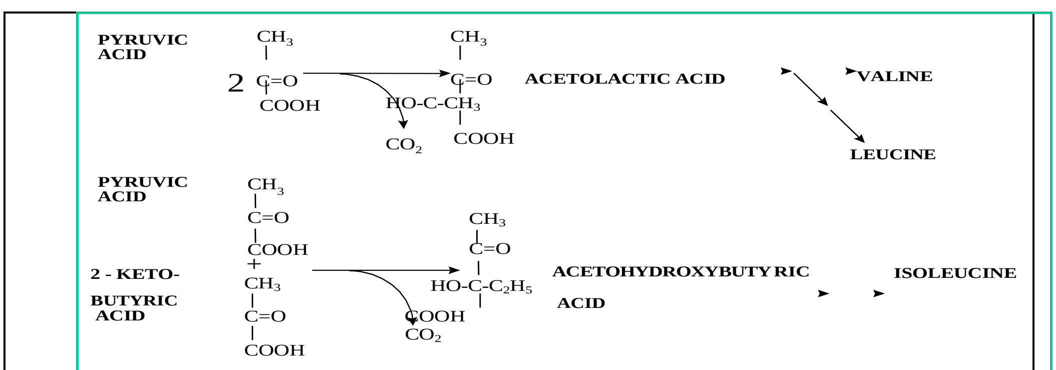
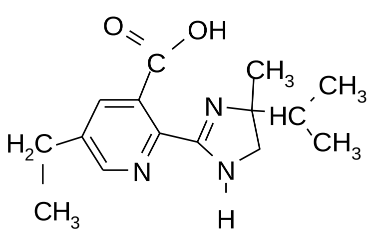


Figure 5. Reactions catalyzed by Acetolactate Synthase.

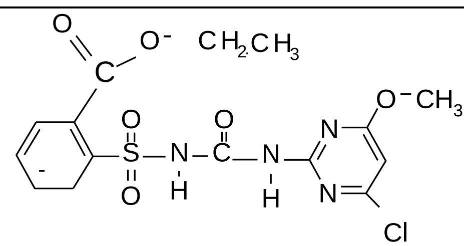
Table 2: Commercial Examples of Acetolactate synthase Inhibiting Herbicides:

Chemical Class	Trade Name	Target Crop	Common Name
Sulfonylureas	Londax® Classic® Oust®	Rice Soybean Non-Crop	Bensulfuron-methyl Chlorimuron-ethyl Sulfometuron-methyl
Imidazolinones	Pursuit® Scepter®	Soybean Soybean	Imazethapyr Imazaquin
Triazolopyrimidines	Broadstrike® FirstRate® Strongarm®	Soybean Soybean Peanuts, Soybeans	Flumetsulam Cloransulam-methyl Diclosulam
Pyrimidinyl thiobenzoates	Staple®	Cotton	Pyrithiobac-sodium
Sulfonylaminocarbonyl-triazolinones	Everest®	Wheat	Flucarbazone-sodium

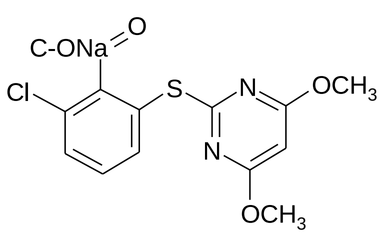
Figure 6: Representative Structures of ALS-Inhibitor Chemical Families



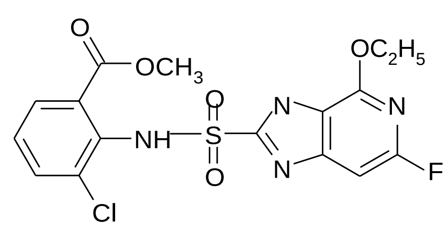
Imidazolinone
Ex: Imazethapyr



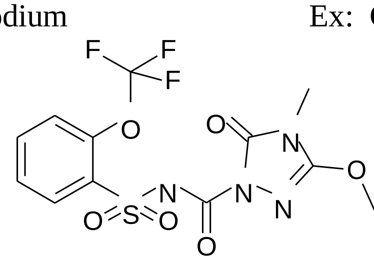
Sulfonylurea
Ex: Chlorimuron-ethyl



Pyrimidinyl Thiobenzoate
Ex: Pyrithiobac-sodium



Triazolopyrimidine Sulfonylanilids
Ex: Cloransulam-methyl



Sulfonylaminocarbonyltriazolinones Ex: Flucarbazone-sodium

ALS-Inhibitor Mode-of-Action:

ALS-inhibiting herbicides prevent the biosynthesis of branched chain amino acids, including valine, leucine, and isoleucine through the specific inhibition of ALS (figure 5). Under laboratory conditions, ALS-inhibitor induced plant growth inhibition can be reversed by supplementing the growth medium with these amino acids. The exact mechanism-of-action resulting in plant death is unknown. Some evidence points to the buildup of one of the substrates of ALS, ✓-ketobuterate, which may cause a general imbalance in 2-ketoacid metabolism and interfere with a variety of biosynthetic processes involved in the utilization of glucose as a carbon source (via glycolysis and the TCA cycle) (LaRossa and T.K. Van Dyk, 1987). However, more recent evidence indicates that the elevation of ✓-ketobuterate occurs only at herbicide concentrations well above the dose required to inhibit growth in plants (Epelbaum *et al.*, 1992; Schloss, 1994). An imbalance in 2-ketoacid metabolism may be important in the inhibition of bacterial ALS and appears to be associated with intracellular acidification and the induction of a stress response (Van Dyk *et al.*, 1998). Whatever the mechanism-of-action, the suppression of branch chain amino acid biosynthesis does results in a rapid inhibition of cell division at the G1 or G2 phases of interphase in the absence of any direct affect on mitosis (reviewed by Brown, 1990). Plant growth can be inhibited within 2 hours following treatment. While cell division and growth are quickly arrested, ultimate plant death is slow. Since plant growth stops almost immediately, the competitive potential of treated weeds is not significant and the presence of affected plants in the field is of no agronomic concern. The rate of plant death is likely related to the total pool of branched chain amino acids available. Thus, small plants will succumb much more rapidly than larger species with more reserves. ALS inhibitor symptomology includes the rapid inhibition of root and shoot growth, vein reddening, chlorosis, and meristematic necrosis.

ALS-Inhibiting Herbicide Resistant Crops:

Several herbicide resistant crops have been engineered through the mutation of the gene encoding ALS. Crops include sulfonylurea tolerant (STS) soybeans and imidazolinone resistant or tolerant (IR/IT) corn, imidazolinone tolerant (Smart®) canola, imidazolinone tolerant (Clearfield®) wheat and rice.

ALS-Inhibiting Herbicide Resistant Weeds:

Unlike most herbicidal enzyme inhibitors, ALS-inhibiting herbicides do not bind to the catalytic domain of the target enzyme (Schloss 1990, 1994). Instead, ALS inhibitors appear to bind to an evolutionary vestige of pyruvate oxidase contained within ALS. Both pyruvate oxidase and ALS apparently share a common evolutionary origin. Since ALS inhibitors do not bind to the catalytic domain of the enzyme, some mutations in the herbicide-binding site are not lethal and have minimal selective disadvantage. This has allowed for the rapid selection of herbicide resistance by compounds with this mode-of-action.

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Free Radical Generators

Kassim Al-Khatib, UC IPM Program, University of California, Davis, kalkhatib@ucdavis.edu

Free radicals are atoms, molecules, or ions with unpaired electrons. In general, the unpaired electrons cause radicals to be highly chemically reactive. Radicals are believed to be involved in the aging process, degenerative diseases, a range of disorders including cancer, arthritis, athero-sclerosis, Alzheimer's diseases, and diabetes. The free radical theory of aging implies that antioxidants such as vitamin A, vitamin C, vitamin E, and superoxide dismutase will slow the process of aging by preventing free radicals from oxidizing sensitive biological molecules or reducing the formation of free radicals.

Free radicals are frequently denoted by a dot placed immediately to the right of the atomic symbol or molecular formula as follows:

$$Cl_2 \Rightarrow Cl. + Cl.$$

$$O_2 \Rightarrow O. + O.$$

Plants naturally have free radicals that are by-products of several chemical processes. However, under normal conditions plants have the ability to mitigate free radical injury by utilizing enzymatic system and antioxidants.

Several herbicide groups can injure plants by generating massive amounts of free radicals. Free radicals are unstable and must obtain an electron from some other chemical to become stable. By taking an electron from another chemical, the other chemical now becomes a free radical and its chemical structure is changed. It must then steal an electron. Thus the chain reaction (of atoms stealing electrons) continues and can be thousands of events long. These events can result in serious damage to cells including lipid periodation, protein damage, and DNA lesions.

In broad terms, there are three groups of herbicides that generate massive amounts of free radicals including those that:

1) Inhibit photosystem II (PSII inhibitors): triazines, triazinone, pyridazinone, phenyl-carbamate, amide, Nitrile, benzothiadiazinone, phenyl ureas, and uracils.

2) Capture electrons in photosystem I (PSI disruptor): bipyridiliums.

3) Inhibit protoporphyrinogen oxidase (Protox inhibitors): diphenyl ethers, phenylpyrazole, N-phenylphthalimide, thiadiazole, oxadiazole, and triazolinone.

The following discussion is about the herbicides under (2) and (3) above, which are often grouped together as free radical generators.

Common properties:

Bipyridiliums (diquat and paraquat, Figure 1), the diphenyl ethers (Figures 2 and 3), and the N-phenyl heterocycles (oxadiazon, carfentrazone, and sulfentrazone, Figures 3) share several properties. Signs of injury to susceptible plants are very similar for all of these herbicides. Symptoms appear a few hours after treatment as dark green areas on foliage, followed by wilting. Necrosis follows, and in a few days the characteristic browning or "burned" appearance is evident. Susceptible species are killed within a few days. Death of tissue is so rapid that none of these herbicides are appreciably translocated. Because of a lack of systemic action, complete coverage is important to prevent weed regrowth. Activity is greater on sunny days, although applications at night that are followed by a bright day may have greatest efficacy.

None of these herbicides are susceptible to leaching from the soil, but for different reasons. Diquat and paraquat are strongly adsorbed by clays and other inorganic soil colloids; thus they are rarely active in the soil (Figure 4). Oxadiazon and the diphenyl ethers are strongly adsorbed by soil organic matter; when applied preemergence, most activity occurs near the soil surface as seedlings emerge. Soil incorporation greatly decreases the activity of oxadiazon and diphenyl ethers.

Principal uses:

Paraquat and diquat are nonselective herbicides. Paraquat is widely used to control vegetation prior to crop emergence, as a dormant season treatment in alfalfa and other perennial crops, and as a directed spray. Diquat is mostly used for aquatic weed control. Application is either postemergent for cattail control, or water-run to control algae and submersed and floating weeds.

Diphenyl ethers and the N-phenyl heterocycles are selective herbicides that must be carefully applied to avoid injury. Sensitivity to these herbicides often varies with crop age, and most crops can outgrow minor, early-season damage. Avoiding contact with crop foliage helps to prevent crop injury, as in directed applications of oxyfluorfen under dormant fruit and nut trees and grapes, or granular applications of oxadiazon in woody ornamentals and turf.

Mode of Action

The mode of action for free radical generators involves membrane degradation. Paraquat and diquat accept electrons from photosystem I (Figure 5) to form free radicals. These free radicals rapidly produce a superoxide radical from molecular oxygen that then undergoes enzymatic dismutation to form hydrogen peroxide (Figures 6 and 7). Hydrogen peroxide and the superoxide radicals interact to produce hydroxyl radicals, which quickly degrade membranes.

The diphenyl ethers and the N-phenyl heterocycles affect the enzyme protoporphyrinogen oxidase (Protox, Figure 8). Protox is found in the chloroplast envelope and in mitochondria (Figure 9). Protox converts protogen IX into protoporphyrin IX (proto IX). Diphenyl ethers and oxadiazon inhibit Protox (Figures 10 and 11). As a result, excess protogen IX moves out of the chloroplast and into the cytoplasm. Enzymatic oxidation of protogen IX into proto IX results in an accumulation of proto IX. The excess proto IX interacts with oxygen and light to form singlet oxygen ('02), which begins the process of lipid peroxidation (Figures 12 and 13). Both lipids and proteins are oxidized, destroying chlorophyll, carotenoids, and rupturing membranes.

Lipid Peroxidation

All of the free radical generators destroy cell membranes, ultimately leading to the death of plant tissue. A major component of cell membranes are lipids. Lipid peroxidation by free radicals involves three steps: initiation, propagation, and termination (Figure 12). The lipid peroxidation initiation factor varies with the herbicide group and includes: triplet chlorophyll from photosystem II inhibitors, singlet oxygen from Protox inhibitors, and hydroxyl radicals from bipyridylium herbicides. All of these initiating factors remove a methylene group from near the double bond (the unsaturation site) of polyunsaturated fatty acids (Figure 13). This is the initiation reaction. The propagation reaction occurs when the peroxidized lipid radical reduces to lipid peroxides when they extract hydrogen from other polyunsaturated fatty acids in the plant cell membranes. The termination reaction occurs because the lipid peroxides are not stable and undergo degradation to small hydrocarbons such as pentane and ethane.

Bioassays

Diphenyl ethers: *Chlorella* (Kratky and Warren 1971), *Chlamydomonas* (Hess 1980), and sorghum seedlings (Fadayomi and Warren 1977).

Paraquat and diquat: *Lemna* spp. (Funderburk and Lawrence 1963; Damanakis 1970).

Toxicology

Diphenyl ethers and oxadiazon: low avian and mammalian, low to moderate fish toxicity.

Paraquat and diquat: fish toxicity is low for both. Mammalian toxicity is moderate for diquat but HIGH for paraquat. Paraquat is often used in suicide attempts, and can be fatal if enhaled, swallowed, or absorbed through the skin. If ingested, drink fluids and induce vomiting immediately. Flush affected skin areas immediately with water. Respirators are required for many paraquat application situations.

Herbicide Resistance

There are no reports of resistance to diphenyl ethers. At least twenty-seven weed species are resistant to paraquat.

Information on Usage

Paraquat is often used for postemergent control of small weeds, or to destroy foliage of larger weeds. Killing above ground tissue to set back the growth of larger weeds ("burndown") allows crops to form a canopy that shades out weeds. Penetration of paraquat through the plant cuticle is critical, so the use of nonionic surfactants is recommended. Paraquat is rapidly absorbed through plant foliage, and rain occurring 30 minutes or more after application has no effect on activity.

Diquat use is restricted to waters with little outflow to reduce risk of accidental poisoning.

Acifluorfen-sodium is used on more acres than any other diphenyl ether because it is registered in three high acreage crops: soybeans, peanuts, and rice. Soybean and rice use is strictly postemergent, and control is effective for many broadleaf weeds that are missed by other herbicides. Use a nonionic surfactant with postemergent treatments. Peanut use is only as a pre-emergent application. Do not plant root crops (e.g. carrots) for at least 18 months into any soil treated with acifluorfen-sodium.

Oxyfluorfen is used in a number of crops for pre-emergent control, or as a directed postemergent treatment. It will injure most crops if applied over-the-top, but can be safely applied over-the-top in onions. Pre-emergent applications will injure direct-seeded cole crops, but can be safe for transplants. Transplanting breaks through the surface barrier of herbicide-treated soil, allowing the crop to grow without contacting herbicide, but still controlling weeds that emerge through the undisturbed surrounding soil.

Oxadiazon is used on warm season turf grass to control annual grasses and in many ornamentals to control grasses and annual broadleaves.

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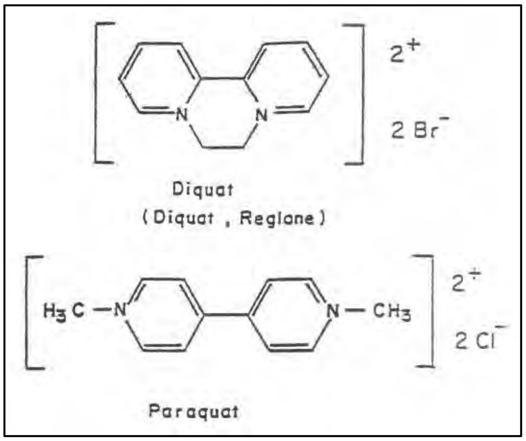


Figure 1. Structure of the two most common bipyridiliums, paraquat and diquat. Note the characteristic herterocyclic rings that contain both carbon and nitrogen atoms. When in solution with water, both paraquat and diquat are bivalent cations, i.e. have two positive charges.

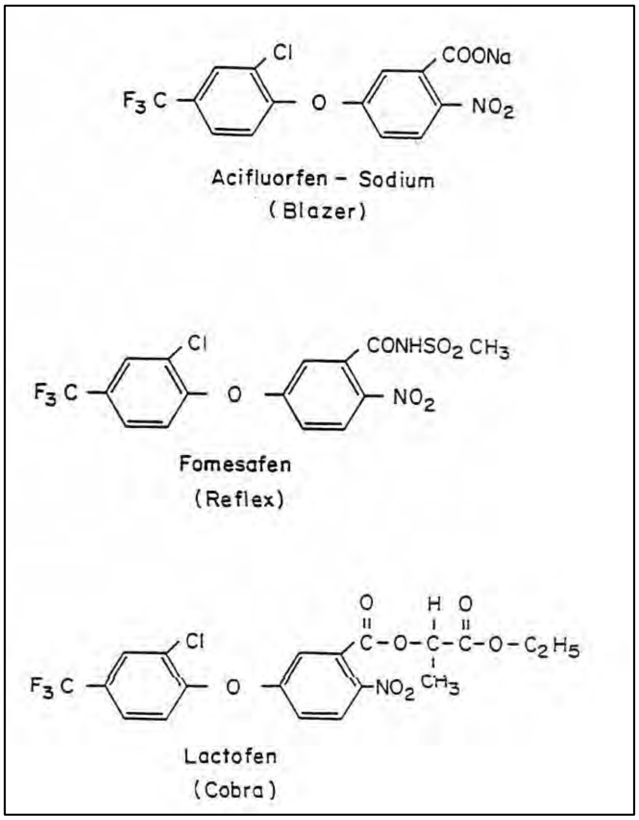


Figure 2. Chemical structure of widely used diphenyl ether herbicides. Diphenyl ethers contain two benzene rings ("phenyl" groups) connected by an ether linkage.

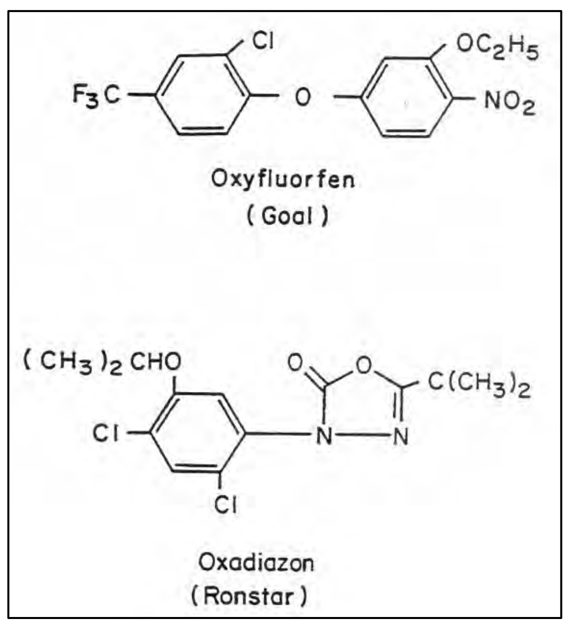


Figure 3. Structure of oxyfluorfen, a diphenyl ether; and oxadiazon, an N-phenyl heterocyclic herbicide. The N-phenyl heterocycles consist of a phenyl group bonded to a nitrogen atom in a heterocyclic ring. Both diphenyl ethers and N-phenyl heterocycles have benzene rings and extensive resonance structures.

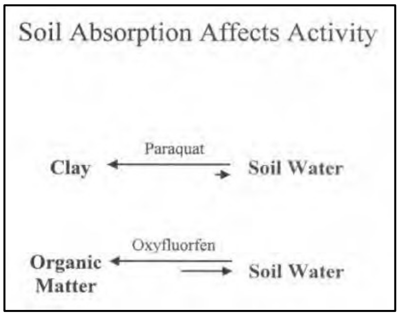


Figure 4. Dynamic equilibrium between soil components and herbicides. Paraquat is so strongly adsorbed onto clay particles that the equilibria is almost completely shifted toward the clay particles, and very little paraquat enters into the soil water solution. As a result, there is usually no injury to plants in soil following paraquat application.

Oxyfluorfen is absorbed onto soil organic matter, which usually prevents significant leaching of oxyfluorfen. However, enough oxyfluorfen enters the soil water solution to injure or kill seedlings that emerge through the surface of oxyfluorfen-treated soil. Thus, oxyfluorfen acts as a barrier to weed emergence. Breaking the barrier, e.g. by digging a hole to plant transplants, prevents injury to plants growing where the soil was disturbed.

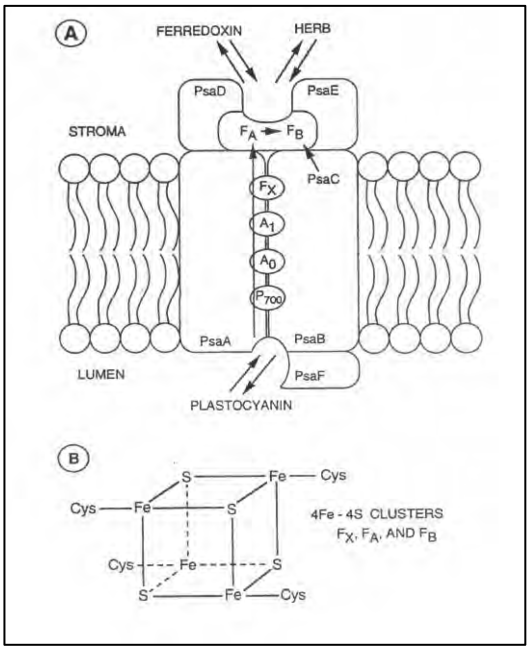


Figure 5. Electron transport in the photosystem I (PS I) complex embedded in thylakoid membranes of chloroplasts. Arrows within the PS I complex represent electron flow. P700, a dimer of chlorophyll a, accepts light energy from the chlorophylls and carotenes associated with PS I. Other electron carriers are: Ao, a chlorophyll a molecule; A1, a phylloquinone; and FX, FA and FBare iron-sulfur clusters (4Fe-4S). Plastocyanin and ferredoxin are soluble electron carrier proteins that dock to PS I. Plastocyanin gives up an electron to PS I (photooxidized) and ferredoxin accepts an electron from PS I (photoreduced). The structural proteins of PS I are termed Psa. PsaA and PsaB make up the core of PS I and are embedded in the thylakoid membrane, whereas PsaC is a peripheral protein housing the iron-sulfur clusters FA and Fe. PsaD and PsaE assist with the docking of ferredoxin, while PsaF assists with the docking of plastocyanin. The bipyridilium herbicides compete with ferredoxin for a binding site at or near PsaC.

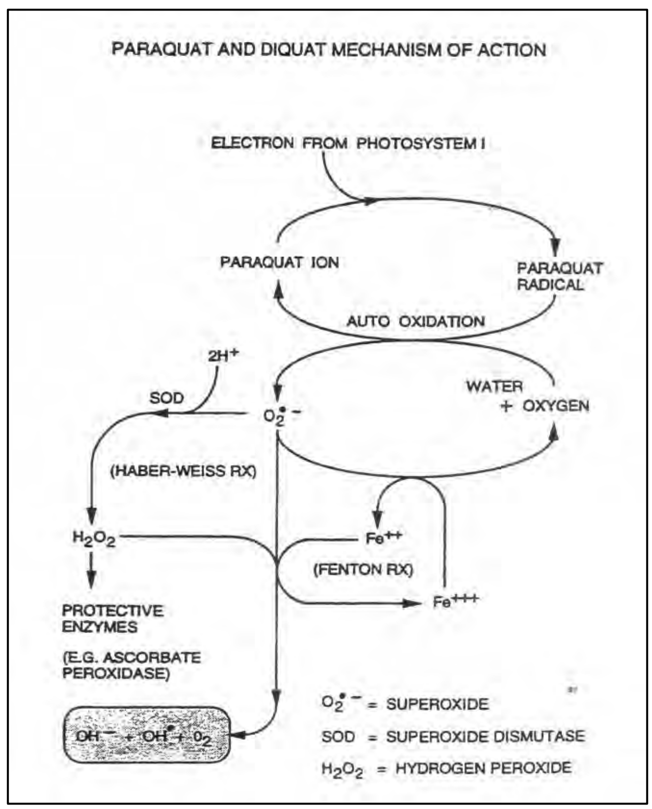


Figure 6. Paraquat, a di-cation bipyridilium herbicide, captures electrons from PS I during electron flow in photosynthesis and becomes a free radical (mono-cation). The paraquat free radical is unstable and rapidly undergoes

auto-oxidation back to the parent ion. During the auto-oxidation process, superoxide radicals (02') are produced from molecular oxygen. Superoxide can undergo enzymatic dismutation (superoxide dismutase - SOD) to form hydrogen peroxide (H202). As hydrogen peroxide and superoxide accumulate in the cell after paraquat treatment, they react to produce hydroxyl radicals (OH') via the Haber-Weiss reaction. The reaction is catalyzed by transition metals, iron or copper, in the Fenton reaction. Hydroxyl radicals efficiently initiate lipid peroxidation in polyunsaturated fatty acids in membranes.

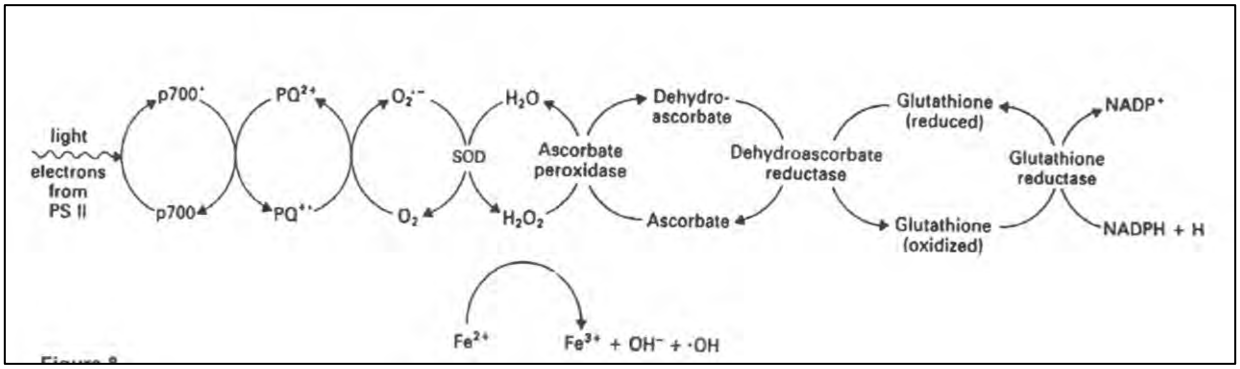


Figure 7. Superoxide generation and detoxification at Photosystem I. PO, paraquat; SOD, superoxide dismutase (after Shaaltiel & Gressel 1986).

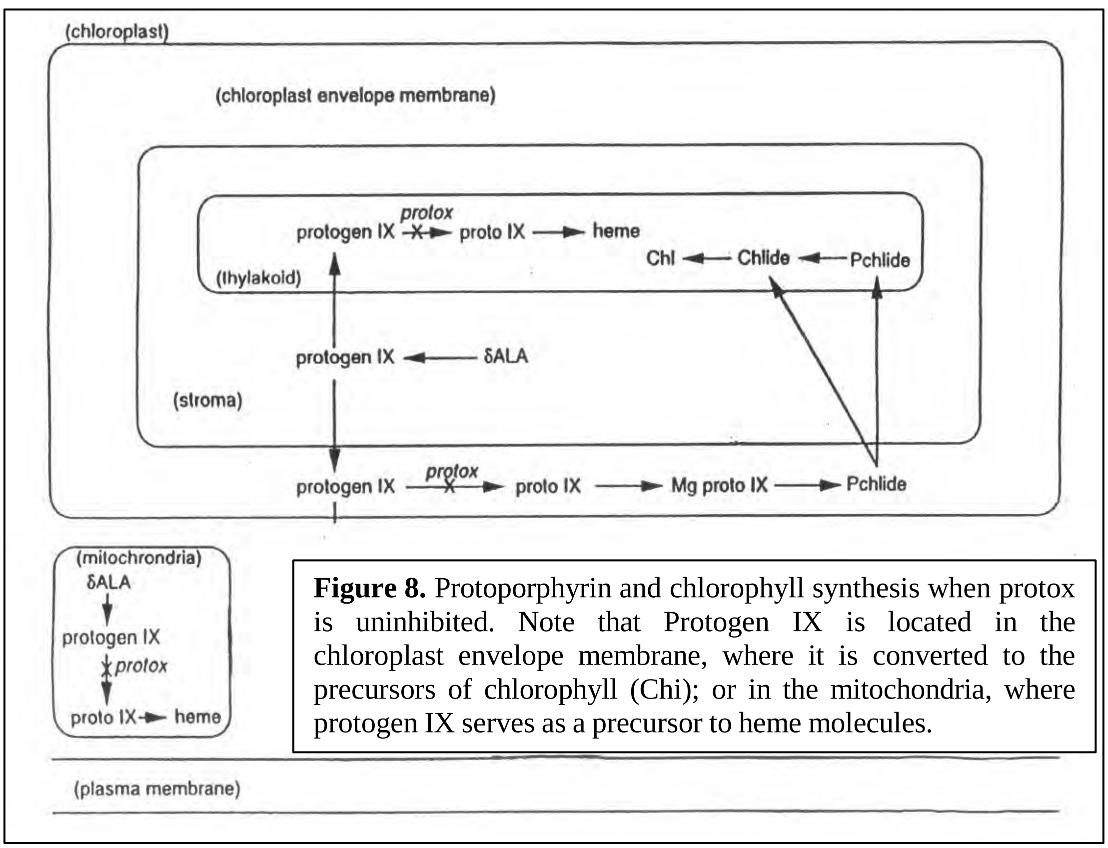
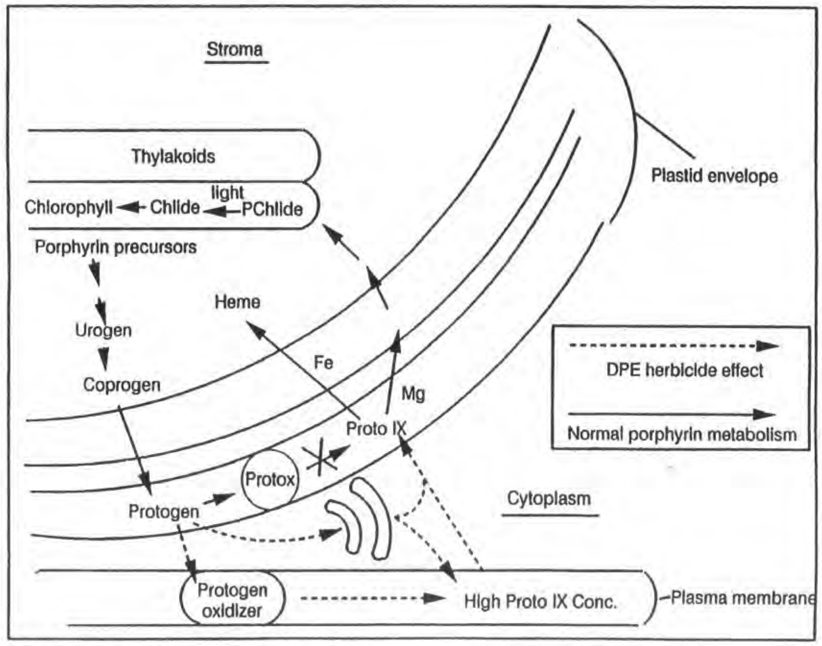


Figure 8. Protoporphyrin and chlorophyll synthesis when protox is uninhibited. Note that Protogen IX is located in the chloroplast envelope membrane, where it is converted to the precursors of chlorophyll (Chi); or in the mitochondria, where protogen IX serves as a precursor to heme molecules.

Figure 9. Diagram of cellular organelles illustrating the locations of precursors and enzymes of chlorophyll synthesis. The solid lines illustrate a normally functioning porphyrin pathway. The dotted line shows how the pathway changes when diphenyl ether herbicides block the activity of the Protox enzyme.



From: Lee, Duke and Duke (1993) Plant Physiol. 102:881-889.

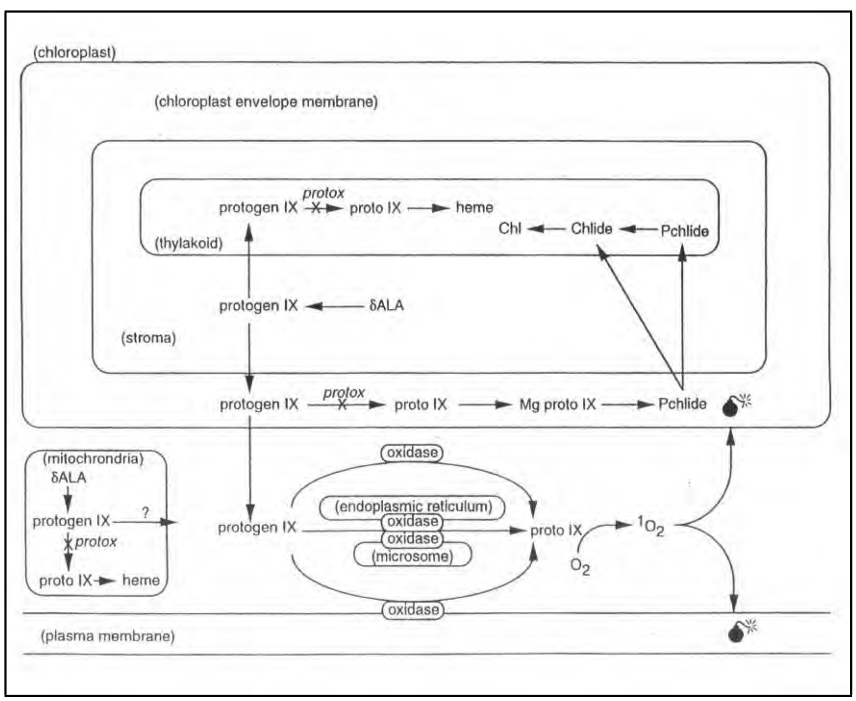


Figure 10. The activity of Protox has been blocked by an herbicide. Protogen IX accumulates and leaks out of the chloroplast envelope membrane, interacting with oxidase and forming singlet oxygen, which ultimately leads to lipid peroxidation and destruction of cellular membranes.

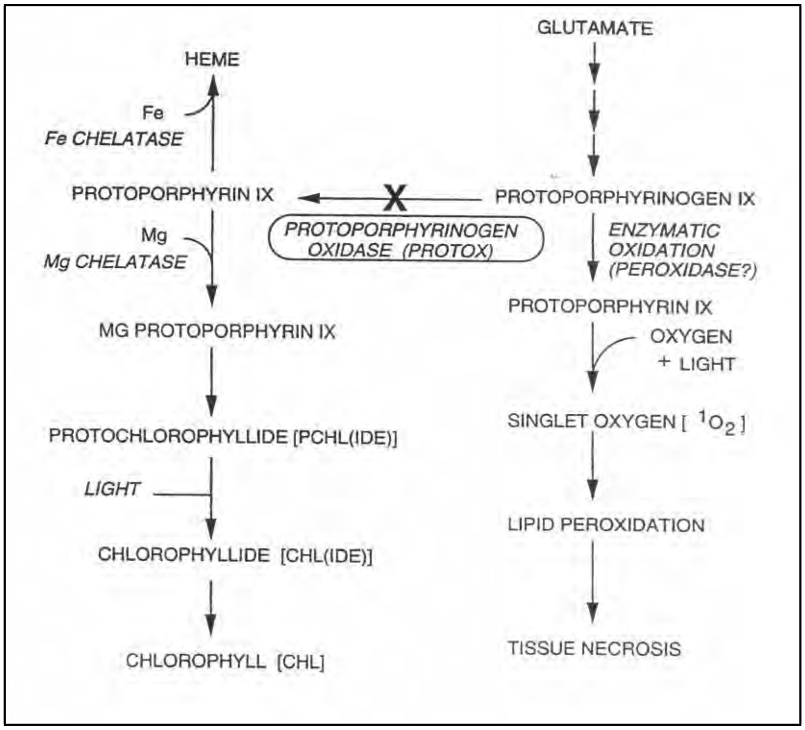


Figure 11. Flow chart of chlorophyll biosynthesis. The left side of the diagram illustrates the pathway when the enzyme protoporphyrinogen oxidase (Protox) functions normally. The right side shows what happens when is inhibited by diphenyl ethers and N-phenyl heterocyclic herbicides.

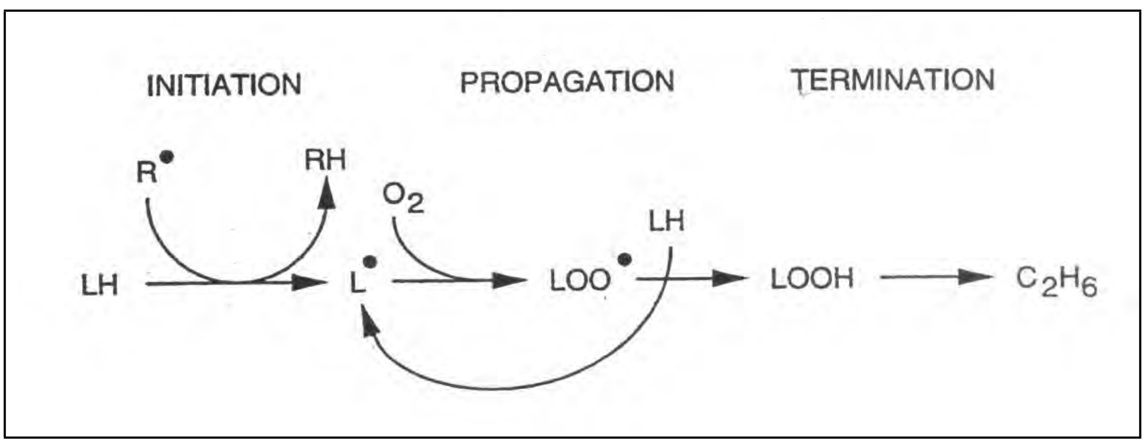


Figure 12. Lipid peroxidation of polyunsaturated fatty acids in plant membranes. An initiating factor (R') such as triplet chlorophyll, singlet oxygen, or a hydroxyl radical removes a hydrogen from a polyunsaturated fatty acid (LH) in the membrane. This hydrogen abstraction process generates a lipid radical (L'). Oxygen reacts with the lipid radical to form a peroxidized lipid radical (LOO'). This peroxidized lipid radical reacts with another polyunsaturated lipid that propagates the reaction within a localized region of the membrane. The lipid peroxides (LOON) formed during propagation are unstable and degrade to short chain hydrocarbon gases such as ethane (CZH6).

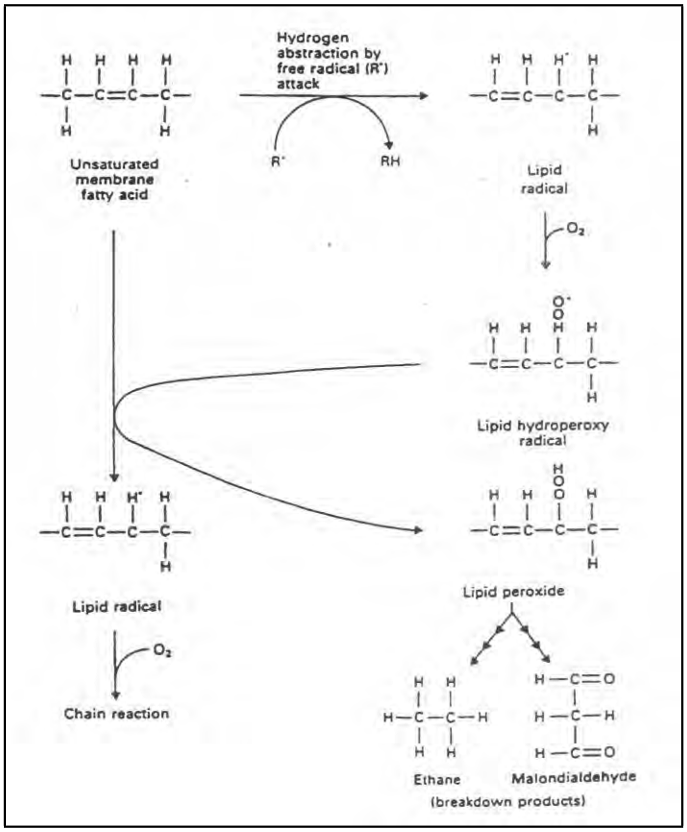


Figure 13. Chemical structure diagrams that illustrate the steps in lipid breakdown that results from free radical generation following herbicide interactions with plant cellular components.

Photosynthesis & Pigment Synthesis Inhibitors

Josie Hugie, Research and Development Scientist, Syngenta Crop Protection
Email: josie.hugie@syngenta.com

1. Photosynthesis II (PSII) Inhibitors

Uptake & Translocation

Chemistry: Lipophilic – penetrates cuticle
Basic molecules - Xylem mobile only --> Transpiration stream

Mode & Mechanism of action

PSII inhibitors compete with plastoquinone (PQ) at QB binding site of D1 protein
- Blocks electron flow through photosynthesis
- Creation of reactive oxygen species (ROS)
- ROS damage membranes

Resistance http://www.hracglobal.com/

HRAC **Group 5**
Triazines (atrazine, simazine), Triazinones, Triazolinones, Uracils, Pyridazinones, Phenyl-carbamates

HRAC **Group 6**
Nitriles (bromoxynil), benzothiadiazinones, phenyl-pyridazines

HRAC **Group 7**
Ureas (diuron), Amides

Resistance: Known mechanisms
Target site resistance: Mutation does not favor binding
Metabolism: Less common - Crop tolerance & selectivity

Symptomology

- Soil Applied Symptoms: Initial injury = first photosynthetic leaves
  Chlorosis leaf margins & older leaves
- Foliar Applied Symptoms: Chlorosis & necrosis at leaf tips, older leaves first
- Injury and carryover: greater with late application, dry season, & soil pH >7.2

2. Pigment synthesis Inhibitors

Mode of action

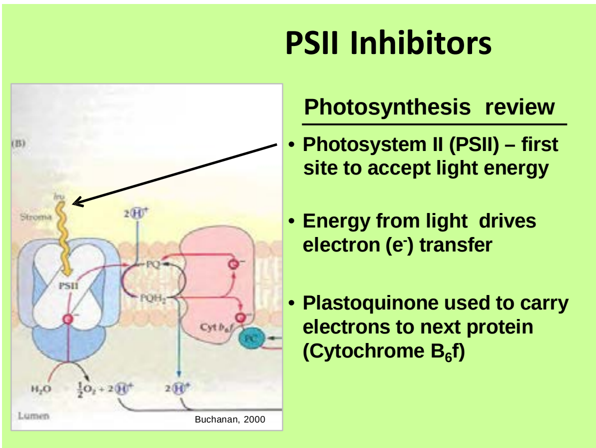
- Depletion of antioxidants (plant protective pigments)
- Increases damage from reactive oxygen (ROS)
- Damages membranes & cellular compartments

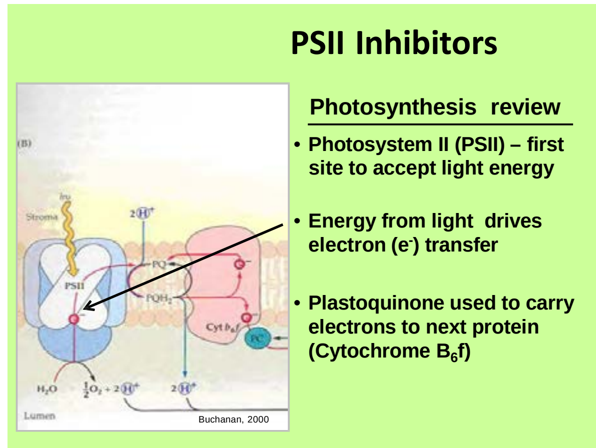
Uptake & translocation

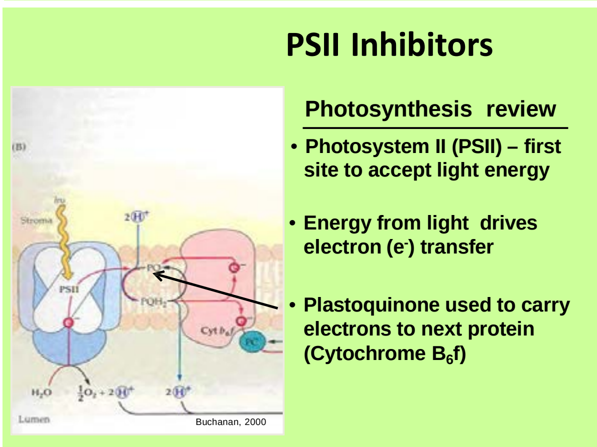
- Weak acids: Penetrate cuticle - Phloem-trapped
- Translocated through phloem to <u>new tissues</u>

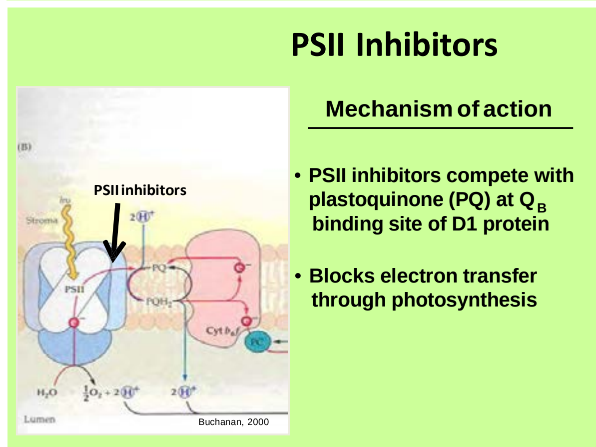
Mechanism of action

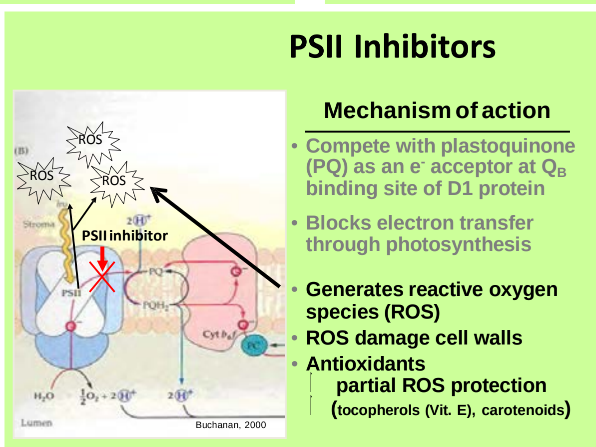
- HPPD inhibitors: Depletes tocopherols, carotenoids, & plastoquinone
- 1-deoxyxylulose-5-phosphate synthase (DOXPS) inhibitors:
  Deplete carotenoids & plastoquinone
- Phytoene desaturase (PDS) inhibitor: Depletes carotenoids
- Lycopene cyclase inhibitor: Depletes carotenoids

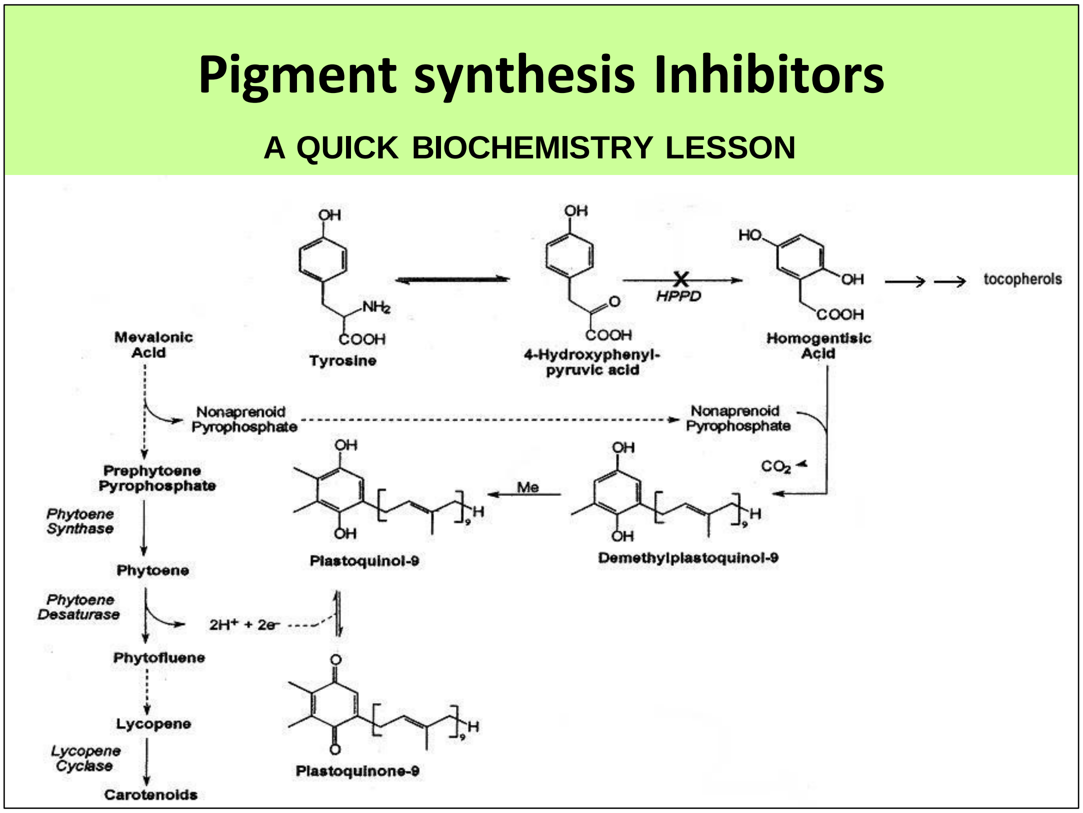


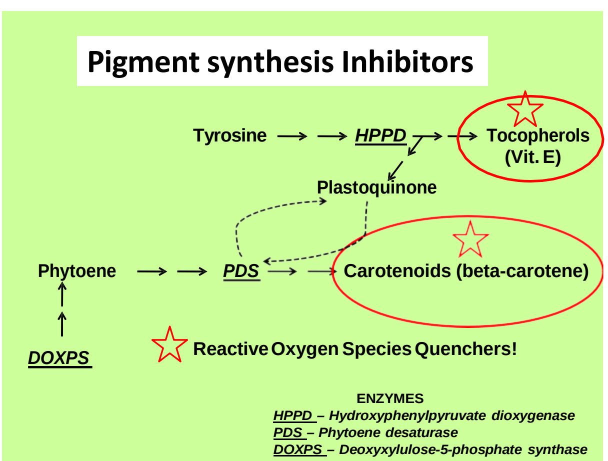


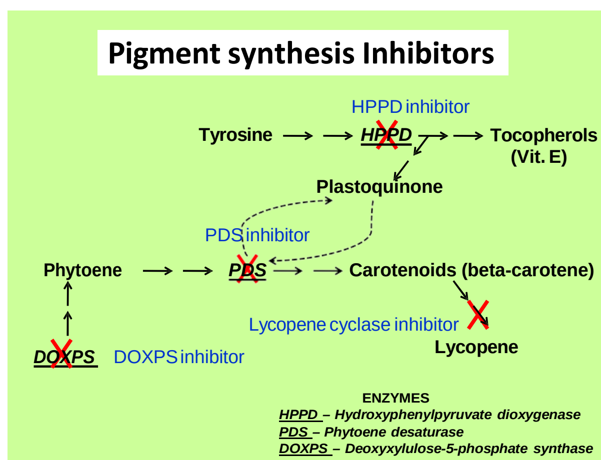







Pigment synthesis Inhibitors
A QUICK BIOCHEMISTRY LESSON
OH
NH2
COOH
Tyrosine
OH
O
COOH
4-Hydroxyphenyl-
pyruvic acid
HPPD
HO
OH
COOH
Homogentisic
Acid
tocopherols
Mevalonic
Acid
Nonaprenoid
Pyrophosphate
Nonaprenoid
Pyrophosphate
CO2
Prephytoene
Pyrophosphate
Phytoene
Synthase
Phytoene
Plastoquinol-9
Me
Demethylplastoquinol-9
Phytoene
Desaturase
2H+ + 2e-
Phytofluene
Lycopene
Lycopene
Cyclase
Carotenoids
Plastoquinone-9


Pigment synthesis Inhibitors
Tyrosine
HPPD
Tocopherols
(Vit. E)
Plastoquinone
Phytoene
PDS
Carotenoids (beta-carotene)
DOXPS
Reactive Oxygen Species Quenchers!
ENZYMES
HPPD – Hydroxyphenylpyruvate dioxygenase
PDS – Phytoene desaturase
DOXPS – Deoxyxylulose-5-phosphate synthase


Pigment synthesis Inhibitors
HPPD inhibitor
Tyrosine
HPPD
Tocopherols
(Vit. E)
Plastoquinone
PDS inhibitor
Phytoene
PDS
Carotenoids (beta-carotene)
Lycopene cyclase inhibitor
Lycopene
DOXPS
DOXPS inhibitor
ENZYMES
HPPD – Hydroxyphenylpyruvate dioxygenase
PDS – Phytoene desaturase
DOXPS – Deoxyxylulose-5-phosphate synthase

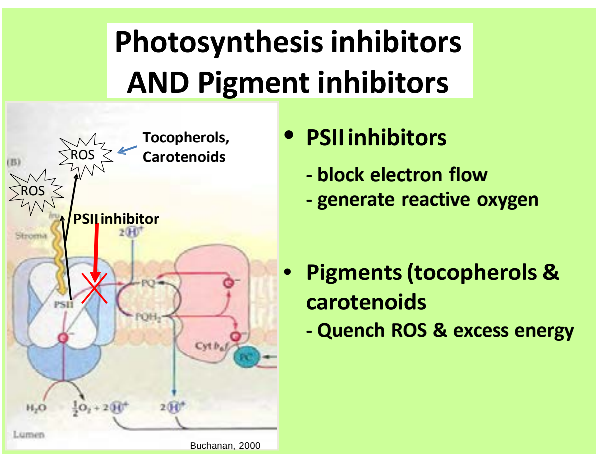
Resistance

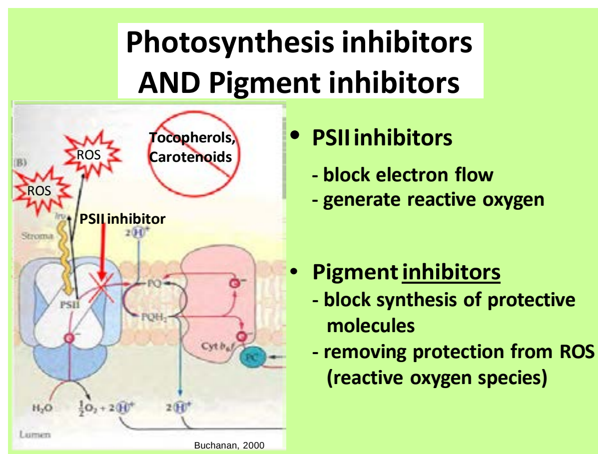
- HRAC **Group 11 (*lycopene cyclase*)**
  Triazoles (amitrole)
- HRAC **Group 12 (*phytoene desaturase)***
  Pyridazinones (norflurazon), pyridinecarboxamides, ‘other’ - fluridone
- HRAC **Group 13 (*unknown*)**
  Isoxizolidinones (DOXP synthase inhibitor), Ureas, Diphenyl ethers
- HRAC **Group 27 (*HPPD*)**
  Triketones (mesotrione), isoxazoles, pyrazoles

Symptomology

- New tissue chlorotic or white
- Bleached tissue - necrotic

3. Interaction of PSII & Pigment inhibitors





4. Summary

- **Photosystem II (PSII) inhibitors**
  - Xylem mobile
  - Block electron transfer
  - Reactive species generation
  - Necrosis on leaf margins, older leaves
- **Pigment synthesis inhibitors**
  - Phloem mobile
  - Block antioxidant synthesis
  - Increased Reactive Oxygen Species damage
  - Chlorotic or bleached young tissue

Evaluation of alternative herbicides and the double knock down technique for control of multiple herbicide-resistant hairy fleabane (*Conyza bonariensis*)

Marcelo L. Moretti[1], Bradley D. Hanson[2], Kurt J. Hembree[3], and Anil Shrestha[1].
[1]California State University, Fresno, CA 93740; [2]University of California, Davis, CA 95616 ;
[3]University of California Cooperative Extension, Fresno, CA.

Weed management in perennial cropping systems of the San Joaquin Valley (SJV) relies on a few array of herbicides for postemergence treatments resulting in a continuous use of the same herbicides. Glyphosate and paraquat are among such herbicides, and due to their repeated use a glyphosate-resistant population of hairy fleabane was documented in 2007. Later in 2009, a glyphosate-paraquat multiple-resistant population of hairy fleabane was reported in SJV as well. This multiple-resistant biotype showed an 8- to 16-fold resistance to glyphosate, paraquat, or both herbicides when treated at the 5- to 8-leaf stage. To avoid rapid spread of this biotype, alternative herbicides were tested for control. A greenhouse study was conducted to evaluate the efficacy of glufosinate (69 fl.oz/ac), 2,4-D (2 pints/ac), carfentrazone (1 fl.oz/ac), saflufenacil (1 oz/ac), and double knock-down with glyphosate (27.6 fl.oz/ac) followed 10 days later by paraquat (4 pints/ac) as postemergence treatments. Rimsulfuron, penoxsulam, and flumioxazin were tested as preemergence applications. It was found that glufosinate, saflufenacil-alone or in any combination with glyphosate, and 2,4-D as postemergence treatments and all three preemergence herbicides provided satisfactory control (greater than 90%) of the multiple-resistant biotype. The double knock-down method did not control the multiple-resistant biotype but controlled the susceptible biotype. Among the preemergence treatments, all tested herbicides provided more than 90% control for over 60 days. Penoxsulam and flumioxazin were significantly better (95% control or more) than rimsulfuron (90% control). Therefore, all pre- and postemergence treatments tested in this study can be used as alternate herbicides to glyphosate and paraquat for control of the multiple-resistant biotype of hairy fleabane in the SJV.

Testing Multiple Herbicides for control of Erodium species

Kristin A. Weathers, Department of Botany and Plant Sciences, 2150 Batchelor Hall, University of CA, Riverside, Riverside, CA 92521. kristin.weathers@email.ucr.edu
Milton E. McGiffen, Department of Botany and Plant Sciences, University of CA, Riverside.
Carl E. Bell, UC Cooperative Extension, County of San Diego
Edith B. Allen, Department of Botany and Plant Sciences, University of CA, Riverside.

Exotic annual filarees (*Erodium* spp.) germinate at high densities and early in the growing season. This is a particular problem in restoration situations, where they germinate a dense carpet that makes it difficult for native species to establish and survive. This study was set up to compare five different herbicides at a variety of rates on two of the most common filaree species. These herbicides included glyphosate (broad-spectrum herbicide), triclopyr and aminopyralid (two herbicides selective for broadleaf weeds), and clethodim and fluazifop (two herbicides selective for grasses). The grass specific herbicides were tested because fluazifop had been documented to control redstem filaree (*Erodium cicutarium*) in the desert where it was applied for grass control. Studies in Australia have also shown *Erodium* species to be sensitive to a grass-specific herbicide not available in the U.S. A grass-specific herbicide that was also selective for Erodium species would be useful in the restoration of filaree-invaded plant communities such as coastal sage scrub, where native species are predominantly forbs and shrubs that would be injured by broadcast application of broad-leaf herbicides. However, field reports of the effectiveness of grass-specific herbicides on filaree in non-desert environments of southern California were highly variable. Therefore, while glyphosate and the broadleaf herbicides were tested at high and low label rates, the grass-specific herbicides were tested at both labeled rates and rates higher than allowed by the label to better determine at what rates and in what situations the grass-specific herbicides might be used to control filaree.

Plots were established at two sites in San Diego County, one dominated by broadleaf filaree (*E. botrys*) and the other dominated by redstem filaree. Herbicides were applied in early winter in both 2009 and 2010. Visual damage ratings were performed at 2-, 4- and 8-week intervals after application, and percent cover readings and density counts were taken at some point after the 8-week rating and as close to peak flower for the plant community as possible.

In the broadleaf filaree trials, triclopyr at both 1 and 2 quarts/acre and glyphosate at both 1 and 2 quarts/acre had the highest damage ratings in 2009, and the differences were significant from the control even 8 weeks after application. In 2010, triclopyr and glyphosate were also the highest at the 4-week damage rating, and by the 8-week reading the ratings for triclopyr and glyphosate while still in the most effective group were slightly less and statistically similar to aminopyralid at 7 oz/acre. In 2009, fluazifop at 12 and 18 oz/acre rates (within the range allowed by the label) showed mid-range damage ratings that were statistically different than the control. However, by 8-weeks, fluazifop at 72 oz/acre (three times the concentration allowed by the label) was the only grass-specific treatment showing damage greater than the control, and it was significantly lower than the damage ratings of triclopyr and glyphosate. The mean percent cover of broadleaf filaree was less than 3% in all the glyphosate and triclopyr plots more than 8 weeks after application in 2009. The mean percent cover of broadleaf filaree was not significantly different in any of the fluazifop or clethodim plots than in the control plots in either 2009 or 2010.

The redstem filaree trials showed similar patterns. Redstem filaree showed more visual damage to damage than broadleaf filaree in the fluazifop treatments. However, the the 12 and 18 oz rates of fluazifop did not provide complete or season long control of redstem filaree. In 2009, 8-week damage ratings at above-label 36 oz and 72 oz rates of fluazifop were statistically similar to the triclopyr and glyphosate as the most effective treatments against redstem filaree. However, in 2010 only the triclopyr treatment had a significantly higher damage rating than the control plots after 8 weeks.

Triclopyr at 2 qts/acre was the most effective herbicide treatment in controlling both species of filaree. Glyphosate at 2 qts/acre and triclopyr at 1 qts/acre was statistically similar results to the triclopyr 2 qts/acre for both species and years. Label rates for fluazifop showed some damage on both species (more on redstem filaree) but did not control either species. Fluazifop at 72 oz per acre controlled redstem filaree, indicating that multiple applications within a growing season might provide control of redstem filaree. Aminopyralid showed activity, but did not control as effectively as the previously discussed herbicides.

CWSS Student Paper and Poster Contest

Title: Comparison of pre-plant weed control treatments in organic broccoli

Authors (names separated by commas): Nathália Mourad, Marcelo Moretti, Sajeemas Pasakdee and Anil Shrestha

Abstract:

Weed control is a major problem in organic vegetable cropping systems. It is essential to start with clean weed-free beds to reduce early season weed competition and potential crop loss. Pre-irrigation followed by postemergence control is an integrated weed management (IWM) strategy. Many methods can be used for postemergence control of the weeds that emerge after pre-irrigation, including mechanical, thermal, and chemical. The objective of this experiment was to compare the efficacy of four postemergence weed control methods prior to transplanting broccoli: hand-hoeing, propane flame, organic herbicide (GreenMatch®), and steam in pre-irrigated organic broccoli plots. A non-treated control plot was also included. Weed densities (prior to planting and prior to hand weeding) was 60 to 80% lower and time for hand weeding was more than 70% shorter in the treated plots compared to the untreated control. Flaming was the most efficacious treatment. The results for steaming, GreenMatch, and hand weeding were similar Therefore, pre-irrigation followed by any of the pre-plant burndown (preferably flaming) treatments may be a good IWM strategy in organic broccoli systems.

Use of Selenium-enriched Mustard and Seed Meals as Potential Bioherbicides and Green Fertilizer in Organic Spinach and Broccoli Productions

Annabel Rodriguez [1,2], Gary Banuelos[2], Sajeemas Pasakdee[1], and Anil Shrestha[1]
[1]California State University, Fresno; [2]USDA-ARS;
Dept. of Plant Sci., 2415 E. San Ramon Ave., M/S AS72, Fresno, CA 93740;
559-278-5784; ashrestha@csufresno.edu

New plant-based products can be produced from seed harvested from Brassica species used for phytomanaging selenium (Se) in the west side of central California. Se-enriched seed meals produced from white mustard (*Sinapis alba*) plants and plants were tested as potential bioherbicides and green fertilizers in spinach (*Spinacea oleracea*) and broccoli (*Brassica oleracea)* production under organic field conditions for one growing season. Treatments consisted of adding either mustard meal (containing 2.2 mg Se/kg dry mass) or control-soybean meal (containing <0.1 mg Se/kg dry mass) (*Glycine max* L. Merr.) to the soil at rates equivalent to 0.5 and 2 t/acre, respectively, 2 ½ weeks before planting. During the growing season we observed that mustard meal treatments (especially high) lowered the emergence of resident winter annual weeds more than soy meal treatments. High rates of mustard meal reduced hand weeding time and weed biomass by almost 50% compared to all treatments. Fresh and dry biomass of both spinach and broccoli plant yields were, however, greatest with high soy treatment followed by high mustard meal treatment. Among the nutrient accumulation, plant Se, calcium (Ca), manganese (Mn), and zinc (Zn) consistently increased in spinach leaves and in broccoli florets with high mustard meal treatments. Amending soils with Brassica seed meals have practical viability for use in organic agriculture as a potential bioherbicide and as a green fertilizer for promoting Se and other nutrient content.

Optimum temperatures for two biotypes of horseweed (*Conyza canadensis*) and hairy fleabane (*C. bonariensis*) germination

Katrina Steinhauer and Anil Shrestha
California State University, Fresno

Horseweed (*Conyza canadensis*) and hairy fleabane (*Conyza bonariensis*) are two common weeds found in orchards, vineyards, and roadsides in the San Joaquin Valley (SJV). In recent years, these two species have become a more widespread problem in the SJV due to the evolution of glyphosate resistance and paraquat resistance (in hairy fleabane only). Therefore, alternate control approaches are required for the herbicide-resistant horseweed and hairy fleabane. An approach would be to develop an integrated weed management (IWM) system for these species. Weed biology is an integral part of IWM and it includes aspects of seed germination and seedling emergence. A major environmental factor driving seed germination and seedling emergence is temperature. In recent years, these species have been noticed to germinate and emerge year-round in the SJV. Hence, the optimal temperature for germination of these species needs to be determined. Studies in the SJV have found differences in the growth and development of glyphosate-resistant (GR) and glyphosate-susceptible (GS) biotypes of these species. However, differences in optimum temperature for germination and emergence of these two biotypes are unknown. Therefore, the objective of this experiment was to determine the optimum temperature for germination and seedling emergence from seeds of known GR and GS horseweed and hairy fleabane collected from the SJV. A growth chamber experiment was conducted at California State University, Fresno in 2010. Pots were filled with media and 30 seeds of each species and biotype were planted on the surface of the media. The experiment was arranged as a split-split plot and replicated four times with temperature as the main effect, species as the sub plot, and biotype as the sub-sub plot. Growth chamber temperatures were set at 5/0, 10/5, 15/10, 20/15, 25/20, and 30/25 C (day/night) temperature, respectively. Seedling emergence counts were recorded every day and an emerged seedling was removed as soon as it was counted. Seedling emergence was monitored for about 6 weeks. Results showed that optimum temperature for germination of both species was 25/20 C. Some germination was observed at temperatures as low as 10/5 C. Germination, in general, was greater for horseweed than for hairy fleabane. This may be because of the differences in maturity of the seeds at the time of collection or other factors. Significant differences were seen in germination of the GR and GS horseweed seeds at the lower and higher temperatures but not at the optimum temperature. The germination of seeds from GS horseweed plants was always greater than those from GR plants at the sub-optimum temperatures. However, the differences were opposite for hairy fleabane because the germination of seeds from GR hairy fleabane plants was greater than those from GS plants at almost all temperature regimes, except at 5/0 and 30/25 C. These findings may be interesting as the study showed that germination of the biotypes at different temperature ranges was different although the seeds were collected from areas within a 50 mile radius. The differences between biotypes could be a result of environmental rather than genetic factors, but this needs to be ascertained. In conclusion, the experiment determined the optimum temperature of both species as 25/20 C and found differences between biotypes in germination and seedling emergence. The experiment is being repeated.

Preliminary screening of suspected glyphosate resistance in Palmer Amaranth (*Amaranthus palmerii*) in the Central Valley finds negative results

Jeff Gallagher, Marcelo Moretti, and Anil Shrestha
California State University, Fresno

Palmer amaranth (*Amaranthus palmeri* S Watson) is a highly competitive annual weed belonging to the Amaranthaceae family. In the last 5 years, glyphosate-resistant (GR) biotypes of Palmer amaranth have been reported from the south-eastern US. In recent years, a few cases of poor control of this species have also been reported in the Central Valley. A suspected case of GR Palmer amaranth in San Joaquin County led to this study.

A study was conducted at California State University, Fresno in the summer of 2010. Seeds were collected from suspected GR Palmer amaranth plants along Hwy 99, Stockton, CA. Seeds from known glyphosate-susceptible (GS) Palmer amaranth were also used for comparison. Sixty 4 x 4" plastic pots were filled with a potting mix and about 12 seeds were planted in each pot. The pots were placed in the sun and regularly monitored for moisture and germination. At 31 days after planting (DAP), the plants were sorted into three categories by height: short (<3"), medium (3-6"), and tall (>6") and sprayed with Glyphosate Weathermax at 27.5 fl oz/ac, 30 psi, 20 gal/ac volume by means of a CO_2 backpack sprayer equipped with a flat fan nozzle. A set of unsprayed plants for each plant size was also included. Each set had 14 pots of short, 5 pots of medium, and 4 pots of tall for a total of 46 pots. About 45 DAP, the plants were cut and placed into brown bags for drying, and then weighed for biomass.

Typical symptoms of glyphosate injury were present at 22 days after treatment on the short and medium plants and they were dead. However, the treated tall plants showed no injury symptoms and appeared similar to their untreated control counterpart. The treated tall plants outweighed the untreated control, which indicated that glyphosate had no affect on them. These results indicate that this Palmer amaranth biotype is still susceptible at the labeled rate of glyphosate. Although this study tested negative for glyphosate resistance, the size of the plant at the time of application made a difference as the taller (> 6") plants survived the glyphosate application. At this point, it is not known if GR populations of Palmer amaranth exist in other locations of the Central Valley. Growers and land managers should be cautious and plan for management strategies to prevent the onset of glyphosate-resistance in this species in California.

State of the State: The Regulator's Perspective

Mary-Ann Warmerdam, Director, California Department of Pesticide Regulation
mwarmerdam@cdpr.ca.gov

The California Department of Pesticide Regulation (DPR), like other state departments and agencies, is in transition under new Gov. Jerry Brown. Gov. Brown has proposed $12.5 billion in cuts statewide. DPR receives no general funds. It is funded by registration and licensing fees and a 2.1-cents-per-dollar "mill assessment" collected at the wholesale level. Our ability to provide services has been affected by furloughs, retirements and a hiring freeze.

The good news is DPR's proposed budget includes $2.5 million to expand the state Department of Food and Agriculture's (CDFA) pesticide analysis capabilities to support DPR's regulatory activities, including monitoring for illegal pesticide residues and investigations. CDFA's laboratory analyzes samples for DPR. This funding would replace equipment, purchase new equipment and hire staff to support the expanded capabilities.

The following are updates on several issues:

- The U.S. Environmental Protection Agency (U.S. EPA) has implemented safety measures for four soil fumigants to increase protections for agricultural workers and bystanders. The fumigants are chloropicrin, dazomet, metham sodium/potassium and methyl bromide.
    - Examples of safety measures include buffer zones, posting requirements, applicator training programs, application method, rate restrictions, emergency preparedness and response requirements.
    - The first phase – primarily buffer zones – is being implemented this year. Don't expect amendments for labels until late spring/summer. The second phase is 2012.
    - Registrants must end sale and distribution of fumigant products bearing old labels no later than Nov. 30, 2010. After that date, registrants can only sell and distribute products bearing new labels.
- Methyl iodide was registered Dec. 20, 2010, when emergency regulations designating it a restricted material took effect. Methyl iodide was registered by U.S. EPA in 2007 as a replacement for methyl bromide, which damages the earth's ozone layer. Our decision to register followed U.S. EPA's approval of CA-specific labels for four methyl iodide products.
    - Methyl iodide is the most evaluated pesticide in DPR's history. We have adopted the toughest health-protective restrictions in the nation.
    - Methyl iodide is a restricted material that requires a use permit from the county agricultural commissioner, who can deny a permit only if it's likely the use would result in a substantial adverse environmental impact that cannot be reduced with additional restrictions.

- A lawsuit challenging DPR's registration and emergency regulations was filed Jan. 4, 2011, in Alameda County Superior Court by the Pesticide Action Network North America, United Farm Workers, Californians for Pesticide Reform, Pesticide Watch Education Fund, Community and Children's Advocates Against Pesticide Poisoning, Worksafe Inc., and two farmworkers by Earth Justice and CA Rural Legal Assistance.

- Methyl bromide regulations took effect on Nov. 26, 2010, after years of litigation. A 2004 lawsuit by California Rural Legal Assistance challenged DPR's level of methyl bromide in ambient air. To comply with the San Francisco Superior Court order, we submitted new regulations "jointly and mutually" developed with the Office of Environmental Health Hazard Assessment to the Office of Administrative Law.
- Permit conditions for MITC (generate methyl isothiocyanate) were finalized. Implementation of permit conditions will be phased in through March.
- As of Jan. 8, 2011, chloropicrin is a toxic air contaminant. This action does not immediately put further restrictions on its use. However, it requires DPR to determine appropriate statewide health-protective measures for residents and bystanders. A full risk assessment that addresses occupational exposures is still under way. Target date for completion is early 2012.
- Regarding surface water protection, DPR has a long history of addressing detrimental effects from pesticides dating back to the early 1980s when large fish kills in Sacramento Valley agricultural drains were linked to the rice herbicide Ordram. In 2007 regulations were adopted to protect surface water from agricultural insecticides applied during the dormant season.
  - Pesticides continue to be detected in surface water despite efforts to control discharges. DPR held three workshops in 2010 to accept comments on development of additional regulations to address drift, irrigation and stormwater runoff. We are working with state and regional water quality control boards to clarify overlapping regulatory roles.
  - We are proposing new regulations to protect surface water quality, initially for non-agricultural uses. We will be looking at pyrethroids and possibly other pesticides. Our target date for submitting a regulatory package to the Office of Administrative Law is late spring. We plan to follow up with proposed regulations for agricultural uses in late 2011 or early 2012.
- DPR encourages integrated pest management (IPM) through its Pest Management Alliance Grants and IPM Innovator Awards.
  - Alliance Grants are awarded to partnerships that develop IPM practices to reduce or eliminate pollution and pesticide exposure in agricultural and urban environments. We have awarded approximately $10 million in grant funding since 1996. A total of $400,000 will be available beginning July 1, 2011. Project concept summaries are due Feb 7, proposals are due April 7 and grants awarded June 30.
  - IPM Innovator Awards recognize efforts to reduce risks associated with pesticide use and share research and methods with others. More than 100 California organizations have been honored since 1994. Applications are accepted year-round.

More information about DPR is posted on our Web site at **www.cdpr.ca.gov**.

The Right of Way Perspective
Balancing Biology, Reality, and Sustainability

William D. Nantt, Landscape Specialist, 4th District CalTrans

The views expressed by the author do not necessarily reflect the views of the CA Department of Transportation. Accuracy, completeness, veracity, honesty, exactitude, factuality and politeness of comments are not guaranteed.

In light of current economic conditions that exist in most places, but especially here in California I think the theme for this year's CWSS is most fitting. I'm going to focus on the "reality" portion of the title. A fellow named James Baldwin once said,

"*Not everything faced can be changed, but nothing can be changed until it is faced.*"

I meet people from many walks of life in my job. Some work for various agencies such as federal, state, county and city governments. Others work for districts of various types. I work with weed management organizations, business interests and interested members of the public. One thing they all have in common is a fundamental misunderstanding of what Caltrans is, what it is allowed to do, and when it comes to managing weeds, how few resources are dedicated to it. Caltrans is a state agency consisting of roughly 21,000 employees. For comparison purposes the department of corrections has triple that number of employees. The maintenance division of Caltrans, where ninety nine percent of all weed management takes place, has only 25% of all Caltrans employees. In the maintenance division well under 1000 employees are fully dedicated to vegetation management and only a fraction of them are full time weed management personnel.

Caltrans is an organization run by Engineers. Unless you are an engineer (or in a few cases, an architect) you can only promote to low level management. Engineers exhibit certain traits that give Caltrans a distinctive feel. Engineers like to design concrete, steel and asphalt solutions and tend to lose interest in mundane maintenance issues. In fact maintenance personnel feel as if engineers look down on them.

Caltrans maintenance has changed fairly dramatically over the past few years in the face of the ongoing state budget crisis. As with many governments, maintenance is often the first thing cut. Caltrans maintenance crews have been reduced over the last five years by 50% and over the last ten years by up to 70%. Currently there is a hiring freeze and in District 4, the nine Bay Area counties, there are 100 openings in field maintenance and another 20 in various office positions. As if this isn't enough of a challenge the average age of a Caltrans employee is fifty years of age.

Maintenance headquarters in Sacramento has its own set of challenges. The Office of Roadsides has multiple openings and the Statewide Landscape Program Administrator position has not been filled in well over 2 years. Issues once addressed at state level are now often addressed at district level, so the overall vegetation program doesn't have the uniform feel it once had. This isn't necessarily bad because we have some good vegetation managers and PCA's at the district level.

Maintenance workers with Caltrans are literally where the rubber meets the road. These men and women are the people who implement the Caltrans vegetation management program. They are much maligned and very much misunderstood. It takes a certain personality type to handle what these folks do on a day to day basis. Because the job is so dangerous and the fact that these are relatively low paying jobs, maintenance employees tend to have no more than a high school education. Maintenance workers tend to be very deliberate, cynical and tend not to trust anyone wearing a tie or holding a Blackberry in their hand. To get things done with these people you must understand them. They need to be shown that a new method or technique works….not told. Once you have their trust these people make excellent friends and allies.

Work on or near the highway is inherently dangerous. Every year there are thousands of deaths and injuries on California highways. On average more than one Caltrans maintenance employee is killed each year and many are injured.

Due to California's unique geographical layout and large population, much of the freight moved is done so by semi truck. Trucks are massive, carry tons of weight and travel at relatively high speeds. Trucks and passenger vehicles often don't coexist very well and when you have to slow them down or move them over in a Caltrans work zone, problems result. In the latest information I can site, there were 70 fatalities in Caltrans work zones in 2008.

Because Caltrans work zones are dangerous to both the public and Caltrans employees, maintenance employs strategies to save lives and reduce injuries. Caltrans uses massive vehicles with articulated crash cushions to absorb the energy of an impact. We also use early warning vehicles to notify motorists of an upcoming work zone and shadow trucks in the immediate vicinity of any work being performed on the roadway or a narrow shoulder. It takes three trucks and three employees to spray a four foot fire control strip. Safety will always trump the expense of using multiple people and equipment to perform any operation. Worked performed in the roadside environment such as mowing, is considered safer and requires fewer safety precautions. Caltrans utilizes many specialty vehicles which have been adapted to perform routine maintenance duties for safety and efficiency reasons. Once requested it can take several years to finally take possession of one of these vehicles. Obviously you can't purchase one of these vehicles off the shelf. The base vehicle is purchased at the headquarters level and sent to a location in Sacramento where it is outfitted to Caltrans specifications. Due to resource reductions and furloughs this process takes years and often the supervisor who requested the vehicle has moved on and another supervisor with different needs has taken their place. Often the recipient of the new equipment has to request a modification at the local level further adding to the time an old or obsolete piece of equipment must be used.

The Shop owns all vehicles and maintenance personnel are not allowed to modify the equipment. This is problematic as the Shop is understaffed and furloughed. It can take weeks just to have basic maintenance performed on a vehicle. Anything more serious can take months. Obviously this is a problem for a spray crew attempting to put down a preemergence herbicide during a narrow weather window when they have equipment problems. Backup vehicles are not an option due to equipment reductions over the past five years. Contracting out repair work is performed on rare occasions with emergency justification only due to Union restrictions.

Politics play a big role in any public service job at any level of government and with Caltrans maybe even more so. Governors can issue executive orders which can supersede any plans you may have at the local level. The Caltrans Director is an appointed position and serves at the pleasure of the governor. With the current governor's appointee this will be the fourth Caltrans director in the last four years. Caltrans Directors can issue orders which supersede your planned duties. This lack of experience and continuity at the top can cause indecisiveness at lower levels, but also gives competent managers at lower levels a little more freedom.

The California legislature can have an effect on what we do as well. In 2010, 750 new bills were passed and signed into law. The total number of laws in California exceeds 57,000. This creates scenarios where after some time we find out that a law has changed and we were late adopting it. With personnel shortages at all levels the information flow isn't what it was.

Another department that influences what we do is Caltrans legal. As you might expect, Caltrans is a big legal target. We get sued not only by outside interests but by our own employees as well. Depending on risk management factors, legal can dictate policy to stem the loss of money paid out in legal rulings. This can work in our favor. In the case of wildfires, we were given the ability to use more herbicides contrary to what our EIR allows. Previous legal decisions have had a big influence on Caltrans policies.

There are a variety of outside interests who have had an influence on Caltrans policy. Anti chemical groups have impacted the vegetation management policy of Caltrans: In the early 1990's Caltrans was sued by a group concerned with Caltrans' over-reliance on herbicides for vegetation control. Caltrans hired a consultant to study the situation and craft an environmental impact report. In 1992 Caltrans adopted the consultant's recommendations. The highlights of the 1992 EIR included adoption of an IVM approach, the reduction of herbicide use by 50% by the year 2000 (which was met) and by 80% by 2012. In addition Caltrans agreed to a reduction of total acres treated.

The 80% reduction by 2012 may have already been achieved depending upon one's interpretation of the original report. The original draft did not include herbicides used for landscape weed control, but have been included in the reductions ever since. Surfactant usage was included as well.

Almost 20 years later and two things are clear. Caltrans ability to address the issues of wildfire management and the spread of noxious weeds in our right of way has been limited. The EIR stated that the ability of Caltrans to adopt certain IVM tactics was resource dependent. Resources have been greatly reduced since 1992 and hopefully decisions made in 2012 will recognize this fact and allow us more flexibility. The EIR resulted in some positive results. Oversight is necessary, so is the ability to adapt.

I've just pointed out some of the challenges we at Caltrans face in getting our job done. Now I'd like to focus on what we can do and what you can do to reach our common weed management goals.

Due to resource limitations which I'm certain are permanent, future weed related accomplishments will have to be done in a spirit of cooperation. Communication will be the key to getting anything done. On the Caltrans side we must do a better job of intra department communication. We are not currently very efficient at working together as an agency. Design, Construction, and Maintenance need to get on the same page, if we are to be successful at structural weed control. For example, weed control mats have been specified for all new guardrail installation statewide. My guess is not even 1% of new guardrail installations receive these mats. Construction is not being held to the standard, but Maintenance doesn't have any recourse other than to complain. This needs to change.

Caltrans needs to do a better job of keeping up with the latest methods and techniques. Due to resource reductions, personnel in some locations are not allowed to travel for training or meetings. In my opinion this is the time we need to maximize efficiency by keeping abreast of the most current methods of getting the job done. Not all landscape specialists were able to attend this meeting due to travel restrictions in their districts. Due to lack of advocates for our position in Sacramento, this sort of situation is difficult to remedy.

Better communication between Caltrans and county agriculture commissioner's offices would greatly improve weed control statewide. Weed Management Area (WMA) meetings are excellent vehicles for accomplishing this. Caltrans responds to organized letters of concern, especially when many parties are involved. For example, if the Ag Commissioner's office is concerned about Yellow star thistle on Caltrans right of way and another letter was produced from a fire management district with fuel load concerns, Caltrans headquarters may allow the district PCA to use more herbicide than they have been allotted. If herbicides were an issue perhaps additional mowing would be authorized.

In addition to various counties, WMA, and landowner concerns, working together helps to deal with political groups with axes to grind. A united front makes for a less inviting target for those who just like to complain. Not all complaints are baseless. Efforts need to be made to mitigate legitimate concerns. One tool we have is the Adopt-A-Highway program. We have used this program to allow groups concerned about pesticide use to maintain a defined area in a manner they can live with. This program is underutilized.

Property owners adjacent to Caltrans right of way have an underused option at their fingertips. The Property Owners Roadside Vegetation Act of 1991 allows property owners to work on our right of way to control vegetation. Due to limits on how many acres we can treat with herbicides or mow, landowners are often dissatisfied with levels of weed control we obtain between the roadway and the fence separating their property from ours. Landowners may have legitimate concerns about the potential spread of noxious weed seed and wildfire onto their land. Encroachment permits can be issued to owners after consultation with a Landscape Specialist.

Working with the private sector is an underutilized avenue for getting things done. If it were not for some chemical representatives, we would not have met our training obligations in 2010. The prolonged budget impasse made it impossible for us to pay for our DPR approved training classes. Dow AgroSciences recognized our plight and paid the DPR fee so we could proceed with our goal of providing continuing education for our certified personnel. Other industry assistance was received from DuPont, Wilbur-Ellis, Helena Chemical, and Target Specialty Products for other matters.

I've mentioned many challenges Caltrans faces in general and specific to weed management as well as some solutions to keep us moving forward. In conclusion I'd like to say that it is challenges that make us increasingly more efficient, as long as the challenges don't overwhelm our capacity to change. My fellow PCAs and I are a stubborn bunch and I liken us to the Black Knight in Monty Python's Search for the Holy Grail. We won't easily admit defeat and if we can't win, we'll call it a draw!

The State of the State on Weeds: The AG Industry Perspective
It's Time to Fight Back Against Environmentalists' Untruths

Renee Pinel, President/CEO Western Plant Health Association

If you believe that it is important for your business to remain profitable and viable in the wake of a continuous barrage of bad publicity - often whipped up by overzealous environmental groups promoting their own agendas and quoting "bad science" to support their claims - then the answer can be found here.

For too many years now environmentalists have been dominating the media with their anti-business messaging that has resulted in a series of what many call frivolous lawsuits in attempts to delay, block or outright ban the use of products that make homes and business safe from disease and pests.

One need only point to the fairly recent citizen uproar involving the aerial pheromone spraying of the light brown apple moth over Santa Cruz and Monterey counties in California to understand how the ill-informed public, local politicians and environmental groups can short-circuit efforts to protect our food source from insect invaders. Even though the U.S. Environmental Protection Agency and California agricultural officials assured anxious residents that pheromone aerial applications posed no safety concerns and was the most effective way of eliminating the invasive pest, the frenzy whipped up by the media and community action groups killed the aerial spraying campaign.

The light brown apple moth known to feed on hundreds of different plants, was first detected in 2007 and has since been found in 18 California counties which have been under quarantine - which requires counties to have crops including nursery stock, regularly inspected and follow strict procedures before their crops can be moved into or out of the quarantined zones.

Let’s consider a world without pesticides, a reality that many green groups have as their end objective. Simply put, that would mean allowing crop-damaging diseases, insect infestations and noxious weeds to decimate the human food supply chain and drive grocery prices through the roof; it would allow vector-borne illnesses caused by rats and mosquitoes, such as encephalitis and West Nile virus, and Lyme disease caused by ticks, to run rampant; and cockroaches and mold/mildew would penetrate uncontrollably into such areas as our homes, restrooms, school cafeterias and elsewhere, spreading known allergens that cause asthma and other diseases.

Let's take it a step further: other insects and plant pests, such as poison ivy, fire ants, spiders, lice, bedbugs and termites, now effectively controlled by pesticides, would be free to wreak havoc on humans and their dwellings. And let's don't forget that poor Fido would be left on his own to scratch away platoons of invading fleas.

Yet, it seems like almost daily there are media reports highlighting the dangers of pesticides, which fruits and vegetables are more safe to consume, new demands for wider and wider buffer zones from residential and business neighborhoods, and this survey and that study pointing out yet new risks and dangers from working or living in and around these products. More often than not, much of this information is "misinformation," passed along and circulated by environmental groups who have their own agendas and fund-raising demands to fulfill.

For instance, between 2000 and 2009, three tax-exempt, nonprofit environmental groups - Western Watersheds Project, Forest Guardians and the Center for Biological Diversity - filed more than 700 cases against the federal government. Between 2003 and 2007 the federal government paid more than $4.7 billion in taxpayer money to environmental firms; and that's a conservative estimate. In one 15-month-long case the Earthjustice Legal Foundation and the Western Environmental Law Center filed for $479,242 in attorney fees. Insult to injury, consider this: the president of the Environmental Defense Fund rakes in an annual $446,072 in salary; in second place for salary is the $439,327 paid to the president of the World Wildlife Fund.

What can you do about it? Well, since public opinion frequently makes its way into the halls of your local elected officials, you can counter the claims of these environmental groups by making your viewpoints heard by attending sessions with your government representatives. The more industry participation we have during these sessions the greater our strength in showing that industry is serious and devoted to enlightening elected representatives about the many benefits available when using sound pest prevention and eradication practices. These benefits obviously enhance and improve environmental safety and public health, and practicing these methods can help dispel the many myths that place our industry in a negative light.

You can help make a difference. Your voice does matter. If we don't do something now, we will continue to be frustrated by the faulty and distorted stories being circulated by those wishing our industry ill. Make up your mind today to take a stand and get involved for the good of our businesses, our industry and for the world's growing population.

What You Can Do To Get Involved

- Write a Letter to the Editor and set the record straight whenever a news item places your business and industry in a bad light.

- Belong to an industry association and make sure it has an active legislative program that fights bad bills and regulations, and provides members with information on these issues.

- Participate in your association's legislative events, whether they are Capitol legislative days or district events.

- Ask your association to arrange group in-district visits with your legislator where you and your peers can make your presence felt.

- Monitor legislative bills that can damage your business interests and let your representatives know of the many flaws, and vote accordingly.

- Contact environmental groups directly and let them know the flaws in a press release or Web site posting if the science is distorted or untruthful.

The Scientist's Perspective: Weed Science Engaging

John Jachetta, Ph.D., President, Weed Science Society of America
Email: jjjachetta@dow.com

As a scientific society, WSSA is uniquely positioned to provide real value through our growing impact and leadership on subjects important to the membership and the Nation. WSSA members have been called on frequently to provide science-based information and National leadership in areas critical to the country's success.

This year, we created a special WSSA Herbicide Resistance Education Committee to address emerging issues on the topic. Lead by David Shaw (Mississippi State University), this committee is developing a comprehensive education strategy on herbicide resistance. One critical deliverable resulting from this committee's activities will be the development of an "Herbicide-Resistant Weeds Management Report", funded by USDA-APHIS. In part, the justification for this report notes that "there exists a need for a systematic understanding of the most contemporary publicly available information on the extent to which weed resistance management programs are being utilized in various managed ecosystems and an understanding of how successful they are at achieving their goals." This report is scheduled to be completed in mid-2011; sooner if possible.

Through our WSSA-EPA Subject Matter Expert, Jill Schroeder (New Mexico State University), we have been steadily moving forward to coordinate our resistance management education efforts with the Agency. As Weed Scientists, we understand that a program of resistance management education will help only if it is based on a comprehensive understanding of resistance, both as an economic as well as a biological phenomenon, and only if it includes active participation by all parties that contribute significantly to herbicide use decisions.

A wide range of new materials are planned for the WSSA website including new training modules targeting the Certified Crop Advisor program, grower organization and Extension Specialist. Additionally, WSSA has formed a sub-committee to begin developing the training modules and materials are planned in a wide range of formats and at a number of levels, including: foundational information, region-specific, commodity-specific, and weed-specific resources.

The regulation of spray drift remains problematical; the risk assessment tools that EPA employs are based on aging data and the application technology in current use has improved significantly. WSSA supports science-based risk assessment that considers the benefits of pest control and the clear validation of the advancements in application technology.

In the further service of our public mission, WSSA has been very involved with the developing National Pollutant Discharge Elimination System (NPDES) permitting program for pesticide use in the riparian corridor. Congress enacted the Clean Water Act (CWA) more than

30 years ago, adding and later updating the NPDES permitting program several times since then. In the decades that EPA has administered the CWA, the Agency has never issued an NPDES permit for the application of a pesticide to target a pest that is present near or in water. Instead, EPA has been regulating these types of applications through the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Overall, this new decision marks a partial pre-emption of FIFRA by the CWA, layering numerous new requirements on applicators of legally-registered products that have wide value in society. This new rule also exposes applicators to extensive legal jeopardy through citizen lawsuits and Agency actions. Without careful design and execution, the implementation of this pesticide NPDES General Permit could have significant unintended consequences. To help EPA understand the impact of this program, WSSA, working with the US Army Corps of Engineers and the Aquatic Plant Management Society, has worked with EPA Office of Water to help them appreciate the need for weed management in the riparian corridor; part of this effort has been the organization of several educational tours for the Agency to more deeply understand aquatic and riparian vegetation management in Florida and New Mexico so that the Agency can communicate directly with those affected.

We know that as Weed Scientists, we have a special responsibility to contribute to both the national and international effort through our basic and applied research into weed physiology, stewardship and the management of natural and managed ecosystems. Because our community of committed scientists provides a unique strength, WSSA has clearly become a visible and recognized force in the public and national discussion.

The Effects of Small Grain Herbicides on Wheat and Barley Growth

Steve Orloff, Steve Wright, Lalo Banuelos, and Rob Wilson*
**UC Cooperative Extension, Siskiyou County, 1655 South Main St. Yreka, CA 96097*
Email: sborloff@ucdavis

Wheat is an important crop throughout most of the agricultural areas of California. Weed control is a significant problem for small grain producers and nearly all fields are treated for weeds each year. Several new small grain herbicides have been developed, some of which are commonly used in other areas of the country. Some of these herbicides may have a fit California but have not been used commercially because producers and pest control advisors are not familiar with them or they are concerned about the possibility of crop injury. Research is needed to evaluate many of the newer herbicides that are used successfully in other production areas.

Most grain fields contain both broadleaf and grassy weeds. This usually necessitates the use of two different herbicides. Ordinarily the application timing for grass and broadleaf herbicides is different. This presents a problem for producers, who for cost reasons, would like to control all weeds in a single herbicide application. Usually the grass herbicide application timing is earlier because small grasses are easier to control. The broadleaf herbicide is often applied later due to crop safety concerns. So, if a grower wishes to combine grass and broadleaf herbicides and treat early, he or she runs the risk of injuring the crop. Conversely, if the grower chooses to combine herbicides and treat at the later application timing, the grower runs the risk of poor weed control (the grass weeds may have become too large to be effectively controlled) or reducing crop yield from prolonged weed competition. In addition some of the grass herbicides require separate applications at least 7 to 14 days apart to avoid antagonism. More information is needed regarding crop safety of different herbicides. This is especially the case when herbicide tank mixes are used. Therefore, research is needed to evaluate new herbicides and herbicide tank mixes to determine their crop safety and effect on yield when applied at different growth stages.

Field experiments were conducted in both the San Joaquin Valley and Northern California. Herbicides that were evaluated included 2, 4-D, Clarity, MCPA, Shark, Osprey, ET, Axial, Puma, Atlantis, and p ryoxsulam (Simplicity). Many of these were applied alone and in tank-mix combinations. Two application timings were evaluated (an early application at the 2-4 leaf stage and a later application at the early tillering stage before canopy closure). In the trial conducted at the Intermountain Research and Extension Center (IREC) in Tulelake we evaluated the crop injury to two spring wheat varieties (Yecora rojo and Alpowa) and a spring barley variety (Metcalfe). Trials were also established at the West Side Research and Extension Center (WSREC) and with cooperating growers in the Tulare County to evaluate crop injury and weed control with the herbicides listed above.

There were hard frosts after both herbicide application dates that may have compounded the herbicide injury in the Tulelake trial. This is a common occurrence in this cold environment and herbicides need to be evaluated under these conditions. Yecora rojo and barley showed far more injury symptoms than did the wheat variety Alpowa. Injury was greatest with Osprey, Atlantis and pryoxsulam (Simplicity) on barley (Figures 1 and 2). This is understandable, as none of these herbicides are registered for this use. Puma also caused significant injury to the barley. The injury was greater with the early application at the intermountain location but not in the Central Valley. At the Central Valley locations, combinations of ET or Shark with Axial tended to cause more injury than when these herbicides were used alone. However, the injury rarely exceeded a rating of 20 percent, and was nearly gone after a few weeks. Early season injury did not translate into a significant yield decrease at either location (see Figure 3 for Central Valley yield results). Barley yield in the intermountain area was significantly decreased with the application of the compounds that are not registered for use on barley. The early application of 2,4-D caused twisted wheat spikes and tended to reduce yield slightly.

Early applications were more effective for wildoat control in the Central Valley study where weeds were present and control evaluated. An early application is not always superior and growers should monitor the wild oat growth stage relative to the wheat growth stage to properly time herbicide applications. Wildoat was controlled with Axial and Puma alone and in tank mixes. Simplicity and Osprey controlled wildoat at the early but not the late application timing. Wild oat control with Simplicity at the later application timing was improved with the use of a crop oil concentrate or adding ammonium sulfate over just using a non-ionic surfactant.

With new herbicides and application timings we are getting closer to achieving complete weed control (grasses and broadleaves) without severe injury in a single application. However, we are not quite there yet with currently available herbicides and with existing label restrictions on tank mixes. More research and perhaps more herbicide products are needed to ultimately achieve this goal.

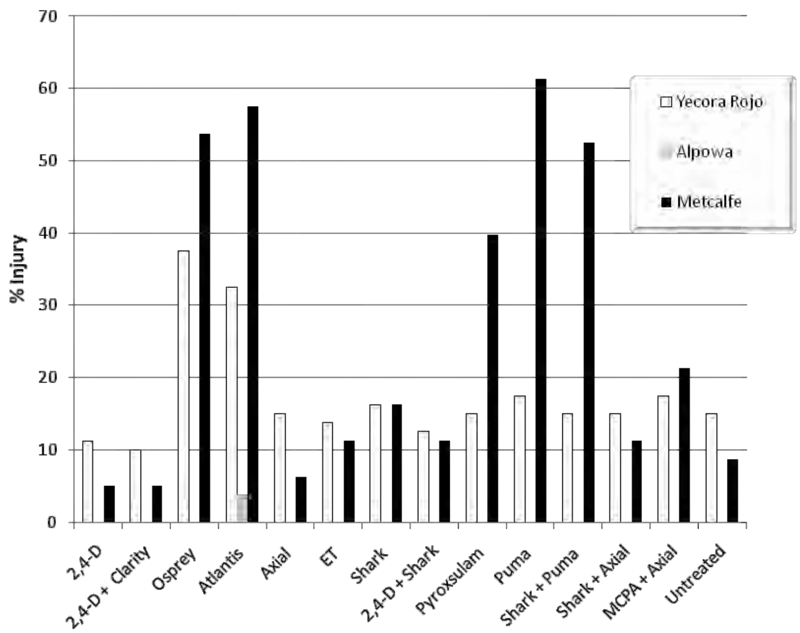


Figure 1. Effect of herbicide treatment on crop injury to Yecora rojo wheat, Alpowa wheat and Metcalfe barley in the Intermountain Region when applied at the early application timing (3 leaf stage).

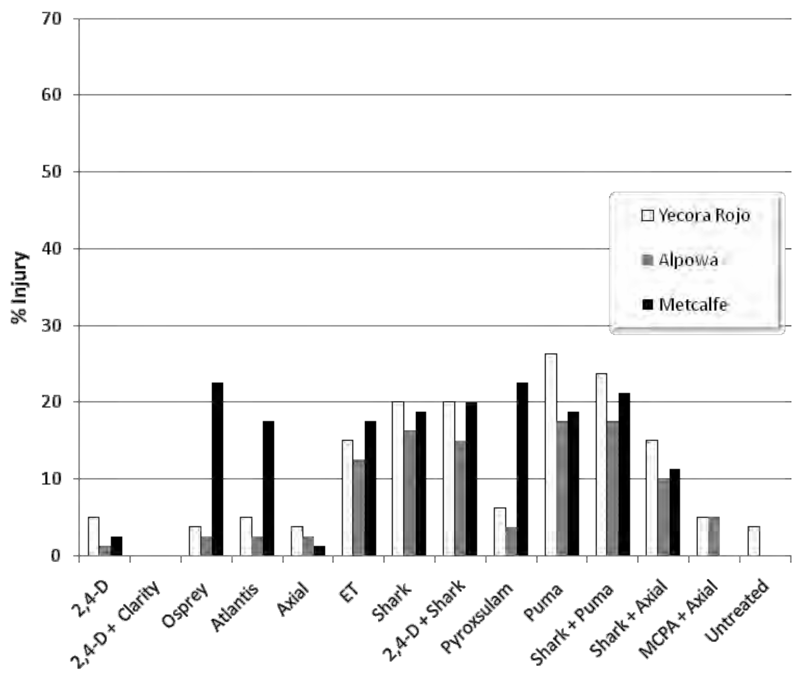


Figure 2. Effect of herbicide treatment on crop injury to Yecora rojo wheat, Alpowa wheat and Metcalfe barley in the Intermountain Region when applied at the late application timing (6-8 leaf stage).

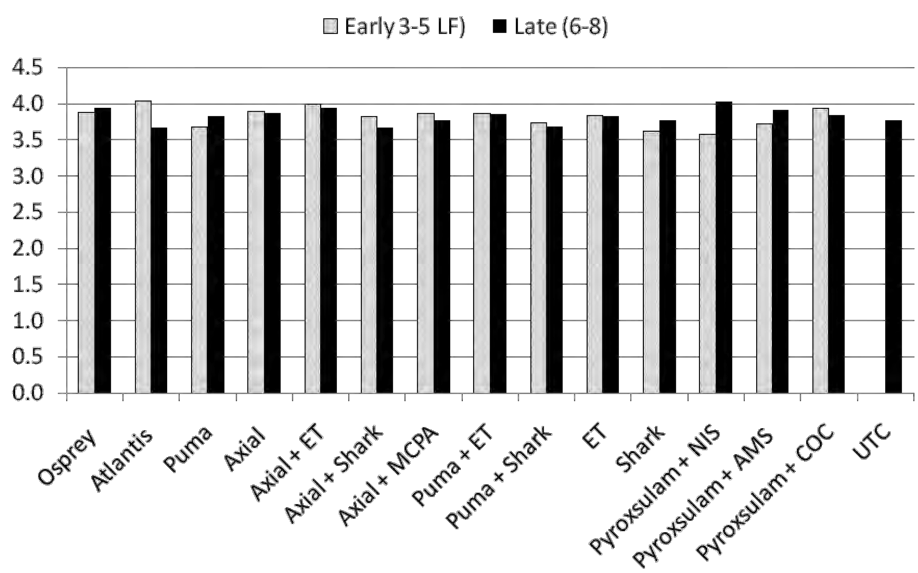


Figure 3. Effect of herbicide treatment and timing on wheat yield (UC West Side Research and Extension Center, Fresno County. 2011).

Impacts of Long-term Cultural Practices on Weed Flora in Cereals

Robert F. Norris
Weed Science Program, Plant Science Department, University of California, Davis, CA 95616.
rfnorris@ucdavis.edu

The Long Term Research in Agricultural Systems project was initiated in the fall of 1993 at the University of California, Davis, research farm. The project compares three nitrogen supply systems: no additional nitrogen, adequate nitrogen fertilizer, and use of a vetch and pea winter legume cover-crop. The systems were either rain-fed or with supplemental irrigation as required in the spring. A two-year wheat/fallow rotation was employed. The wheat versus fallow entry points into the two-year rotations were maintained separately. Weeds in clean fallow systems were controlled with glyphosate. Broadleaf weeds in the wheat were controlled with a mixture of MCPA and bromoxynil. All treatments were replicated three times, and each individual plot was one acre (220 ft by 220 ft). Winter annual weeds were evaluated by annual counts in five quadrats per plot; quadrat size was adjusted according to weed density so that at least 100 weeds were assessed at each location.

Long Term Research in Agricultural Systems

A 100-year experiment located at the Russell Ranch, west of Davis: 1994-2008 **Photo by Ford Denison**

The total number of weeds showed no consistent change over the first 14 years. Species composition of the weed flora did change, however, in relation to nitrogen supply, irrigation, and weed management.

- Shepherd's purse (*Capsella bursa-pastoris* (L.) Medic.) was the dominant weed at the initiation of the experiment in 1994, but had been reduced to a minor species in all systems by 2008. All other weed species constituted less than 1% of the population at initiation in 1994.

- Systems using a winter legume cover-crop to provide nitrogen had higher, but variable, overall weed populations, which were dominated by common chickweed (*Stellaria media* (L.) Vill.) and miner's lettuce (*Claytonia perfoliata* Willd.) by 2008. Miner's lettuce did not increase in cover-crop systems with the fallow entry point until after 2003.

- After an initial lag period of about 8 years, yellow sweetclover (*Melilotus officinalis* (L.) Lam.) became a significant component of the weed population in systems that did not receive additional nitrogen.

- Henbit (*Lamium amplexicaule* L.), unexpectedly, became a significant component of the weed flora in the fallow entry point systems that did not utilize winter legume cover-crops; no increase occurred in systems that started as the wheat rotation at initiation.
- Species such as little mallow (*Malva parviflora* L.), coast fiddleneck (*Amsinkia intermedia* Fisch. & Mey.), wild mustard (*Sinapis arvensis* L.), common sowthistle (*Sonchus oleraceus* L.), and tooth-pick ammi (*Ammi visnaga* (L.) Lam.) were present in several systems, but populations were variable and remained at low levels.
- During the first eight years of the project littleseed canarygrass (*Phalaris minor* Retz.) populations increased in all systems with wheat as the crop at entry. Annual applications of the grass-killing herbicide fenoxaprop-p-ethyl since 2002 resulted in a subsequent decline in the grass population. However, for reasons that are not clear, the littleseed canarygrass increased between 2004 and 2008 in systems that were fallowed at initiation.
- Annual bluegrass (*Poa annua* L.) has increased in all systems with supplemental irrigation in contrast with rain-fed systems, and has become more abundant in systems employing the winter legume cover crop.

The following conclusions can be made after 14 years of different management strategies. Changes in weed populations required multiple years to be manifested; short term predictions (less than 5 years) were usually wrong.

- The two entry points into the rotations resulted in different changes in weed populations; no explanation can be provided for these differences.
- Utilizing a winter legume cover crop to provide nitrogen resulted in a small overall increase in total weed density; major population shifts towards increased common chickweed, miner's lettuce and annual bluegrass occurred. The winter legume cover crop suppressed the invasion of henbit into that treatment, but caused increases in miner's lettuce populations.
- Using only a broadleaf herbicide in the wheat crops resulted in steadily increasing littleseed canarygrass populations in all systems during the first eight years.
- Lack of nitrogen fertilizer allowed invasion by the nitrogen fixing weed yellow sweetclover.
- Several weeds developed larger populations in response to supplemental irrigation used in the spring to improve wheat yield.

The results clearly demonstrate that different management practices can result in alteration of species composition of the weed flora in wheat agricultural ecosystems, and that some changes could be expected based on understanding the ecology of weeds.

ROUNDUP-READY ALFALFA: The Long and Winding Road

Daniel H. Putnam, Department of Plant Sciences, One Shields Ave., University of California, Davis, CA 95616 dhputnam@ucdavis.edu

INTRODUCTION

Alfalfa is the fourth largest crop in both acreage and economic importance in the United States, with over 20 million acres of alfalfa hay grown nationwide (USDA-NASS data). It is principally grown for consumption by dairy animals, but a portion is used by horses, beef cows, sheep and goats. Western states, from Colorado west, account for about 42%, Midwest states 50%, and Eastern states 8% of US alfalfa hay production. Alfalfa is California's largest acreage crop, and alfalfa hay production is greater in CA than in any other state.

Genetic engineering (GE) has had a major impact on the major US-grown field crops, particularly corn, soybean, and cotton, which have had very high rates of adoption of both Glyphosate-Tolerant (GT), and *Bacillus thuringiensis* (BT) traits. GT-Tolerant alfalfa, also known as Roundup-Ready Alfalfa (RRA) has had a major effect on herbicide options for alfalfa growers during the past 6 years, but has also had a checkered legal and regulatory history. This paper reviews the history and the issues surrounding the introduction of Glyphosate-Tolerant (also known as Roundup-Ready) Alfalfa (RRA) through early 2011.

INTEREST BY THE INDUSTRY

There have been some claims that a small minority (7%) of US alfalfa fields receive herbicides (USDA-NASS data, Center for Food Safety statements on website), and thus there is little need for this technology. However, this is certainly not true of California alfalfa fields. California alfalfa fields had 1.4 million acres with herbicides applied in 2009 (CA-DPR, Pesticide Use Reporting) – this alone is 7% of the US alfalfa acreage, indicating that the 7% figure on a national basis is highly suspect. I estimate that a minimum of 90% of California alfalfa fields have herbicides at some point during their lifetime, importantly for stand establishment. Current herbicide strategies have been effective in many environments, but have limitations in terms of crop injury, restrictions due to rainfall, temperature and growth stage, and groups of weeds that are controlled, as well as environmental impacts on water quality. Thus there has been considerable interest among alfalfa growers in this technology. Interest in RRA has been keenest by growers who have had difficulty in controlling weeds such as nutsedge, dodder, common groundsel and dandelion which are not easily controlled by other methods.

ROUNDUP-READY ALFALFA SAGA-Regulation, Lawsuits, and Science

The introduction of GT alfalfa began with the transformation of the first GT lines in 1997 (Table 1). The first RRA varieties were released by Forage Genetics International in 2005 after USDA-APHIS deregulation, but production was halted in 2007 due to a lawsuit that stopped further plantings (APHIS, 2007). The risks of unwanted pollen-mediated gene flow as well as the possibility of Roundup resistant weeds were the key legal and regulatory issues raised in the lawsuit and addressed by APHIS during their subsequent regulatory reviews. These controversies have remained even after USDA-APHIS re-deregulated the trait in 2011, with the issuance of its final Environmental Impact Statement (EIS) in January of 2011 (see USDA-APHIS documents), and will very likely be subject of further lawsuits.

THE TECHNOLOGY

The GT-Tolerant alfalfa technology, or Roundup-Ready Alfalfa (RRA), which enables the use of glyphosate safely on RRA varieties, has been more extensively reviewed in other publications. In brief, Van Dynze et al. (2004) and others (Canevari et al., 2007) reviewed the pros and cons of this technology, and found a range of positive traits for RRA, including its broad spectrum efficacy, high flexibility in application timing, lack of plant-back restrictions, lack of crop injury, economic benefits, benefits for animal feed safety, water quality, and the prevention of spread of noxious weeds. Potential problems of this technology were recognized to be the potential for herbicide resistance, weed shifts to weeds not controlled by Roundup, market acceptance of the hay by GE-sensitive growers and buyers, notably export and organic, and gene flow which might infect neighboring growers during seed production. As it turned out, the possibility of excessive gene flow contamination of neighbors, and the possibility of rampant herbicide resistance were the key subjects of the lawsuit and subsequent APHIS EIS.

THE GENE FLOW ISSUE

Figure 1. Steps necessary for gene flow to occur between alfalfa forage production fields sufficient to cause adventitious presence (AP) in hay.

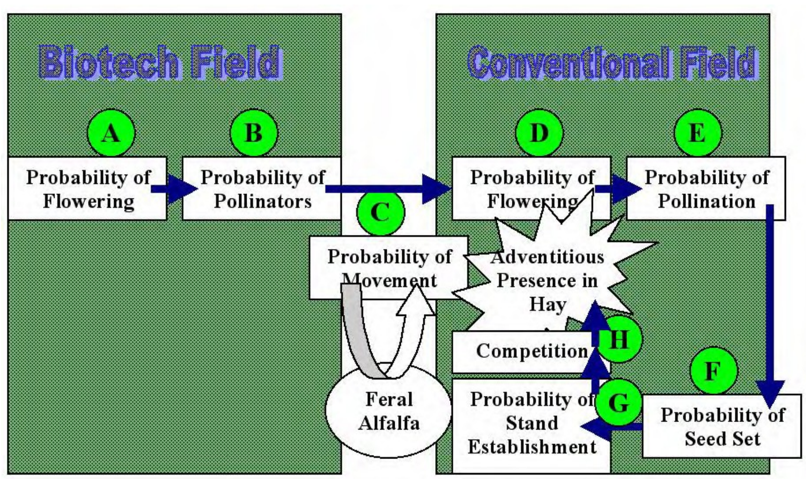


Figure 1. Steps necessary for gene flow to occur between alfalfa forage production fields sufficient to cause adventitious presence (AP) in hay.

Alfalfa is a cross-pollinated crop. Therefore, in seed production, gene flow is a necessary phenomenon and promoted by seed growers since pollinators are required for maximum seed production. However, in production systems, unwanted gene flow from field to field can create contamination (also known as Adventitious Presence or Low Level Presence) of an unwanted gene in a neighboring field. For hay production, a range of barriers to gene flow can prevent inadvertent gene flow (Figure 1). A series of probabilities for separate events are required, and these probabilities are much lower than with seed. The question of market tolerance threshold is a key aspect of this issue- that is whether markets will tolerate small amounts (e.g. less than 0.1%) AP, or whether markets will demand zero levels. It is anticipated that export hay is likely to tolerate somewhat higher AP whereas organic may be lower, levels that will be largely determined by markets.

THE ROUNDUP RESISTANT WEED ISSUE

The excessive development of roundup-resistant weeds as a consequence of the one more GT crops (in addition to corn, soy, cotton) were listed during the lawsuit and de-regulation process as a risk to be considered. A more complete analysis of this issue, and methods to prevent weed resistance, can be found in Orloff et al., 2009.

While it is yet undetermined whether RRA presents a higher risk of resistance than with annual crops (it is my view that the risk is lower), there is no dispute that greater repeated applications of the same herbicide over large acreage increase the risk of both weed shifts and weed resistance. A few key points about this issue: 1) Weed shifts (to weeds not normally controlled by Roundup) are clearly a more important than weed resistance, which requires selection pressure over years. 2) Genetic resistance to an herbicide results from the application of any herbicide, not just glyphosate, and is not necessarily linked to GE crops. 3) Diverse strategies of cultural practices, diverse herbicides are required to prevent resistance or shifts in any system, not just GT cropping systems. 4) There are readily available and well –understood methods to prevent either weed shifts or weed resistance in alfalfa (Orloff et al., 2009). 5) The development of resistance to glyphosate is primarily a technological issue – negating the usefulness of the herbicide. It is a practical problem for farmers, not necessarily an environmental problem. 6) It is important for growers to adapt resistance strategies from the outset, not just wait for weed resistance to occur and then try to address it later.

THE CONCEPT OF CO-EXISTENCE and NEED TO PREVENT RESISTANCE

The de-regulation of Roundup-Ready alfalfa in January of 2011 has determined that GE (genetically-engineered) crops are very likely going to be a part of the future of alfalfa production. RRA is really only the first of several proposed GE traits in alfalfa, with low lignin, higher quality, salt tolerant and other traits proposed. Thus it is abundantly clear that the alfalfa industry must discover methods that GE-adapting and GE-rejecting growers can continue to farm in the method of their choice. This requires coexistence strategies involving better knowledge of gene flow and crop contamination risks, human factors such as communication and willingness to work with neighbors, and awareness of the need to respect and protect differing production systems. Additionally, strategies to prevent the excessive development of Roundup-resistant weeds are required.

Table 1. Important landmarks in the history of Glyphosate-Tolerant (Roundup-Ready) alfalfa.	
1997	First GT-Tolerant Events (Montana State University)
1998-2011	Variety Development (ongoing)-Forage Genetics
2003	Petition for deregulation submitted (contained Environmental Assessment)
2005	USDA-APHIS comes to a FONSI (Finding of No Significant impact), OK's release of RRA.
2005-2007	>300,000 acres planted in US
2006	Lawsuit filed by Center for Food Safety alleging important environmental effects of 'gene flow' and resistant weeds not addressed by APHIS.
2007, January	Legal Decision by 9^{th} Circuit Judge stopping further plantings, requiring APHIS to do a more involved Environmental Impact Statement (EIS)
2007, March	No Further Plantings allowed; Current plantings were allowed to be harvested, with restrictions.
2007-2009	EIS under development by USDA-APHIS
2009, Dec.	Draft EIS issued by APHIS for public comment. Tens of thousands received.
2010, June	Alfalfa Case reaches Supreme Court. Court decides in Favor of Monsanto, that 9^{th} Circuit should not have forced the ban, and that the decision should have been under the control of APHIS.
2010, December	Final EIS issued by APHIS. Additional public comment allowed. Proposed 3 solutions. Two potential de-regulations were presented, one with restrictions, one without.
December-January	More than 16,000 comments received by APHIS. Majority of public comments were against GT alfalfa, as a symbol of GMOs in the food system, comments solicited by activist groups. Majority from farming community were in favor.
2011 January	Aphis makes final determination of non-regulated status for GT-alfalfa, rejecting partial de-regulation (restrictions on planting in seed growing areas)
February, 2011	First opportunities for planting GT-alfalfa after 4 year ban.

REFERENCES - please see: http://alfalfa.ucdavis.edu biotechnology link.

Integrating Transgenic and Conventional Herbicides in Cotton

Steve Wright, Lalo Banuelos, Jamie Changala, Nancy Loza,
Sara Avila, Katie Wilson, Matt Mills, Tony Garcia
Univ. of Calif. Coop. Extension, Kings/Tulare Co., Tulare, CA (sdwright@ucdavis.edu)

Herbicide tolerant cotton acreage has increased dramatically in the United States and amounts to approximately 90 percent in other cotton growing states whereas in California Roundup Ready cotton is grown on 50 percent of the upland and 65 percent of California Pima cotton. The herbicide tolerant acreage of cotton should continue to increase as higher yielding varieties receive these traits. Last season approximately 400,000 acres of cotton was produced and acreage should be over ½ million in 2011 due to extremely high prices.

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 horseweed in California. Cotton growers have also reported poor control of barnyardgrass, pigweed and lambsquarter in some cases.

Roundup Ready technology has provided growers with an excellent tool for managing many annual and perennial grasses, including difficult to control weeds such as nightshades, annual morningglory, and nutsedge. Some of the advantages to this system include the following: Glyphosate can be applied post emergence so growers can wait and see the weeds present. There are no plant back restrictions. This technology has allowed growers to reduce tillage operations and also experiment with ultra narrow row systems. 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.

Even with the herbicide tolerant technology weeds like annual morningglory, lambsquarter, and barnyardgrass are increasing especially when growers are only relying on glyphosate. In other cotton growing states where Roundup Ready cotton is grown on greater than 90 percent of the acreage weed shifts have developed after many years of a reduced tillage systems coupled with extensive use of glyphosate. These weeds include palmer amaranth, horseweed, giant ragweed, and tropical spiderwort.

With the adoption of herbicide tolerant systems there are concerns that certain weeds would develop resistance or cause weed shifts due to the repeated use of a single herbicide. Concerns have already surfaced in California regarding reduced control in some cases of barnyardgrass, sprangletop, pigweed, and lambsquarter with continual use of Roundup Ready systems. In several of the southern states, several weeds have developed resistance to glyphosate where cotton has been grown for a number of years in conservation tillage fields. Amaranth species (pigweed) is becoming more difficult to control. Roundup Ready corn in Roundup Ready cotton is now a problem. Sprangletop, horseweed, and fleabane have now infested most canals, roadsides, and field edges throughout the San Joaquin Valley. In some cases these weeds are just beginning to encroach into the cotton fields.

In many regions, reduced tillage, spot treatments, early postemergence-directed applications, and hand hoeing has decreased because of this technology. Now with more resistant weeds such as palmer amaranth, growers have to bring some of the older technologies back into the system such as the use of some tillage, hand weeding, and the use of residual herbicides. If glyphosate usage continues to increase, the industry incentive to support existing and older active ingredients may decrease. If glyphosate resistant weeds continue to develop and major shifts in weed populations occur, fewer herbicide options may be available due to the number of older herbicides lost to re-registration and the decline in the number of herbicides brought to market.

Dr. Stanley Culpepper reported that a recent survey of weed scientists focused on weed shifts in GR cotton systems. Six scientists in six states (AL, GA, FL, MO, NC, and TX) responded to the survey. All scientists noted weed shifts have occurred, and *Amaranthus* species, annual grasses, dayflower species (*Commelina* sp.), morningglory species *(Ipomoea* sp.), and winter annuals were becoming more problematic in response to currently utilized GR management systems. Four of six states noted these shifts are of economic concern and all specialists are addressing weed shift issues by recommending 1) the use of residual herbicides in current GR programs, 2) the addition of other herbicides in mixture with glyphosate, 3) rotation to other herbicide chemistry, and 4) rotation away from GR crops when feasible.

A major concern for an increase in glyphosate resistant weeds is that cotton is often rotated with Roundup Ready corn. There has been considerable interest in reduced tillage corn. A crucial aspect of no-till corn management should revolve around weed control. Keeping noxious weeds and grasses out of dairy silage is essential if the highest quality silage is to be harvested. Corn growers have access to a variety of different herbicide programs, but the Roundup Ready® corn system is the easiest in terms of managing weeds when the tillage is eliminated or used less frequently. By the 2010 season, Roundup Ready Corn comprised 50 percent or more acreage. Most no-till corn growers who use the Roundup Ready system do not use a pre-emergence herbicide, preferring instead to rely on over-the-top applications of Roundup UltraMAX® herbicide, often alone but sometimes in either tank mixes with 2,4-D, dicamba, halsulfuron (Sempra) or in conjunction with separate treatments of these herbicides. Corn growers who use dairy manure as fertilizer need to work extra hard to stay on top of weed control. Some tillage once in awhile, and combined with use of different herbicides, may be necessary where dairy manure is applied to fields.

The results of several cotton studies demonstrate the value of Glytol + Liberty Link Cotton, which will provide an alternative to glyphosate but broadleaves must be small. Research with

“Widestike" Technology gave a 1X safety rate using glufosinate on cotton. Our research demonstrated no advantage to increasing spray pressure or water volume for annual morningglory control when using glyphosate or glufosinate. One study demonstrated a need to use a 4X rate of glyphosate to obtain control of lambsquarter in a field that was in no-till Roundup Ready corn for several years.

Summary

The potential for herbicide resistance should receive serious and thoughtful attention. As weed management systems change with new herbicides and herbicide resistant crops are introduced, resistant management must be an integral part of the production system. If selection pressure is maintained through the continuous use of the same herbicide, herbicide resistance will soon render it ineffective.

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. Keep in mind many of the weeds were not being easily controlled before herbicide tolerant technology was available. Therefore it will continue to be necessary to use every available tool in the future to economically control weeds in this year’s crop and effectively control weeds from building up in the seed bank for future crops.

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Dry Bean Weed Control in California: Past…Present…Future.

Kurt Hembree
Farm Advisor, UC Cooperative Extension, Fresno County
1720 S. Maple Ave. Fresno, CA 93702, email: kjhembree@ucdavis.edu

The first dry beans commercially produced in California were limas, in the early 1900's. Today, the four major classes of dry beans grown in the state are blackeye, lima, red kidney, and garbanzo. Other types grown include black turtle, cranberry, pinto, small red and white kidney. In 2009, California produced 68,100 acres of dry beans with a value of over $78.7 million (table 1). Dry beans are legumes so add nitrogen to the soil, making them a good rotational crop. Production costs range from $300 to $500/acre, depending on variety, location, and cultural practices used. Weed control costs also vary for similar reasons. Growers spend about $35/acre for preplant herbicide treatments and another $20 to $30/acre for postemergent treatments. Cultivation and in-season hand weeding is needed in weedy fields, adding additional costs to production.

Table 1. Harvested acres of dry beans in CA

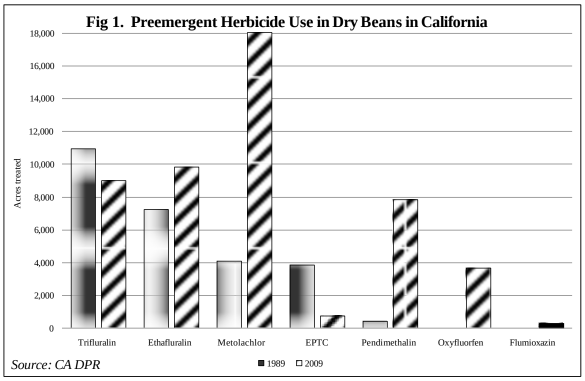
Bean Type	2007	2008	2009
Baby lima	15,600	11,700	14,600
Large lima	15,600	11,700	14,300
Blackeye	12,500	7,100	12,400
Garbanzo	6,000	6,300	14,000
Kidney	2,000	2,600	2,800
Other	6,300	12,500	10,000
Total	58,000	51,900	68,100

Source: USDA NASS

Problematic weeds commonly found in dry bean fields include black nightshade, prickly lettuce, barnyardgrass, volunteer cereals, annual morningglory, and nutsedge. Weeds impact bean growth and production directly by hindering stand development, delaying crop maturity, and lowering yields. Bean quality can also be impacted by the presence of weeds. For example, the juice from black nightshade berries can stain mature beans, reducing seed quality and price.

The number of herbicides labeled in dry beans in California has not changed significantly over the last 20 years (figures 1 and 2). This is, in-part, because the different bean types often exhibit different sensitivities to the same herbicides. Consequently, it has been challenging to identify herbicides that provide effective weed control without harming the different bean types. So growers continue to face similar weed problems as in past years. The herbicides currently registered for use in dry beans in California are listed in table 2. Most of the products used at the time of planting have similar modes of action, so control similar weeds. Also, post-plant preemergent herbicides are limited to garbanzo beans only. Furthermore, products used after crop establishment only provide postemergent control of grassy weeds. Unfortunately, there are no preemergent products labeled for use at lay-by before row closure. So, one to two early-season cultivations plus a mid- to late-season hand weeding is often required for complete weed control, increasing the cost of production. Late-season hand removal of weeds in dry beans is not encouraged because bean pods can be shattered. A pre-harvest desiccant is sometimes used to help control annual morningglory if it is present before harvest.

Since herbicides options are limited, growers should plant into fields with an historically low weed population. Equally important is consideration for the specific weeds that are known to be present and whether or not the labeled herbicides are effective on those particular weeds. Efforts should be made to control weeds during the fallow period and before planting to help reduce the impact of weed competition on early crop stand development. Applying pre-irrigation water, followed by a shallow tillage operation or a postemergent herbicide treatment (usually glyphosate), can be used to kill emerged weeds and reduce the weed population before planting. Until new and effective herbicides become available, particularly for mid- to late-season applications, weed control in dry bean production will continue to be a challenge for growers.



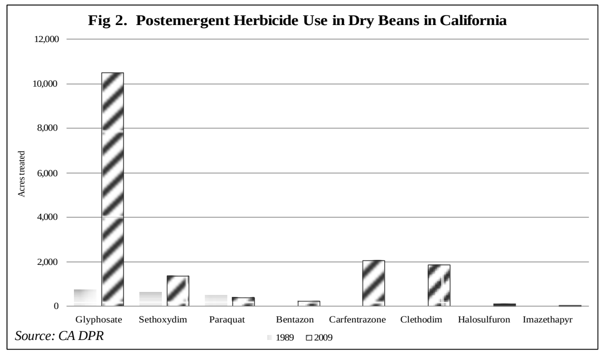


Table 2. Herbicides registered for use in dry beans in California

Herbicide	Treatment information
	Fallow ground or preformed beds
carfentrazone	up to 1 day after planting
glyphosate	up to before crop emergence
oxyfluorfen	up to 60 days before planting
paraquat	anytime before planting
pyraflufen	up to 30 days before planting
	Preplant mechanically incorporated
EPTC	not for blackeye, garbanzo, or limas
ethafluralin	crop injury if deep seed, overlaps, and stress
metribuzin, pendimethalin	garbanzos only
s-metolachlor, trifluralin	all bean types
	Post-plant before crop and weed emergence
flumioxazin, metribuzin, oxyfluorfen, pendimethalin	garbanzos only
imazethapyr	garbanzos only (up to 3 days after planting)
	Post-plant after crop and weed emergence
carfentrazone	hooded sprayer for row middles
clethodim, sethoxydim	controls only grasses; 30-day PHI
	Pre-harvest desiccant
carfentrazone	All bean types; 0-day PHI

Sources: UC IPM Guidelines and CDMS.net

The Challenge of Weed Management in One - Two Acre Ponds

John A. Roncoroni UCCE Weed Science Farm Advisor, Napa
Email: jaroncoroni@ucdavis.edu

In recent years there has been an increase in the number of one and two acre ponds. These ponds are important sources of irrigation water and frost protection. In the high value vineyards of California's North Coast these ponds provide water for drip irrigation from June through October. Many vineyards use these same ponds to provide frost protection (through overhead irrigation) from March through April.

These ponds are often used as part of the overall 'winery experience' provided to visitors and must be clean and attractive. Many ponds also provide recreation through boating, swimming and fishing. In mansy of these ponds aquatic weeds have become a major problem. The major weed and algae problems come from floating mats of filamentous algae, Pacific mosquitofern (*Azolla filiculoides*), Eurasian watermilfoil*(Myriophyllum spicatum)*, American Pondweed *(Potamogeton nodosus)*, Creeping waterprimrose *(Ludwigia species), and* Common cattail *(Typha latifolia).*

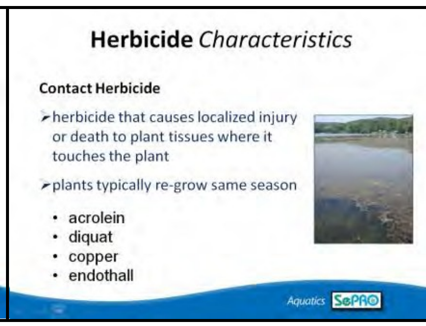
There is a lack of trained personnel to assist the grape growers manage their 1 and 2 acre ponds and many small problems become big problems very quickly. Weed control options in vineyard ponds are often expensive. These options include mechanical harvesting of weeds, dredging the ponds to increase depth and manual removal of weeds above and below the waterline. Herbicide treatments can be effective but are also costly; some examples of approximate costs for one acre herbicide treatment: Glyphosate: $300, Fluridone: $900 to $1,000, Endothall: $650, 2,4-D: $300-600, Diquat: $300 to $400. Grapes are very sensitive to growth regulator type herbicides such as 2,4-D and Triclopyr and because of this many growers are reluctant to use them. Safe and effective herbicides such as Fluridone-have a long waiting period which makes there use difficult at best.

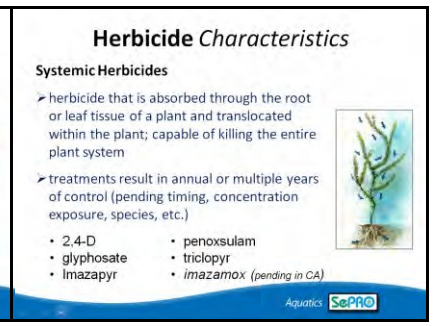
Field days that provide information to the growers on available services and management options were very popular. Even in very wet years water available for crop production is always and issue and the management of small ponds for irrigation and frost protection will become an even more important issue in the future.

Characteristics and Modes of Action of Aquatic Herbicides

David C. Blodget, SePRO Corporation, daveb@sepro.com

Herbicides are an effective part of integrated plant management programs. The United States Department of Environmental Protection, Office of Pesticide Programs has approved registration of approximately 300 herbicides for use sites such as agriculture, rights of way and aquatics. Today, there are 10 herbicide active ingredients currently approved for aquatic use in California. Utilization of herbicides for the control of nuisance and invasive plants in and around water can be challenging. Baseline knowledge of herbicide characteristics and mode of action is essential when evaluating the use of herbicides as part of any plant management program. This presentation will highlight and discuss common herbicide classification categories, best management practices, and how they influence aquatic herbicide selection. In addition, how characteristics of water dynamics, concentration exposure requirements and application technique should be integrated in operational aquatic plant treatment program design and implementation.





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Aquatic Algae: Characteristics and Methods of Control

Paul Westcott, Southwest Regional Manager, Applied Biochemists / Arch Chemicals, Inc
e-mail: paulwestcott@appliedbiochemists.com

Algae are one of the most diverse and widespread organisms, inhabiting almost every habitat on Earth and generating more oxygen via photosynthesis than all other plants combined. Their many forms, structures and other adaptations for survival can make control of problematic algal species difficult. In many situations, algaecides are the preferred management option due to rapid activity and their ability to at least temporarily alleviate the problems associated with high densities and secondary compounds (i.e. toxins, taste, and odor) that restrict critical water resource usages and require immediate intervention. For these situations, selection of an efficacious algaecide is crucial, since application of an ineffective algaecide or excessive amounts can be costly in terms of time, resources, as well as ecological risks.

Applied Biochemists in conjunction with Clemson University and other researchers have cooperated with public and private stakeholders over the past 10 years in advancing the science of algae control and aquatic management. A key focus and objective has been to optimize the use of U.S. EPA Registered Algaecides to manage algal problems within acceptable margins of safety to both man and environment. This Targeted Algal Management has involved development of effective algaecide screening protocols; corresponding algal toxin measurements; determination of impacts on non-target organisms; post-treatment residue levels; field trials to verify laboratory results and establishment of successful operational treatment programs. Applied Biochemists continues to develop and produce specific algaecide formulations to optimize the control of problematic algae and cyanobacteria species.

The Ever Changing California NPDES Aquatic Pesticide Permit: What Now?

Michael S. Blankinship,
Blankinship & Associates, Inc. Agricultural & Environmental Consultants
322 C St., Davis, CA 95616 Email: mike@h2osci.com

Aquatic weed specialists working for drinking water, flood control, and irrigation interests manage algae and a variety of aquatic weeds including submersed, floating, emergent and riparian species. These weeds can create flow restrictions in irrigation canals and flood control structures and pose taste, odor and aesthetic problems in drinking water storage and conveyance facilities. Use of chemicals to control these weeds in surfacewater in California is limited to the following:

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

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

Year	Action	Permit Required?
1996	Talent Irrigation District Acrolein/Copper 90,000 juvenile steelhead dead	No
1998	Headwaters Suit; Alleged CWA Violation	No
2001	9th Circuit Court Decision Overturns Lower Court; CWA violation cited; NPDES Permit Required. Permit Required	Yes
2002	CA issues Emergency General Permit for Discharge of Aquatic Pesticides	Yes
2002	Forsgren Case: Permit Required	Yes
2004	New 5 year Permit Issued by CA	Yes
2005	Fairhurst Case: Permit NOT Required	No
2007	EPA states that Permit NOT Required	No
Jan 2009	6th Circuit Court: Permit Required	Yes
June 2009	6th Circuit Court: 2 Year “Stay” Granted = Permit NOT Required	No
Mar 2010	Supreme Court will not hear the case	Yes
Aug 2010	Congress introduces bill to overturn 6th Circuit Court	Maybe
Apr 2011	EPA issues final aquatic pesticide permit	Yes

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

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

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

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

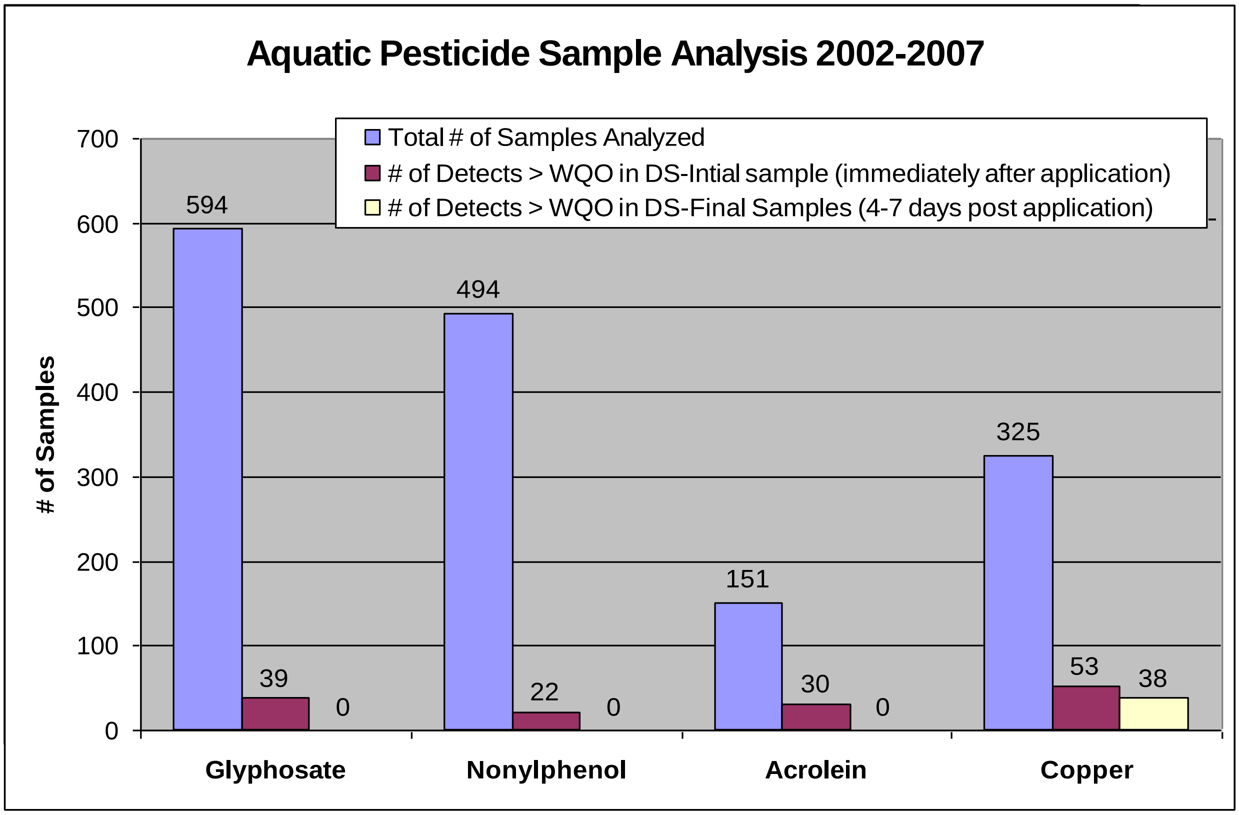
USEPA

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

California

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

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



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

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

- California Aquatic Pesticide Permit ("Weed Permit")
  http://www.waterboards.ca.gov/water_issues/programs/npdes/aquatic.shtml
- Goby 11 Injunction
  http://www.epa.gov/oppfead1/endanger/litstatus/factsheet.html
  http://www.epa.gov/oppfead1/endanger/litstatus/use-limitation.html
- Red-Legged Frog Injunction
  http://www.cdpr.ca.gov/docs/endspec/rl_frog/index.htm
  http://www.epa.gov/espp/litstatus/redleg-frog/rlf.htm
- Salmonid Injunction
  http://www.epa.gov/espp/litstatus/wtc/maps.htm
- USEPA NPDES Aquatic Pesticide Permit
  http://cfpub.epa.gov/npdes/home.cfm?program_id=410

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

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

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

Biological and Cultural Control of Aquatic Weeds in Ponds

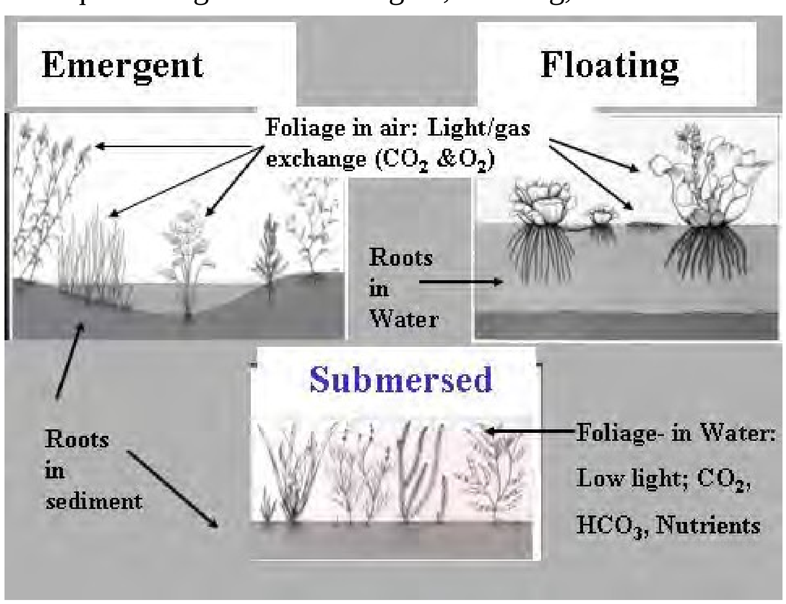
Lars Anderson
USDA-ARS Exotic and Invasive Weed Research, Davis, CA

Topics: Actions to Control Aquatic Weeds

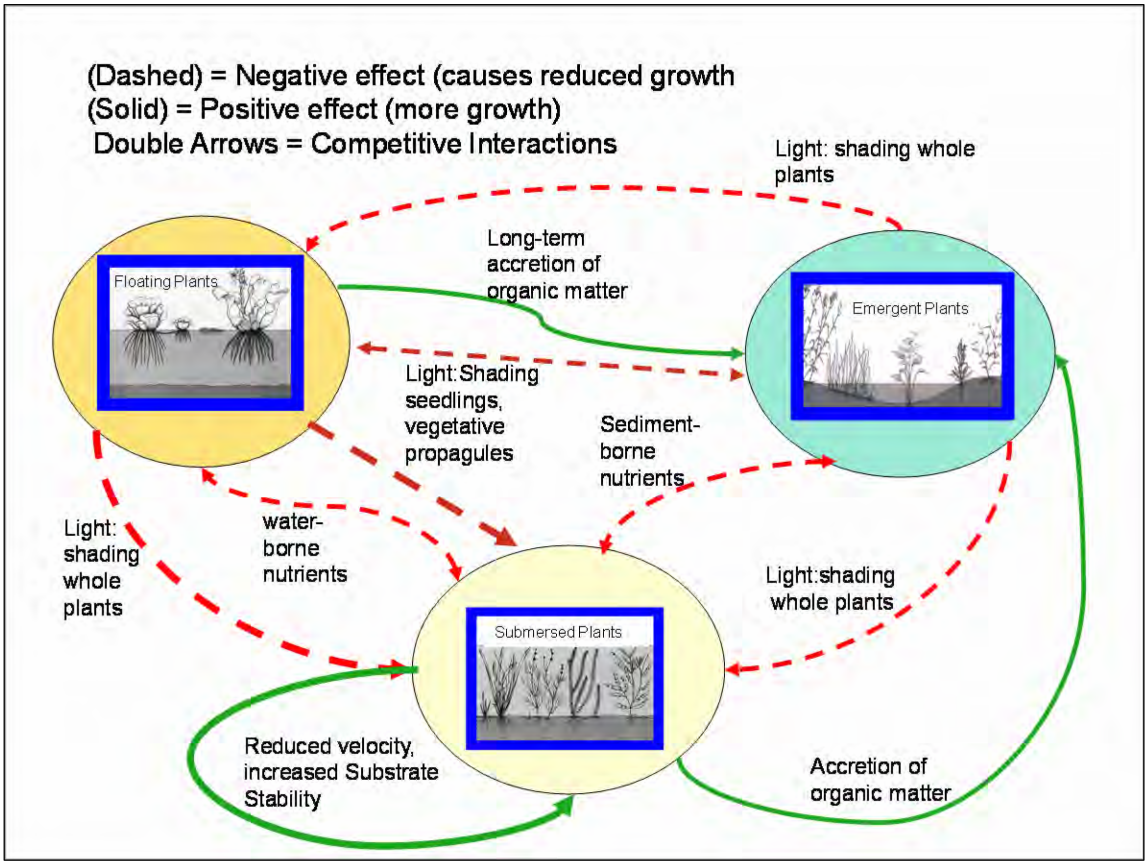
- **Define the Goal(s) –** What is the use of the pond?
- **Prevention**
- **Remediation** - Already infested? Now what?
- **Maintenance** - Protecting management investment

Pond Uses	Constraints/Regulations/Liabilities
Irrigation	Water demands, Crops, Herbicide residues, Drift, Timing
Frost Control	Herbicide residues, Sprinkler functions, Timing
Swimming	Exposure/toxicity, "Re-entry", Perceptions (phobias)
Fishing/Aquaculture	Fish toxicity, Residues, Harvest, Water quality (e.g. DO)
Aesthetics	Perceptions (phobias), Waterfowl
Fire fighting	Access, Clogged pumps
Flood detention	Holding capacity, Drainage
Inlet/outlets	Riparian rights (neighbors)

Types of Aquatic Vegetation: Emergent, Floating, and Submersed Plants



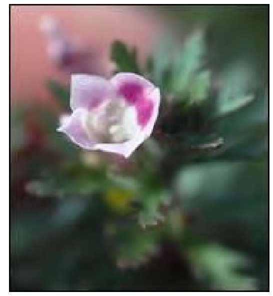
Interactions between Submersed, Floating, and Emergent Aquatic Vegetation Affecting Their Establishment and Growth



<u>Preventative Actions to Minimize Aquatic Vegetation in Ponds</u>

1. Design ponds with steep slopes
2. Design ponds with margin-berms
3. Design so stormwater drains AWAY from pond, not into it
4. Design with circulation (solar?)
5. Design with water-level management
6. Choose **native plants**- <u>in pots preferably</u>
7. Provide mixed plant canopy
8. Monitor for *introduced* Aquatic Invasive Species!!

“Residential Ponds” Require Constant Management



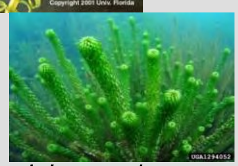
Movement of Aquatic Plants in the Horticultural Trade

- In S. New England 76% of non-native aquatic plants are escapes from cultivation. (Les and Mehrhoff, 1999)
- In New Zealand 75% of aquatic invasive plants are of horticultural origin. (Champion and Clayton, 2000)
- The 1st monoecious hydrilla in CA was traced to a contaminated lily shipment.

Recently published Water Garden “Guides” and “How-To” Books often recommend Aquatic Plants that are prone to becoming invasive.

Do Not Use These Plants!

Trapa natans



Lagarosiphon major

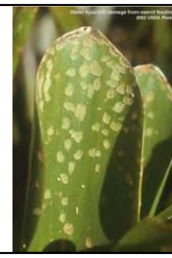
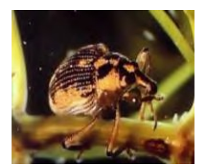
Trapa natans
“Water Chestnut”
An INVASIVE Aquatic Species

Lagarosiphon major
“African Curly Leaved Water Weed”
An INVASIVE Aquatic Species

<u>Remedial Actions for Weedy Ponds</u>

1. Identify unwanted plants
2. Options for biological control?
3. Stop or minimize nutrient loading
4. Feasibility to rake/harvest/use bottom barriers?
5. Feasibility for suction removal?
6. Feasibility to install circulatory system?
7. Drain and restart!!

Biological control Agents for Pond Management

Type	Target Weeds	Biological Control Agent	
Fish	Eat anything green	Sterile (triploid 3n) Grass carp	
		Tilapia	
Insects	Waterhyacinth	*Neochetina bruchi (weevil)* Weevil feeding causes leaf damage 	
	Hydrilla	*Hydrellia pakistanae (fly)*	
	Eurasian watermilfoil	*Bagous affinis (tuber weevil)*	
		 *Eurhychiopsis lecontei (weevil)*	
	Giant waterfern (Salvinia) 	*Acentria ephmemerella (moth)*	
		Cyrtobagous salviniae (weevil)	
	Water lettuce	*Neohydronomous affinis (weevil)*	
Pathogens	Eurasian Watermilfoil & Hydrilla	*Mycoleptodiscus terrestris (“MT”)*	
Bacterial “Products”	?	Beware of Labels	
Natural products		Barley straw	

Triploid Grass Carp

- Must have permit from CA Dept of Fish and Game (cannot use carp in areas that are considered flood zones)
- Must certify that the fish are indeed triploid (3n)
- *Generalist herbivore – they eat anything green*

Average Plant Density /(# fish per acre)

Low Plant Density / 5 fish per acre

Medium Plant Density / 10 fish per acre

High Plant Density / 15 fish per acre

Sustained Maintenance Actions

1. Monitor fish populations: types, and abundance.
2. Discourage excessive waterfowl use.
3. Establish a routine maintenance schedule.
4. Have a plan to contain/remove new Aquatic Invasive Species.
5. Develop a contingency water source.
6. Maintain pump/drain/fill options.

Evaluation of Herbicides for Postemergent Control of Mature, Highly Stoloniferous Kikuyugrass *(Peranisetum clandestinum)* Maintained Under Rough Conditions

Mark Mahady, President
Mark M. Mahady & Associates, Inc.
P. O. Box 1290
Carmel Valley, CA 93924
(831) 236-2929
markmmahady@aol.com

Introduction

Kikuyugrass *(Pennisetum clandestinum)* is a warm season grass native to East Africa. Kikuyugrass was introduced into Southern California during the I920's by the Soil Conservation Service to control erosion along water ways. This highly aggressive and invasive perennial exhibits medium leaf texture and a yellow green color that spreads by rhizomes, stolons and seeds.

Kikuyugrass exhibits better cool temperature tolerance than other warm season grasses. Germination temperatures range from 66° F to 93° F, with 78° F representing the optimum germination temperature. In many respects kikuyugrass represents a warm season grass that enjoys growth conditions generally best suited for cool season grasses. Kikuyugrass is able to maintain relatively high rates of photosynthesis, even greater than that of cool season grasses, at low temperatures, and, exhibits a higher temperature optimum (86° F) for photosynthesis than tall fescue (57° F). In the moderate Mediterranean climate of the Monterey Peninsula, the peak growth period for kikuyugrass occurs from May to October. Kikuyugrass exhibits slow growth and in some cases under cold conditions, a semi-dormant growth phase during Northern California winters.

In field research trials conducted in the Monterey Peninsula during 2006, SpeedZone Southern (PBI Gordon) applied at standard label rates of 5 pints per acre (pt/A) showed dynamic knockdown on young, non-stoloniferous stands of kikuyugrass 7 days after application (DAA). The addition of QuickSilver (FMC) at 2.7 oz/A enhanced kikuyugrass desiccation, collapse and dissipation. Three sequential treatments of SpeedZone Southern applied at 5 pt/A showed 85% control of young, non-stoloniferous kikuyugrass.

The primary objective of this replicated field research trial was to determine if multiple applications of designated herbicide products would result in acceptable levels of control of mature, highly stoloniferous stands of kikuyugrass maintained under rough conditions.

Materials & Methods

This replicated field research trial was conducted in a rough area located on the 14th hole at the Pebble Beach Golf Links located in Pebble Beach, California. The site was heavily inundated with mature kikuyugrass. The first replication had a mixture of kikuyugrass, perennial ryegrass and *Poa annua*. Replications II, III and IV consisted of virtually 100% mature, highly stoloniferous kikuyugrass.

This coastal area is characterized as a Mediterranean climate with frequent early morning summer fog. During the summer, daytime high temperatures generally range from 62° F to 72° F. with nighttime low temperatures of 44° F to 56° F. Average yearly rainfall is 18.8 inches with a very high percentage of precipitation occurring during the winter months from November to March.

Treatments as presented in Table 1 were first deployed on September 23, 2010 and then followed the specific application schedule presented. The site was mowed one to two times per week at a mowing height of 2.0" and irrigated to avoid moisture stress. The kikuyugrass turf was lush and actively growing on the day of treatment deployment.

Table 1. Treatment and application protocol. Pebble Beach Golf Links. Mark M. Mahady & Associates, Inc., 2010.

	Treatments	**Rate**	**Application** Frequency
1)	Untreated Check		*
2)	Turflon Ultra*	32 oz/A	3x: 21-Day Interval
3)	Turflon Ultra + Drive XLR8**	32 oz/A + 43.5 oz/A	3x: 21-Day Interval
4)	Drive XLR8**	43.5 oz/A	3x: 14-Day Interval
5)	Drive XLR8**	43.5 oz/A	2x: 14-Day Interval
6)	OneTime**	43.5 *oz/A*	2x: 30-Day Interval
7)	SZS' + Drive XLR8** + QS2	6 pt/A + 43.5 oz/A + 2.7 oz/A	3x at 21-Day Interval
8)	Drive XLR8** + QS2	43.5 oz/A + 2.7 oz/A	3x at 21-Day Interval
9)	Drive XLR8** + QS2	65.3 oz/A + 2.7 oz/A	3x at 21-Day Interval

* Treatments included a non-ionic stufactant (NIS) at 0.125% v/v

** MSO (methylated seed oil) was added to Drive XLR8 tank mixtures at 21,8 oz/A

SpeedZone Southern

QuickSilver

Herbicides Reviewed

SpeedZone Southern - PBI Gordon

- Carfentrazone 0.54%: 0.04 lb. ai/gallon
- 2,4-D, 2-ethylhexyl ester 10.49%: 0.52 lb. ai/gallon
- Mecoprop-p acid 2.66%: 0.20 lb. ai/gallon
- Dicamba acid 0.67%: 0.05 lb. ai/gallon
- Other ingredients 85.64%

QuickSilver - FMC

- Carfentrazone-ethyl 21.3%: 1.9 lb. ai/gallon
- Other ingredients 78.7%

Drive XLR8 - BASF Corporation

- Quinclorac 15.93%: 1.50 lb. ai/gallon
- Other ingredients 84.07

Turflon Ultra - Dow AgroSciences

- Triclopyr 60.45%: 4.0 lb, ai/gallon
- Other ingredients 39.55%

OneTime - BASF Corporation

- Quinclorac 15.95%: 1.50 lb. ai/gallon
- Mecoprop-p acid 7.98%: 0.75 lb. ai/gallon
- Dicamba acid 2.13%: 0.20 lb. ai/gallon

Individual treatment plots measured 10' x 10' and consisted of a 5' x 10' application plot directly adjacent to a 5' x 10' in-plot check. Side-by-side in-plot checks are very valuable when attempting to observe and measure subtle treatment effects. Treatments were replicated four times. Prior to treatment deployment all plots were rated for percent kikuyugrass cover. A randomization was established that balanced kikuyugrass cover across all treatments in order to ensure equal weed pressure for all treatments.

A calibrated CO_2 propelled spray system pressurized to 26 psi and equipped with four 11004LP Tee-Jet nozzles applied treatments at a spray volume of 1.5 gallons per thousand square feet (1000 ft^2). A pacing watch was used for spray applications to ensure uniform and accurate delivery. Field plots were not irrigated for 24 hours after application nor mowed for 72-96 hours after application.

Field plots were evaluated for percent cover day of application and 56 days after the third application. Percent kikuyugrass control was statistically calculated by comparing percent cover in treatment plots versus percent kikuyugrass cover in untreated check plots. Data were summarized and statistically analyzed. Differences between means were determined via LSD.

Results and Discussion

On the final rating date, 56 DAA3, the four treatments that exhibited the greatest reduction in percent kikuyugrass cover and the highest level of percent kikuyugrass control included the following.

1. Trt #3: Turflon Ultra + Drive XLR8 — 99.9% kikuyugrass control
2. Trt #2: Turflon Ultra — 99.2% kikuyugrass control
3. Trt #7: SZS + Drive XLR8 + QS — 94.7% kikuyugrass control
4. Trt #8: Drive XLR8 + QS — 93.9% kikuyugrass control

Table 2. Percent kikuyugrass control by treatment. Pebble Beach Golf Links. Mark M. Mahady & Assoc, Inc. 2010.

	Treatments	**Rate**	Application Frequency	% **Control**
1)	Untreated Check	*	*	*
2)	Turflon Ultra*	32 oz/A	3x: 21-Day Interval	99.2%
3)	Turflon Ultra + Drive XLR8**	32 oz/A + 43.5 oz/A	3x: 21-Day Interval	99.9%
4)	Drive XLR8**	43.5 oz/A	3x: 14-Day Interval	53.9%
5)	Drive XLR8**	43.5 oz/A	2x: 14-Day Interval	6.8%
6)	OneTime**	43.5 oz/A	2x: 30-Day Interval	45.5%
7)	SZS1 + Drive XLR8** + QS2	6 pt1A + 43.5 oz/A + 2.7 oz/A	3x at 21-Day Interval	94.7%
8)	Drive XLR8** + QS2	43.5 oz/A + 2.7 oz/A	3x at 21-Day Interval	93.9%
9)	Drive XLR8** + QS2	65.3 oz/A + 2.7 oz/A	3x at 21-Day Interval	87.0%

Treatments included a non-ionic surfactant (NIS) at 0.125% v/v
* MSO (methylated seed oil) was added to Drive XLR8 tank mixtures at 21.8 oz/A
SpeedZone Southern
QuickSilver

Summary and Practical Perspectives

Under these soil and turf conditions and under these timing and rate formats, the following conclusions are presented for control of mature, highly stoloniferous kikuyugrass maintained under rough conditions following three sequential applications of the described treatments:

- **Rank #1: 99.9% Kikuyugrass Control, Treatment #3, Turflon Ultra (32 oz/A)** + **Drive XLR8** (43.5 oz1A) + **MSO (21.8 oz/A):** Excellent performance. This top performing tank mix showed dynamic burn down and necrosis with very high levels of control and virtually no observable kikuyugrass regrowth. This tank mix is safe to use on solid stand perennial ryegrass and mixed perennial ryegrass/*Poa annua* turf stands. The high rate of Turflon may show yellowing on *Poa annua.* This tank mix would be highly injurious to fine fescue and creeping bentgrass.

- **Rank #2: 99.2% Kikuyugrass Control, Treatment** #2, **Turflon Ultra (32 oz1A) + NIS (0.125%** vlv): Excellent performance. Turflon Ultra showed consistent, uniform burn down and necrosis with very high levels of control and virtually no observable kikuyugrass regrowth. Turflon Ultra is safe to use on solid stand perennial ryegrass and mixed perennial ryegrass/*Poa annua* turf stands. The high rate of Turflon may show yellowing on *Poa annua.* Turflon Ultra would be highly injurious to fine fescue and creeping bentgrass.

- **Rank #3: 94.7% Control, Treatment** #7, **SpeedZone Southern (6 pt/A)** + **Drive XLR8 (43.5 oz/A)** + **QuickSilver** (2.7 **oz/A)** + **MSO (21.8 oz1A):** Good performance. The addition of Drive to this SpeedZone Southern and QuickSilver tank mix greatly improved activity and kikuyugrass control. This tank mix showed *very* rapid browning and necrosis of kikuyugrass. Minimal kikuyugrass regrowth.

Life After MSMA

Cheryl A. Wilen, University of California Cooperative Extension and UC Statewide IPM Program. 5555 Overland Ave. Suite 4101, San Diego, CA 92123
Email: cawilen@ucdavis.edu

MSMA (Mono Sodium Methane Arsonate) is an older postemergent herbicide used primarily for weed control in turf for control or suppression of dallisgrass crabgrass, sedges, kikyugrass, oxalis, other hard to control weeds. It is safe on bermudagrass, bluegrass, zoysia but on tall fescue may yellow. Currently, there are only 4 turf/landscape products registered in California that are not mixtures with other herbicides:

–DREXEL DREXAR 530 (35.8%)
–DREXEL MSMA 6 PLUS (47.6%)
–TARGET 6 PLUS (48.3%)
–TARGET 6.6 (51%)

Because arsonate is a component of this herbicide, it was re-reviewed by EPA because of potential exposure to arsonate through drinking water. Subsequent to that review, new restrictions were implemented to prevent exposure to inorganic arsenic in drinking water. The restrictions include limiting use in areas of particularly vulnerable ground water, using buffer zones around surface water bodies, limiting the number of applications, and restricting golf course use to spot treatment only.

The current EPA ruling as it applies to turf and landscape uses is that MSMA is allowed on golf courses, sod farms and highway rights of way with sales until December 31, 2012 and material can be used only until December 31, 2013. During 2012 EPA will evaluate the scientific information available on any risk posed by inorganic arsenic and if the evaluation finds no health concern at the doses of exposure of normal use, the use of MSMA will continue beyond 2013.

Pest control advisers and applicators should be aware of the changes on the current label:

- **Golf courses:**
  –One broadcast application allowed on newly constructed courses.
  –Application on existing courses limited to spot treatment (100 sq ft per spot), not to exceed 25% of the total course in one year.
- **Sod farms**:
  –Two broadcast applications allowed per crop.
  –25 foot buffer strip required for fields bordering permanent water bodies.
- **Other MSMA Uses Not Allowed** (sales stopped in 2009, usage stopped Dec.31, 2010).
  –Residential turf
  –Drainage ditch banks, railroad, pipeline, and utility rights of way, fence rows, storage yards and similar non-crop areas
  –Others

With the loss of MSMA, other herbicide options may be used but the site, the turf species, and weed spectrum needs to be considered. Possible alternatives[1] to MSMA include:

- Acclaim - fenoxaprop-p-ethyl (ACCase inhibitor)
- Certainty – sulfosulfuron (sulfonylurea)
- Dismiss – sulfentrazone (aryl triazolinone)
- Drive XLR8 – quinclorac (quinolinecarboxylic acid)
- Monument – trifloxysulfuron-sodium (sulfonylurea)
- Revolver - formasulfuron (sulfonylurea)
- Sedgehammer - halosulfuron (sulfonylurea)

The tables below list the turf species where the herbicides may be safely used and some weeds that are listed on the label as being controlled. This list was developed because the herbicides are safe on the same turf species as MSMA or have an expanded list of turf species where they are safe. They also control or suppress some of the weeds that MSMA was historically used for in turf such as crabgrass, dallisgrass, and sedge species. Note that there are no exact matches for MSMA but knowing the turf species and weed spectrum will help find a suitable replacement. In some cases, these herbicides will control a broader weed spectrum.

A drawback is that these herbicides should not be used without considering a rotational plan. Four of the herbicides on the list are sulfonylureas and resistance may develop if these herbicides are used exclusively.

Turf Species Safety[2]

Herbicide	**Active Ingredient**	**Bermuda-grass (common)**	**Bermuda-grass (hybrid)**	**Buffalo-grass**	**Creeping Bentgrass**	**Fine Fescue**	**Kikuyu-grass**
Acclaim Extra	fenoxaprop-p-ethyl				T	T	
Certainty	sulfosulfuron	T	T	T	T		T
Dismiss CA	sulfentrazone	T	T	T	T	T	T
Drive XLR8	quinclorac	T	M		M	M	N
Monument	trifloxysulfuron-sodium	T	T				
Revolver	formasulfuron	T	T	T			
Sedgehammer	halosulfuron-methyl	T	T		T	T	T
MSMA	**Mono Sodium Methane Arsonate**	**T**	**T**				**N**

[1] Products discussed are for informational use only. Their mention anywhere in this document does not constitute a recommendation or endorsement.

[2] This is not an exclusive list of turfgrass species for herbicide safety for each product. Consult label for more information and sites where they may be used.

Turf Species Safety

Herbicide	Ky Bluegrass	Per. Rye	Rough Bluegrass	Seashore Paspalum	St. Augustine	Tall Fescue	Zoysia-grass
Acclaim Extra	T	T				T	T
Certainty	T		N	T	T	N	T
Dismiss CA		T	T	T	T	T	T
Drive XLR8	T	T	M	M	N	T	T
Monument						N	T
Revolver							T
Sedgehammer	T	T		T	T		T
MSMA	**T**				**N**	**M/N**	**T**

T=Tolerant
M=Moderately tolerant
N=Not tolerant

Weeds Controlled or Suppressed[3]

Herbicide	Barnyard-grass	Common bermuda-grass	Dallis-grass	Foxtails	Goose-grass	Johnson-grass (rhizome)	Johnson-grass (seedling)	Kikuyu-grass
Acclaim Extra	C	S		C	C	S	C	
Certainty			S					
Dismiss CA					C			
Drive XLR8	C			C				C
Monument			S					
Revolver			S		C	C		
Sedgehammer								
MSMA	**C**		**C**		**C**		**C**	

Weeds Controlled or Suppressed

Herbicide	Kyllinga spp.	Large crabgrass	Panicum spp.	Purple nutsedge	Smooth crabgrass	Tall fescue	Yellow nutsedge
Acclaim Extra		C	C		C		
Certainty	C/S			C/S		C	C/S
Dismiss CA	C/S			C/S			C/S
Drive XLR8		C			C		
Monument		S		S	S	C	C
Revolver		S				C	
Sedgehammer	S			C			C
MSMA		**C**			**C**		**C**

C=Control
S=Suppression

[3] This is not an exclusive list of weed species controlled or suppressed for each product. Consult label for additional information and rates.

Emerging Trends in Landscape Weed Management

John T. Law Jr. Ph.D. ValleyCrest Companies
jlaw@valleycrest.com

The theme of this year's conference is Biology, Reality and Sustainability. This is also a good description of concepts to consider for weed management plans in commercial landscapes. Biology is certainly a good place to start. Weed management plans should have a biological science foundation. Scientific knowledge is built up over time by testing what is assumed to be true. Repeated hypothesis testing by many people, in many places, with many different methods can be very powerful. Scientists who study weeds can tell us a lot about weed management. They have tested different weed management plans, production systems and herbicides. The science may be incomplete since the scientific method of conducting controlled studies is expensive and time consuming. However, a weed management plan that includes practices that are not supported by the work that has been done by weed scientists will probably fail. An important part of science based problem solving is defining the problem.

What is the biological definition of weeds? A weed is often a plant that is adapted to disturbed habitats, and consequently weeds are often the best adapted plant on the landscape. Definitions like "a plant out of place" are not very useful. People have been disturbing plants and the soil for a long time. This disturbance became extensive when people domesticated grazing animals. Domesticated grazing animals were selected because they are manageable. Almost all species of domesticated large animals had ancestors that share three social characteristics: they live in herds; they maintain a well-developed dominance hierarchy among herd member; and the herds occupy overlapping home ranges, rather than mutually exclusive territories. These characteristics mean that different groups of animals can be bunched up around our ancestral villages, and they will hang around because they imprint on humans as the leader. The plants around the village were more intensely grazed and more intensely "fertilized" than in naturally occurring habitats. One of the adaptations of many weeds is the production of new leaves to replace those grazed off. Another adaptation is response to fertilizer. Grazing results in high amounts of fertilizer to be dumped in small discrete locations (e.g. cow pies). Plants that survived these conditions were presumably those that could use the fertility and turn it into new growth and/or lots of seeds and/or other ways to rapidly propagate in soil dug up by people or their animals.

When developing a commercial landscape there is a lot of soil disturbance. The existing vegetation is removed and the soil is reshaped, compacted and consolidated to remain stable, and for California, to remain stable during an earthquake. This disturbance usually continues as the site development goes through all the phases required to go from the initial state, through temporary roads, utility installation, constructing buildings and to the final landscape. Weeds are not only adapted to disturbance, they usually can maintain their abundance in repeatedly disturbed landscapes. This often creates the situation where a large seed bank is created over the course of site development. These seeds can be viable for many years and will germinate for many years, especially when soil is re-disturbed in the landscape by digging up weeds, tweaking and repairing irrigation etc. An important part of landscape weed control is not disturbing the soil once the landscape is installed.

Weeds probably initially evolved their invasive characteristics in natural disturbances such erosive water flows, big trees falling over, earthquakes and landslides. As discussed above, people and their domesticated animals have been disturbing climax vegetation for many thousands of years. Many weeds adapted to grazing and Mediterranean climates are hard to control. The roots and other underground parts usually need to be controlled. Short of extensive digging, soil pasteurization or soil fumigation, the only way to do this is with systemic herbicides. Many hard to control weeds in the West are:

- Adapted to fire - weeds are tolerant of loosing their tops either by burning off using flaming or herbicidal soaps, or mechanically with hoes.
- Adapted to drought - many broadleaf weeds immediately grow a large root system which makes them tolerant of loosing their tops from flaming, contact herbicides, or hoeing.
- Adapted to intense grazing by sheep and goats - which makes them tolerant of loosing their tops from flaming, contact herbicides, or hoeing.
- Many weeds from Europe have gone through intense selection from the ice ages squeezing all life into small areas between the ice and the Mediterranean Sea. This also is where people and their grazing animals have been for many thousands of years.

That is some biology of weeds. What about the second part of the Weed Conference theme, Reality. What is the reality of managing weeds for the landscape maintenance business? Probably the most important part of landscape maintenance business is that landscapes need to look good and be maintained at a competitive price. The standard for commercial landscapes like business offices, shopping centers and condominium or apartment complexes is a neat and clean appearance. Most landscape maintenance clients expect at least “Green grass, no weeds, no trash, pretty flowers”. They might not know much about plants, but they “know” weeds do not belong in the landscape. A landscape maintenance term for this attention to neat and clean is “detailed”. From a weed management perspective the “detailing” should not include soil exposed to sun and should not disturb the soil. A common example of a detail that can encourage weeds is edging that leaves a gap between a curb, wall or walkway. This kind of detailing conflicts with sustainability.

Sustainability is the third part of this year’s Conference theme. Business sustainability goals started with recycling, carpooling, lights that shut off automatically and other energy saving encouragements and building enhancements. However, these sustainability goals have now moved to the landscape with IPM programs, irrigation mandates and other policies that impact use of herbicides and other aspects of weed management. Landscape maintenance clients are now addressing weed concerns in ways other than “I shouldn’t see any”.

There are now sustainability terms and concepts commonly used by clients, the media and product marketing. These terms include Green, LEED, native, carbon footprint, natural organic, food web, healthy soil etc. Everyone thinks they know what these terms mean. They are widely used by the media to tell stories and marketing departments to sell products. However, they are not really operational terms. Discussions with clients all too often end with the landscape maintenance account manager asking, “What exactly do you want us to do differently?” Most of the “real” part of sustainability is already incorporated into landscape maintenance. Part of sustainability is don’t waste energy and water. A term for this part of sustainability is efficiency; efficiency is almost always part of business. After all, most savings on utility bills or water bills drop straight to the bottom line. It is no different with herbicides. Herbicides are expensive, as is the training and equipment to apply the herbicides. Much of the time weeds can be efficiently and effectively controlled by not disturbing the soil, never letting soil be exposed to the sun and allowing the surface layer of the soil to dry out as much as possible. These practices do not require extra labor and can be part of regular landscape maintenance. They are part of “working smarter” which good management always promotes. When weeds are encouraged, such as by not using mulch or keeping the soil surface wet, the weeds have to be controlled with labor and herbicides. Just like an electric bill that includes waste, avoidable use of herbicides and/or extra labor reduces profits.

The problem of not being able to define sustainability concepts well enough to develop a sustainable landscape maintenance plan has given rise to various rating systems. The largest national one is LEED (Leadership in Energy and Environmental Design). This is a scoring system devised by the non-profit organization dedicated to sustainable building design and construction called the US Green Building Council. It provides an “agreed upon” system to achieve a sustainability rating. It is important to recognize that it is a consensus based rating system, not a science or evidence based system. Benefits of achieving a LEED rating can include tax breaks, or favorable attention by planning departments. The part of LEED that has the most impact on weed control plans is called Sustainable Sites (SS). The two that include weed control are:

- SS Credit 3: Integrated Pest Management, Erosion Control and Landscape Management Plan.1 point

- SS Credit 5: Site Development — Protect or Restore Open Habitat. 1 point

A common requirement of LEED and other sustainability plans is to keep organic “debris” on site. The organic material is supposed to be composted or used as mulch. The process of achieving stable, weed and disease free compost is difficult on a commercial landscape site. Composting requires equipment and a site where the organic landscape debris can be chopped and mixed and then composted with temperature and moisture control. Using “raw” landscape debris on landscapes has aesthetic problems, and can easily spread weed seeds and stolons.

The water conservation part of sustainability plans, often include drip irrigation. Robust and reliable drip irrigation systems can be designed, installed and managed. However economics and ignorance often results in landscape drip systems that are not that robust and they often develop leaks and clogs. Also, with drip irrigation systems you cannot water in preemergent herbicides and cannot do “grow and kill” to reduce weeds. Any irrigation system and landscape should be designed for irrigation cycles that allow the soil surface few inches to get dry between cycles. The irrigation has to be designed for the very slow infiltration rate on soils that have been engineered for stability.

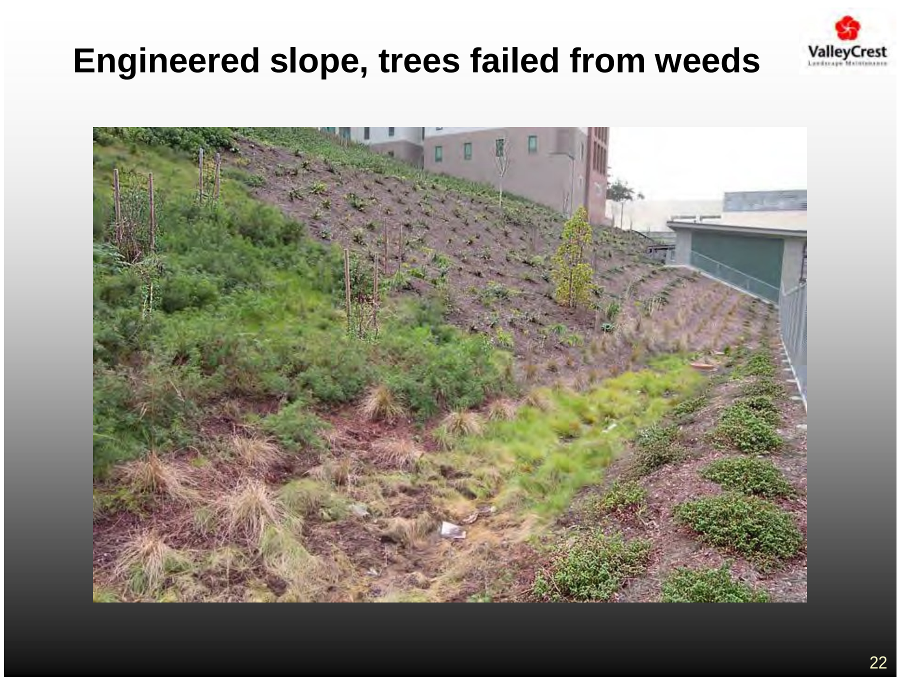
Even though many landscape designs include specifications to loosen construction compacted soil in the areas to be planted, these are not evidence based specifications. In other words, no one has done before and after measurements to prove they are effective. They are just “accepted practices”. Remember that civil engineers specified soil modification by heavy machinery to last the life of the buildings, associated infrastructure and hardscape. By design, this soil compaction is very hard to undo. In my experience, most post construction ripping, tilling and amending of areas to be planted does not result in much lasting improvement of the soil water infiltration rate. Physics tells me that if you change the soil from 95% compaction to 70% compaction, the soil volume will expand and soil will have to be moved to maintain the design contours or not overfill planting beds. Microbiology tells me that incorporated organic amendment is food for microorganisms and they will quickly consume the carbohydrates. This causes the soil to subside, often resulting in depressions that accumulate water, which supports weed seedlings and can cause aeration deficits and poor plant health. When the microorganisms consume the carbohydrates they release a lot of nutrients like phosphate that the landscape plants do not need and cannot use. If these excess nutrients leave the site, they can degrade aquatic systems downstream. Soil science tells me that Western clays are geologically young, very reactive and will stick much tighter to itself than organic amendment. One result of dense soil and shallow rooting is that frequent irrigation cycles are required. This is very favorable for weeds. In spite of the widespread practice and requirement, amending soils for trees and shrubs with organic matter has no scientific support.

IPM plans usually require details on how dependence on traditional herbicides can be reduced. Often non-traditional herbicides are encouraged. These are typically “burn down” type materials. These are usually hazardous, and in the case of acetic acid very hazardous materials for employees to use. Their mode of action is direct plant tissue damage. This mode of action is generally biocidal and the materials are just as damaging to human eyeballs and mucous membranes as they are to weed leaves. These burn down materials require high volume applications and are very expensive. However, as discussed above, weeds can be managed without herbicides, traditional or non-traditional much of the time. To use no herbicides at all, even for establishment greatly increases the amount of landscape labor. Unfortunately, no herbicides is part of many IPM programs promoted by agencies and sustainability consultants. What should be in an IPM program?

The IPM plan should include using shrubs in the landscape design. As discussed before, weeds are the usually the best adapted plants on the landscape. Shrubs are usually next best adapted, and increasing the use of shrubs can reduce weeds. Use shrubs that tolerate hard pruning. Examples of shrubs for California could include Xylosma, Rhaphiolepsis, Ligustrum, non-invasive Cotoneaster species, Pyracantha, Rhamnus, Cotinus, Dodonea, Grevillea, Mahonia, and Pittosporum. There are others. These shrubs can be kept relatively short while maintaining a continuous cover to shade the soil. Also, many planting beds are too small for trees. Other parts of a weed control plan are 4 inches of coarse mulch or 3 inches of finer mulch. If aesthetically acceptable, chipped branches from pruning can be used. They are also good food for the soil food web. Irrigation that wets the entire soil surface will benefit the plants and allow fertilizer and preemergent herbicides to be watered in. Herbicides are very important for establishment or re-establishment after repairs or landscape enhancements. Weeds in the root ball of establishing plants exacerbate water deficit problems new container plants often have.

Fertility is an important part of weed control. Soil testing labs have no calibration data for woody ornamentals in California or the West in general. This means they cannot really interpret the results of their soil tests. They typically do not want to have no interpretation and they typically do not want to recommend nothing, so they often recommend fertilizer when it is not needed. In particular, P is rarely needed by woody ornamentals, and surface applied P is unfortunately a “starter” fertilizer for weeds. Unless the soil P level is less than 5 ppm do not apply it, or at least do not make a surface application.

Herbicides become less important when adapted landscape plants are used. The plants should be adapted to compacted, engineered soil. Shrubs usually are best. The plants should grow well with shallow roots and tolerate both dry soil and saturated soil. Again this is usually certain shrubs. Native and “xeriscape” plants are often poorly adapted. They are not usually adapted to soils engineered for earthquakes.



Optimizing Organic Herbicide Activity

W. Thomas Lanini, University of California, Davis Email: wtlanini@ucdavis.edu

In recent years, several organic herbicide products have appeared on the market. These include Weed Pharm (20% acetic acid), C-Cide (5% citric acid), GreenMatch (55% d-limonene), Matratec (50% clove oil), WeedZap (45% clove oil + 45% cinnamon oil) and GreenMatch EX (50% lemongrass oil). All are contact-type herbicides and will damage any green vegetation they contact. However, they are safe as directed sprays against woody stems and trunks.

These herbicides kill weeds that have emerged, but have no residual activity on those emerging subsequently. While these herbicides can burn back the tops of perennial weeds, perennial weeds recover quickly.

These organic products are effective in controlling weeds when the weeds are small and the environmental conditions are optimum. In a recent study, we found that weeds in the cotyledon or first true leaf stage were much easier to control than older weeds (**Tables 1** and **2**). We also found that broadleaf weeds were easier to control than grassy weeds, possibly due to the location of the growing point (at or below the soil surface for grasses) or the orientation of the leaves (horizontal for most broadleaf weeds).

Organic herbicides could be applied when preparing the seedbed for turfgrass sod production and then again with the first flush of weeds. Grass seed could be planted a bit deeper (1/4 to ½ inch deeper) to delay turfgrass emergence, so that the organic herbicide could control the broadleaf flush without adversely affecting the turfgrass.

Organic herbicides kill only contacted tissue so good spray coverage is essential. A large, flat nozzle (ie. 8006) would be preferable in turfgrass production. In tests comparing various spray volumes and product concentrations, high concentrations at low spray volumes (20% concentration in 35 gallons per acre) were less effective than lower concentrations at high spray volumes (10% concentration in 70 gallons per acre). We also found that adding an organically acceptable adjuvant resulted in improved control. Among the organic adjuvants tested thus far, Natural wet, Nu Film P, Nu Film 17 and Silwet ECO spreader have performed well.

Although the recommended rate of these adjuvants is 0.25 % volume per volume (v/v), increasing the adjuvant concentration up to 1% v/v often leads to improved weed control, possibly due to better coverage. Work continues in this area, as manufacturers continue to develop more organic adjuvants. Because organic herbicides lack residual activity, repeat applications will be needed to control new flushes of weeds.

Temperature and sunlight have both been suggested as factors affecting organic herbicide efficacy. In several field studies, we observed that organic herbicides work better when temperatures are above 75° F. Sunlight has also been suggested as an important factor for effective weed control. Anecdotal reports indicate that control is better in full sunlight.

However, in a greenhouse test using shade cloth to block 70% of the light, we found that weed control with WeedZap improved in shaded conditions (**Table 3**). The greenhouse temperature was around 80° F. It may be that under warm temperatures, sunlight is less of a factor.

Recent experiments have assessed winter weed control during cool conditions (Table 4). In spite of cold temperatures, plantain control was very good with Weed Pharm, or the high rates of Weed Zap or Biolink. Annual bluegrass control was also good with these same materials.

Organic herbicides are expensive and may not be affordable for commercial crop production at this time. Moreover, because these materials lack residual activity, repeat applications will be needed to control perennial weeds or new flushes of weed seedlings. Finally, approval by one's organic certifier should also be checked in advance as use of such alternative herbicides is not cleared by all agencies.

Table 1. Broadleaf (pigweed and black nightshade) weed control (% control at 15 days after treatment) when treated 12, 19 or 26 days after emergence.

	-----------------Weed age	---------------------	
	12 Days old	19 days old	26 days old
GreenMatch Ex 15%	89	11	0
GreenMatch 15%	83	96	17
Matran 15%	88	28	0
Acetic acid 20%	61	11	17
WeedZap 10%	100	33	38
Untreated	0	0	0

Table 2. Grass (Barnyardgrass and crabgrass) weed control (% control at 15 days after treatment) when treated 12, 19 or 26 days after emergence.

	-----------------Weed age	---------------------	
	12 Days old	19 days old	26 days old
GreenMatch Ex 15%	25	19	8
GreenMatch 15%	42	42	0
Matran 15%	25	17	0
Acetic acid 20%	25	0	0
WeedZap 10%	0	11	0
Untreated	0	0	0

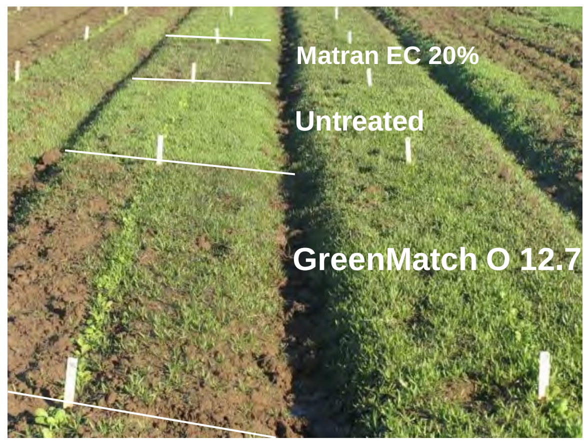
Table 3. Weed control with WeedZap (10% v/v) in relation to adjuvant, spray volume and light levels. Plants grown in the greenhouse in either open conditions or under shade cloth, which reduced light by 70%.

	Pigweed control (%)		Mustard control (%)	
	Sun	Shade	Sun	Shade
WeedZap + 0.1%v/v Eco Silwet (10 gpa)	31.7	93.3	26.7	35.0
WeedZap + 0.5%v/v Eco Silwet (10 gpa)	31.7	48.3	43.3	71.7
WeedZap + 0.5%v/v Natural Wet (70 gpa)	26.7	94.7	26.7	30.0
Untreated	0.0	0.0	0.0	0.0
LSD.05*	5.7		11.5	

* Values for comparing any two means. Pigweed and mustard were each analyzed separately.

Table 4. Plantain and annual bluegrass control (%) at 4 and 9 days after treatment (DAT). Applications made on Jan. 6, 2011 - 40ºF. All treatments included Eco Silwet 0.5% v/v.

Treatment	Plantain control		Annual bluegrass control	
	4 DAT	9DAT	4DAT	9DAT
Biolink 3% v/v	52	48	15	35
Biolink 6% v/v	63	80	40	63
MOI-005 5% v/v	2	13	0	2
MOI-005 10% v/v	10	20	0	3
GreenMatch 7.5% v/v	12	13	3	5
GreenMatch 15% v/v	23	38	10	52
Matran 7.5% v/v	5	8	2	3
Matran 15% v/v	20	17	5	30
Weed Zap 7.5% v/v	18	28	10	42
Weed Zap 15% v/v	52	78	23	78
Weed Pharm 100%	82	90	53	87
Untreated	2	0	0	0
LSD .05	23	19	13	29



Managing Herbicide Resistance in Turf and Landscape Sites

Todd Burkdoll, Market Development Specialist,
BASF Corporation, Turf and Ornamentals   Email: James.burkdoll@basf.com

What does managing herbicide resistance have in common with fighter aircraft?

- Something better may come along and make you obsolete
- What you think is a superior defense program may have some inherent weaknesses that can cost you Big $$$ or worse…..

The goal of any production system is efficiency resulting in sustainable profit

- The performance of any tool is determined by how it is used
- Crop protection products can be your best friend or your worst enemy, depending upon how you use them.
- Operator resources (tools) are finite
  - Too much input $$$ will reduce profit $
  - New tools are expensive to produce

First steps in managing weeds

- Know your enemy (weeds) and what they need to thrive
  - Annual vs. Perrenial,
  - cool season vs. warm season,
  - propagation strengths-weaknesses
- Understand what tools/weapons are available to manage
  - Cultural
  - Chemical
    - Pre-emergent vs post

Know your tools and how to use them.

- Efficiency is the result of effective planning.
- Think ahead before you plant,
  - What are problematic weeds indigenous to the area.
    - Check with local extension or pest control advisors
  - Read an understand the labels of any crop protection tools before using them.
    - Know your tools and how to use them.
  - Make sure the necessary tools are available—communicate with your supplier

Know your tools and what their strengths and limitations are.

- Contact activity vs. Systemic
- Residual-how long doe it really last?
- Weed activity spectrum
- Rainfast or not?

- Worker safety, REI, PHI
- Read the labels and do your homework first.

Know your tools and when to use them.

- What should you start with and what should you use next?
    - Product selection and plan of attack.
    - Alternation is necessary for resistance mgt. and weed shifts
    - Alternation is required depending on the target weeds

Does the product fit?

- Site
- Growth stage
- Weed

Understanding resistance

- Resistance does not arise from pesticide exposure
- Repeated, uninterrupted use of a pesticide selects a population that is tolerant.
    - similar to backcrossing plants to bring out a phenotypic trait
- Natural tolerance or physical barriers (waxy cuticles, hairy leaves/stems) can impede herbicide efficacy---weed shifts.
- Repeated use of the same chemistry year after year will result in weed shifts and can select for a resistant population.

Every Crop/Site use is different and the management of weeds for each crop is different

- There are no silver bullets
- Each chemistry has its strengths and weaknesses
- Use each according to the label and in rotation with other chemistries with differing MOA.

Chemical Control Efficiency

- **COVERAGE**
- High Enough Rate
- **COVERAGE**
- Proper Timing
- **COVERAGE**
- Preventive Program
- **COVERAGE**
- Resistance Management
- **COVERAGE**

References:

Better Plants Pest Management Guide 2010, BASF Corporation.
Freehand product label, BASF Corporation

New Vegetation Management Herbicides from DuPont

Ronnie G. Turner and Stephen F Colbert, DuPont Crop Protection

Registration of four new vegetation management herbicides from DuPont is anticipated to occur in early 2011. The new products combine the proven efficacy of DuPont's sulfonylurea herbicides with the new active ingredient aminocyclopyrachlor. Aminocyclopyrachlor is a new auxin mimic herbicide discovered by DuPont Crop Protection. It combines foliar and residual activity with upward and downward movement to provide excellent annual and perennial broadleaf and brush control.

- DuPont™ Plainview™ herbicide is a broad-spectrum bareground weed control product designed specifically to help utility and industrial site managers improve site safety.
- DuPont™ Viewpoint™ herbicide delivers broad-spectrum brush control for greater safety at utility sites and along roadways.
- DuPont™ Streamline™ herbicide was designed to help land managers maintain desired grasses without sacrificing brush control.
- DuPont™ Perspective™ herbicide controls invasive weeds and helps restore desirable grasses to more natural habitats.

Alternative Roadside Weed Control in Santa Cruz County

Steve Tjosvold and Richard Smith, University of California Cooperative Extension
Email: satjosvold@ucdavis.edu and rifsmith@ucdavis.edu

The County of Santa Cruz maintains approximately 600 miles of public roads. Of those, approximately 340 miles are actively managed for weed control. The diverse and discontinuous vegetation in the country or mountains presents a challenge for the County Public Works Department suffering from budget constraints and personnel shortages. The Department goals are to: (1) maintain sufficient sight distances for drivers, pedestrians, and cyclists, (2) Prevent vegetation encroachment that might infringe on the safe use of the roadway and (3) Reduce fire hazard. Traditionally management has consisted of an initial mowing where necessary to reduce biomass, followed by a carefully timed Roundup® (glyphosate) application to the vegetation regrowth. A correctly timed application of glyphosate often eliminated the need for additional vegetation control measures for the remainder of the year.

Roundup®, however, has received considerable attention by groups and individuals questioning its safety in the environment. On May 17, 2005 the Santa Cruz County Board of Supervisors the Board of Supervisors established a moratorium on roadside spraying of herbicides on county maintained roadways. Mowing was left as the only viable option for roadside vegetation management. In a recent cost analysis by Public Works (October 2010), mowing was more than 275% the cost of a comparable glyphosate application.

French broom (*Genista monspessulana*) is one of the most common and important invasive weeds found growing on these roadways, as well as other areas of the central coastal area and other parts of California. It resprouts readily from the root crown and is a prodigious seed producer. In light of the budgetary constraints that the County faces, it is the intention of this research to evaluate the use of alternatives to Roundup®, especially those herbicides that are organic, biorational, or exhibit characteristics that could be used for vegetation management in a sustainable way.

The trial was established along Empire Grade Road near Bonny Doon, California. Plots were selected that had predominantly French broom, California blackberry (*Rubus ursinus*), perennial pea (*Lathyrus latifolius)*, and various other broadleaf and grass weeds. Each plot was 15 feet long by 5 feet wide (0.00172 acre). Treatments were applied on May 4, 2010. Applications were made with three passes of a wand with one 8005VS air induction nozzle applying the equivalent of 50 gallons of water per acre. Air temperatures peaked at 75º F on the day of application. Weed control evaluations were carried out 7, 14, 28, 56 and 112 days after application by rating the percent of weed control on the following scale: 0 = no weed control to 10 weed completely dead.

Treatments (Table 1) were selected to contain organic, biorational, and other herbicides that had the "caution" safety category and therefore meet the County of Santa Cruz IPM pesticide use policy without specific exemption. The exception was WeedPharm (acetic acid) which is labeled with a “danger” category and Finale (glufosinate) which is labeled with a “warning” category. Roundup® was included as the former herbicide standard used by the County. Some treatments had contact activity and were effective by essentially desiccating weeds, while others had some systemic activity and therefore absorbed by weeds and resulted in weed control by other modes of action.

Table 1 Treatments in trial

Product Trade Name	Active Ingredient	Activity	lb a.i. /A	Product/A	Safety Information
Greenmatch EX	lemongrass oil	Contact	15% v/v	7.5 gals	organic “caution”
Weed Pharm	acetic acid (20%)	Contact	100% v/v	50 gals	“danger”
Matran	clove oil	Contact	15% v/v	7.5 gals	organic “caution”
Scythe	pelargonic acid	Contact	9%	4.5 gals	“caution”
Milestone VM Plus	aminopyralid triclopyr	Locally systemic	0.22 ae	9.0 qts	“caution”
Finale	glufosinate	Locally systemic	3%	1.5 gals	“warning”
Roundup	glyphosate	Systemic	2%	1.0 gal	“caution”
Untreated			---	---	

Surfactants: Nufilm P, 0.25% v/v added to Greenmatch, WeedPharm, and Matran.
Dynamic added 0.25% v/v to Milestone VM Plus.

Roundup was found to be very effective in controlling French broom and other weeds. Its past use as the standard and effective product by the County was justified in this trial. Products that had locally systemic properties, Milestone and Finale were effective in killing some smaller French broom plants (basal diameters less than 9 mm) and inhibiting growth of larger plants. Organic and other contact herbicides do not kill French broom. French broom recovery occurred quickly and was demonstrated in almost all cases just 2 weeks after herbicide treatment. Of those that were contact herbicides Scythe and Matran desiccated foliage most effectively (Figures 1-4).

Figure 1. Overall vegetation control

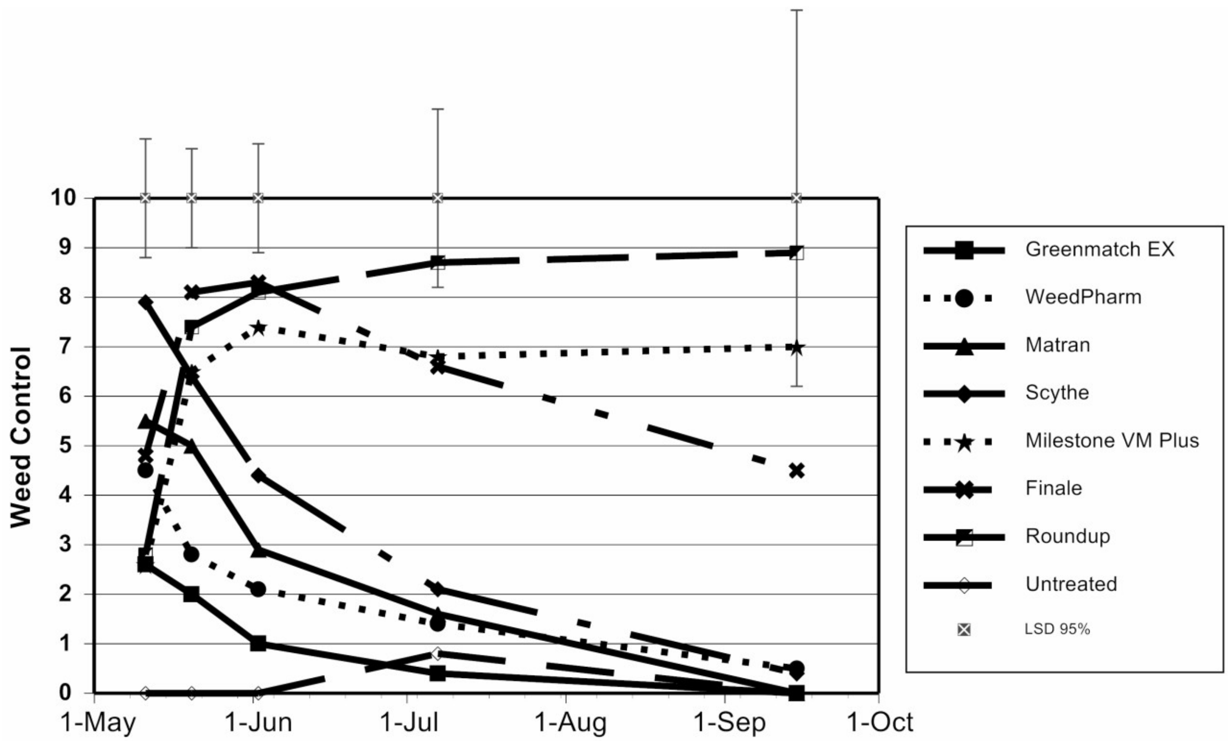


Figure 2. French broom control

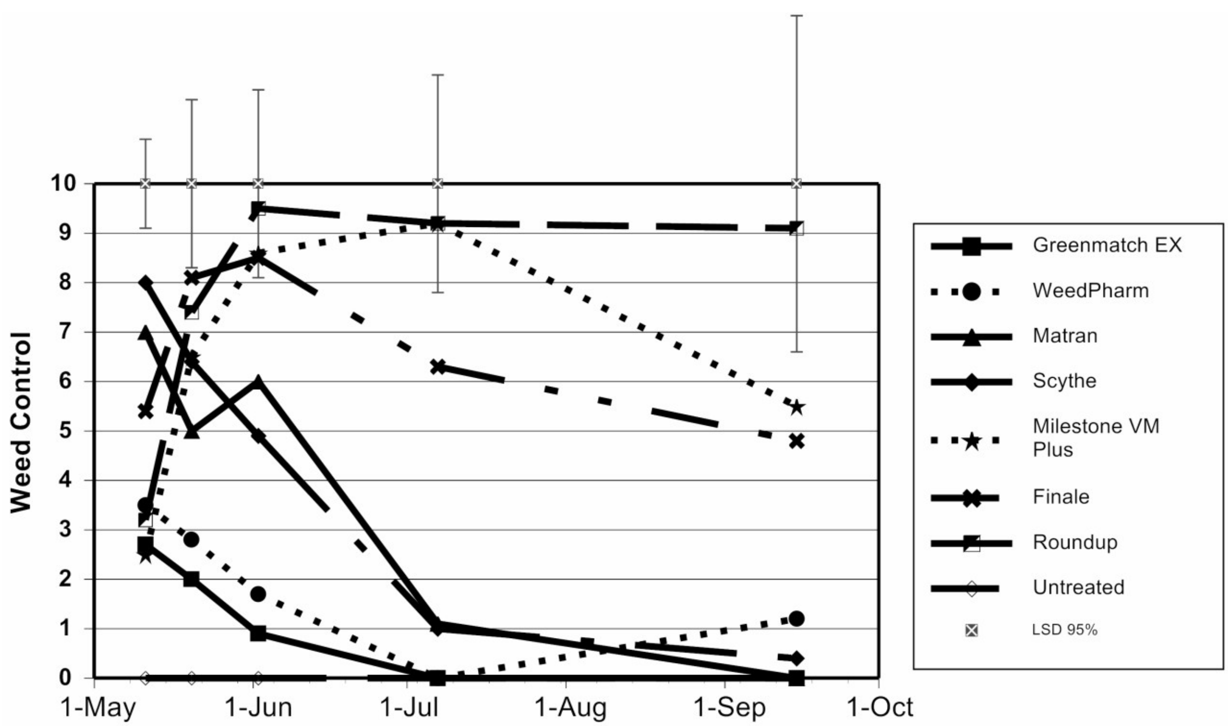


Figure 3. Blackberry control

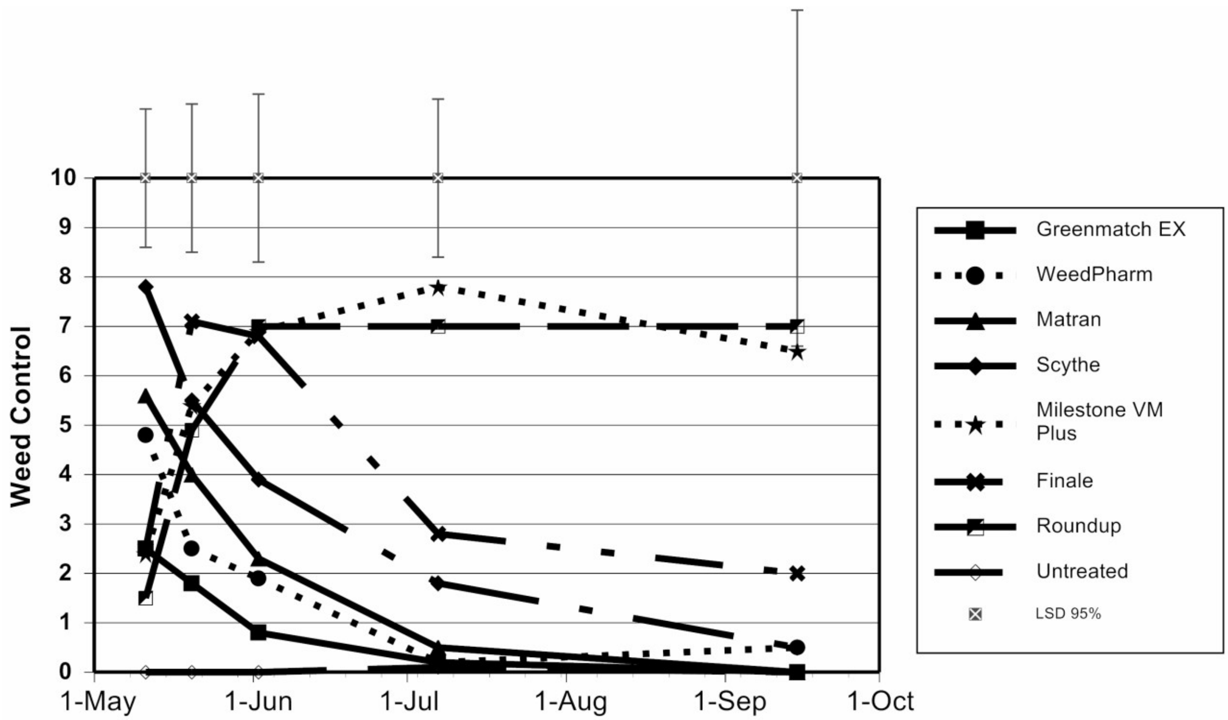


Figure 4. Perennial pea control

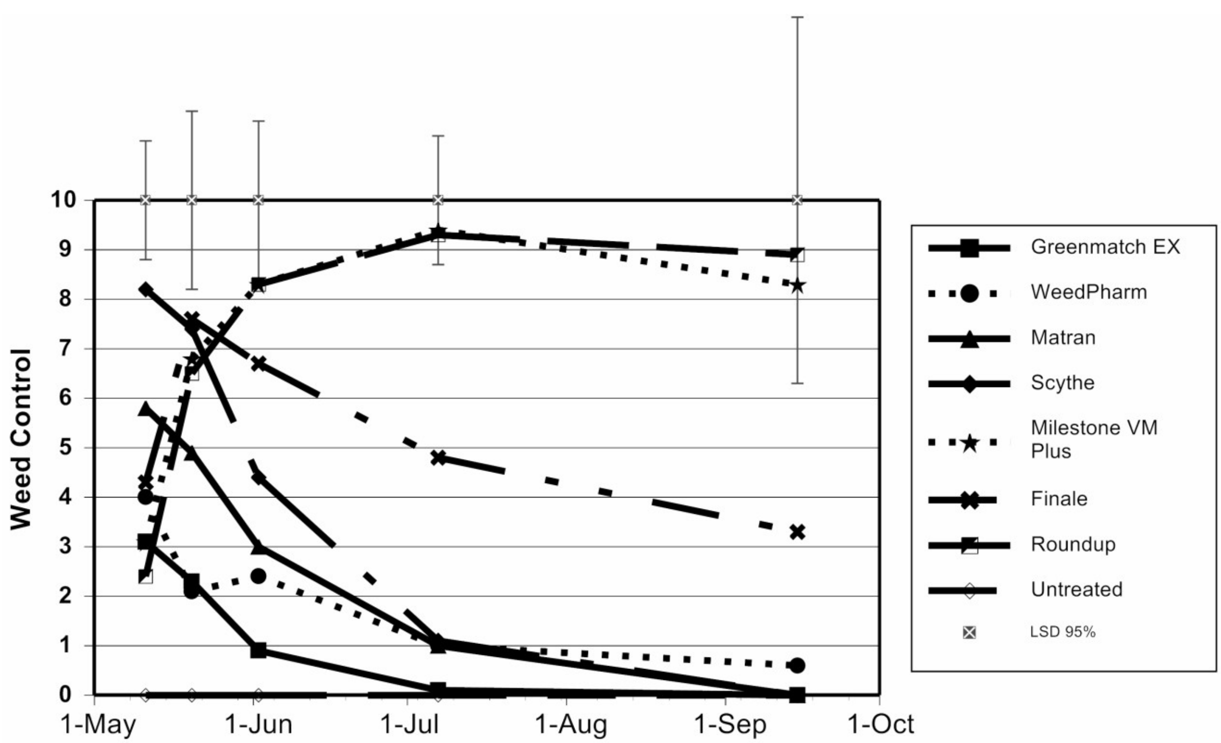
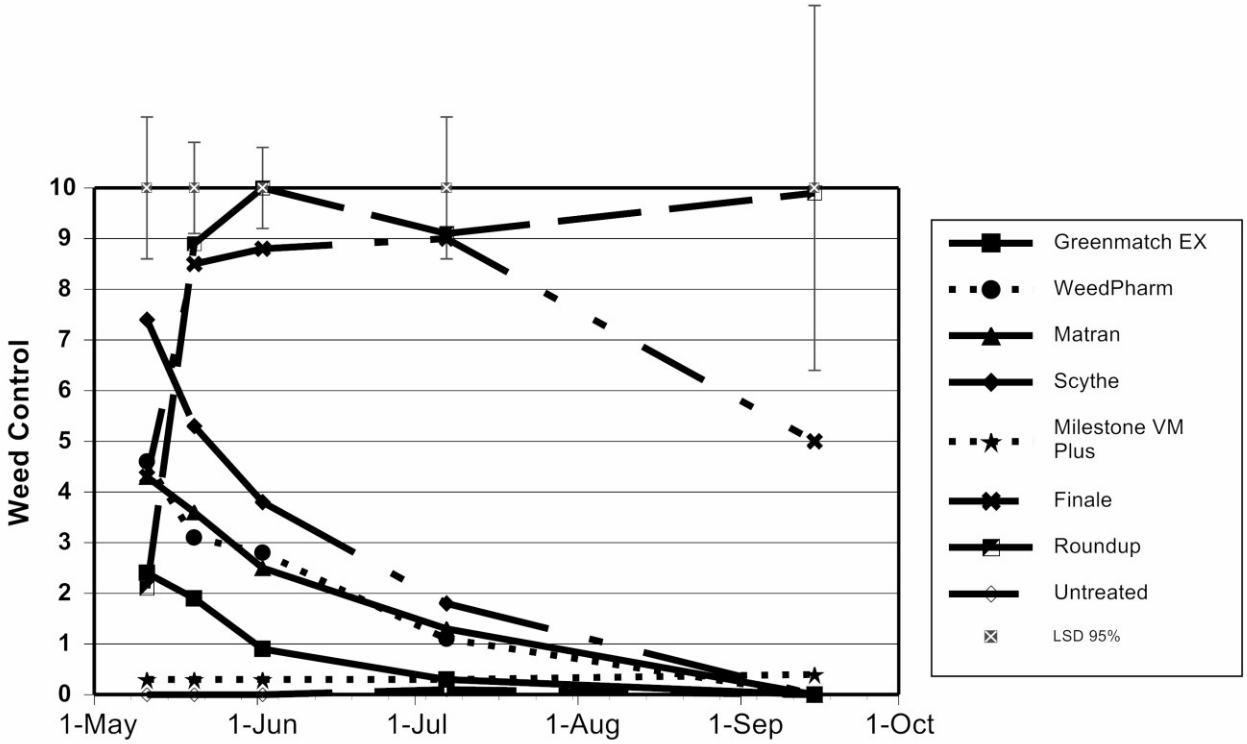


Figure 5. Grass control



Update on Physical Barriers for Weed Control

Jennifer A. Malcolm, Caltrans Headquarters, Division of Maintenance
(Now at California Department of Corrections and Rehabilitation
916-255-3860 email: jennifer.malcolm@cdcr.ca.gov)

Caltrans Integrated Vegetation Management Program consists of seven different methods of vegetation control. When using structural or physical barriers, Caltrans has a variety of materials and products to choose from. Hardscape (or hardscaping) and structural methods are interchangeable terms. Basically, hardscape is the use of hard inert material surfaces such as stamped asphalt, patterned concrete and rock cobble – in comparison to living soft material surfaces such as organic mulches and fully landscaped areas. Caltrans has ten different highway hardscaping treatments. Four products will be discussed further in detail - fiber weed control mats, rubber weed control mats, CRMCrete and cullet.

When choosing an appropriate vegetation management strategy, Caltrans considers safety for our highway maintenance workers, safety for the traveling public, and how structural controls can lead to increased mobility. Generally, structural methods involve higher costs during initial installation (which sometimes get expensive), but they lead towards reduced maintenance needs, resources and costs in the long run. Structural elements are the best way designers can assist maintenance forces in achieving Caltrans' herbicide reduction goals. Hardscaping can unify and tie elements together and be aesthetically pleasing. There are a wide variety of treatments, colors and patterns available. Structural methods can also decrease sight distance concerns, improving safety. Hardscaping works best is in small areas that are difficult to access and maintain, such as under guardrails and bridgerails, around signs and delineators, and in narrow areas that motorists drive into, such as gores and areas between ramps.

It is important to really KNOW your site before deciding upon which type of product might work best for you and your site. Are there defined edges such as concrete borders or curbs? Is the site an unusual shape or area – such as a triangular area being covered with rectangular products? Is the site inconvenient for worker and equipment access? How much time is allowed in your work window? Every site has slightly different characteristics and issues to consider before choosing one product over another.

Fiber Weed Control Mats are synthetic polyester fibers spun together to create a mat that prevents weed growth but allows water and air to percolate. Steel guardrail posts have fabric collars slipping over their top, which are then sealed to the mat below with caulking to prevent openings.

Fiber weed mats have been installed at Caltrans sites since 1999. The first installation was at the Mad River Bridge approach area, between two raised separated two lane highways going each way. The product was installed in the narrow, steeply-sloped center drainageway where vegetative growth was unwanted. The product is still performing well today, 12 years later.

Recent new three-beam and guardrail project installations are bladed evenly down the center divide, then installed with excellent ground preparation work. Wrap the product up and around the guardrail to tie it off above the ground when doing paving overlays directly adjacent to the product. A site near Garberville in Northern California has performed well over the past 12 years. Fiber weed control mats are considered a successful treatment by Caltrans. Current installation costs (at prevailing wage) are approximately $35 - $80 per square yard.

Rubber Weed Control Mats were originally developed for the recreation industry to address playground safety surfacing and the American Disabilities Act. The product consists of recycled tire rubber bonded together with a resin through a cold press process into a mat that lies directly on the ground. Rubber weed control mat tiles prevent sunlight and water from reaching the ground surface, thus retarding seed germination and plant growth. Flammability can be a safety concern due to toxic smoke produced when burning. The first Caltrans installation was underneath median guardrail over 8 years ago in the Santa Cruz area.

Rubber Weed Control Mat Installation includes uses under new and existing guardrail, thrie-beams, and bridgerails, around sign posts and under fences. The tile's weight keeps the mat in place, so normally staking or stapling is not required. Tiles are joined together with an overlap that is usually sealed with asphalt crack filler or resin adhesive. Manufacturers have different methods of joining their products. Staples, overlaps, glue strips, caulkings, and sealants have been used, depending upon the specific manufacturer. However, after time, the rubber product tends to shrink and pull away from wood posts. Follow-up maintenance is necessary.

Installation methods have improved over the years. No more kneeling, gluing and sealing small squares or mats. Break out the big equipment! Use long linear rolls of product and drive the new steel guardrail posts directly through it. Use individual large mats for curving areas and rolled mats for the straight-aways. Costs now run approximately $25 to $45 per square yard (at prevailing wage).

CRMCrete stands for Crumb Rubber Modified Concrete. CRMCrete is a concrete-based product that includes recycled scrap tire crumb rubber material and homopolymer polypropylene high performance reinforcing fibers, all blended into a slurry. CRMCrete utilizes a product that currently adds to California's existing waste stream. It helps to keep tires out of our landfills and gives a 'gold star' to agencies willing to partner with other agencies.

Caltrans has installed CRMCrete around sign posts and guardrails. Placement/installation is similar to that of concrete and stamped concrete. Typical CRMCrete installation includes pouring CRMCrete into place, tamping and leveling as necessary, and finishing. CRMCrete normally doesn't require the same level of formwork as standard concrete. Polypropylene fibers act like rebar or welded wire mesh. 'Leave-out sections' around the posts are necessary to allow the safety rail post to twist and bend upon impact. It also allows simple repairs for maintenance crews, since the leave-out section is the only area typically needing repairing. It breaks first upon impact due to its grout mix (instead of concrete in the leave-out sections), thus saving the rest of the area from breakage.

Caltrans crash tested the product in 2006 to determine if FHWA safety guidelines have been achieved. Caltrans' Standard Plans have been revised to include this product statewide as a standard for use in guardrail, bridgerails and thrie-beam installations.

Current installation techniques also became bigger, faster and included larger paving equipment. A recent application covered 3,000 feet in one day. The cost has been greatly reduced too – the product came in at $3.25 per square foot, or just under $30 per square yard installed on the recent Redding Interstate 5 site (at prevailing wage). CRMCrete is closer in price to that of fiber and rubber mats and has longer durability and lifecycle costs. CRMCrete has become a successful hardscaping product for Caltrans.

Cullet is the professional term used when referring to recycled glass mulch. Results are not yet conclusive, with half the sites passing and the other half failing. Cullet is applied similarly to wood mulch. Lay a barrier between the soil and the recycled glass mulch (just in case it may need removal at a later date). We have tried Visquene and the typical black weed fabric. Dump the glass mulch on top and spread it out to an even thickness. Caltrans typically uses cullet in the ½" to $^{5}/_{8}$" size, in a wide variety of colors, and sometimes up to 1" size. If you want to be creative, pick specific colors of glass for aesthetics.

Once successful cullet location is downtown Los Angeles in the median along Highway 101, behind the guardrail, installed to prevent homeless from setting up their tents and living in this area. It has been very successful at this location in reducing homeless squatting, although currently there are some weeds sprouting through the recycled glass mulch. At a northern California site, Caltrans put cullet under guardrail without an underlayment. Seven years later, cullet is still successful in the compacted areas underneath the guardrail! Unfortunately, cullet has not been successful in landscaped areas with weeds coming through the product in less than 3 years after application. More test sites are needed to determine whether or not cullet will be successful.

Driving Issues in Utility Vegetation Management

Nelsen R. Money, NRM-VMS, INC., Grass Valley, CA
Email: nelsen.money@gmail.com

Today's Utility Vegetation Managers can be successfully in an integrated vegetation management, IVM, program if they also consider an integrated resource management approach, IRM. Many vegetation managers are incorporating all the tools of IVM except herbicides due to a lack of knowledge on how to successfully implement them with an IRM strategy.

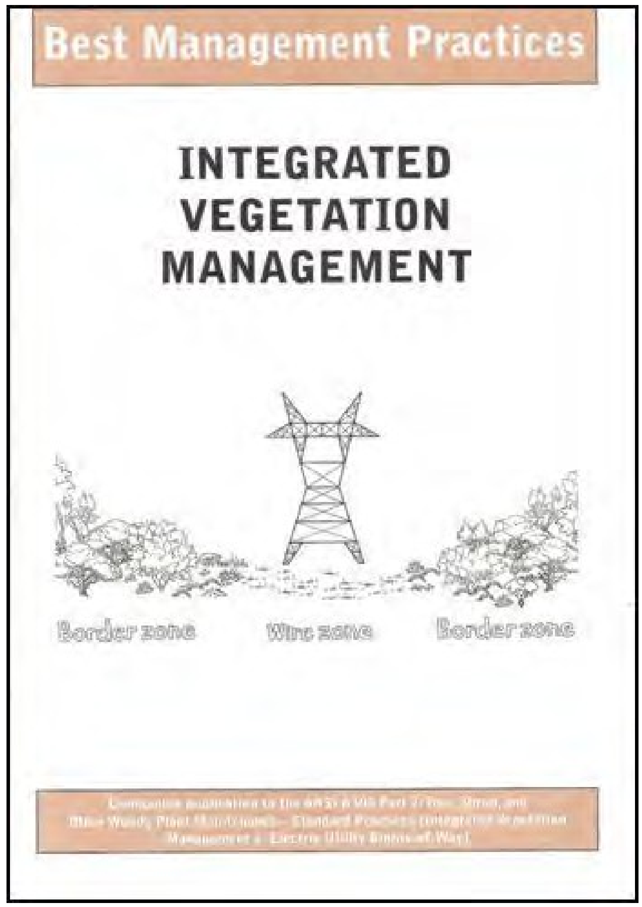
We know that IVM is a system of managing pest vegetation in which action threshold are considered, then all possible control options are evaluated and finally the management tactics are selected and implemented. Control options are based on worker/public safety, environmental impact, effectiveness, and site characteristics and economic. All utilities should be following ANSI A300 Part 7, Integrated Vegetation Management that can be found on the ISA Website. The tools are manual, mechanical, biological, cultural and chemical. Manual is generally chainsaws, chippers, hand saws, etc. Mechanical can be rubber tired or track mounted mowers or saws on booms. Biological can be goats, cattle and some biological pest controls are available. Cultural can be mulches, grass seeding, and agricultural control of right of ways. Chemical is the use of herbicides. There are many herbicides to choose from depending on the vegetation to be controlled and protected. Chemical application methods can vary from broadcast foliar, backpack foliar, basal stem, hack and squirt and spot gun. Chemical tools seems to be the most challenging for many utilities but can create more sustainable vegetation types at the most economical cost.

Many utilities see the IRM as a series of challenges to vegetation management. IRM can actually be the foundation to support the use of herbicides in your utility vegetation program. IRM is an interdisciplinary and comprehensive approach to land and natural resource management decision making that is designed to protect the ecological resources, cultural resources and economic resources. **IRM** is used to build mutual benefits between landowner and the Right of Way Owner. **IVM** Provides the tools to successfully manage for IRM.

Ecological resources are threatened, endangered and sensitive species, noxious and exotic species, wildlife and Fisheries, and watershed. Utilities need to see these challenges as opportunities to build partnerships with landowners and agencies. Threatened, endangered and sensitive plant species can be protected and their habitat enhanced if the vegetation manager is talking with the botanist about how they can protect and enhance the habitat that the plant needs. For example, when controlling fast growing cottonwoods in right of ways with protected elderberry in the understory, we can manually get clearance with climbers and then use hack and squirt to kill the remaining tree in place. You also get the added benefit of a cavity nesting snag for wildlife. These rights of ways can also be very valuable to pollinators and Vegetation Managers can gain support from the Pollinators Partnership.

Utility vegetation managers can also use the presence of noxious or exotic weeds in a right of way to build partnerships with the landowners and agencies. Usually including spot applications to control noxious weed within the right of way and access roads is a minimal increase in cost and builds long term partnerships with landowners.

Wildlife resources can be enhanced in right of ways with the encouragement of stable early succession plant communities. We have seen a decrease in earl succession plant communities with the reduction of ranching and logging and the control of wildfires. Vegetation managers can encourage more species richness by maintaining early succession habitat next to mature forest types. Some of the endangered or threatened wildlife species can benefit from the right of way vegetation. Vegetation managers need to talk with wildlife biologist on what species would benefit from a wire zone-border zone concept. The use of backpack foliar or basal applications to selectively control invading trees and brush species usually have fewer disturbances on wildlife than manual and mechanical mowing.



Cultural resources are usually protected with the elimination of mechanical and some manual treatments. Backpack foliar or basal stem applications can control tree and brush species without any disturbance of the cultural resources. Vegetation managers should promote these IVM tools to help protect the cultural resources.

Economic resources can be the recreational resources that intersect right of ways. Partnerships with park managers, city foresters and arborists can help utility vegetation managers accomplish their goals and meet some of the landowner's goals. Bike and hiking trails can frequently benefit from selective herbicide use instead of the large manual mowers. The use of backpack foliar, basal or hack and squirt applications can be made in the late fall and winter for low impact on recreational use.

As utility vegetation managers, we need to use all the tools of IVM to create sustainable plant communities and remember that herbicides can be a cost effective and reduce many of the environmental issues of other tools when applied by professional applicators.

Control of Brush and Weeds with Milestone (aminopyralid) and Combinations

Ed Fredrickson, Thunder Road Resources and Vanelle Peterson, Dow AgroSciences

<u>Species Evaluated</u>

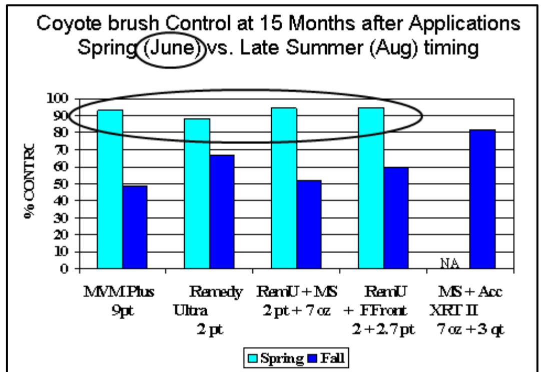
- Coyote Brush (*Baccharis pilaris*)
- Scotch Broom (*Cytisus scoparius*)
- Russian Thistle (*Salsola tragus*) and
- Common Field Mustard (*Sinapis arvensis*)

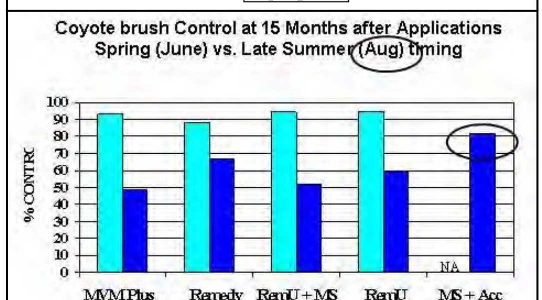
<u>Coyote Brush Trial</u>

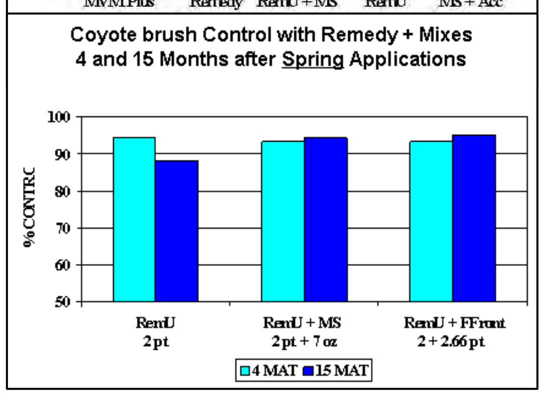
- Fort Bragg, Ca
- 2 Spray Timings
  - June 1, 2009
  - August 21, 2009
- 20 Gpa
- Broadcast Applications
- Milestone®, Milestone Vm Plus, Remedy® Ultra, Forefront® R&P, Accord® XRT II

<u>Conclusions</u>

1. Milestone VM Plus, Milestone + Remedy Ultra, and Remedy Ultra+ Forefront R&P provided excellent control in the Spring.
2. Spring timing better than late summer timing.
3. Addition of Milestone appears to suppress sprouting.
4. Late summer application of Milestone + Accord XRT II gave excellent control and appears to still be dying back.

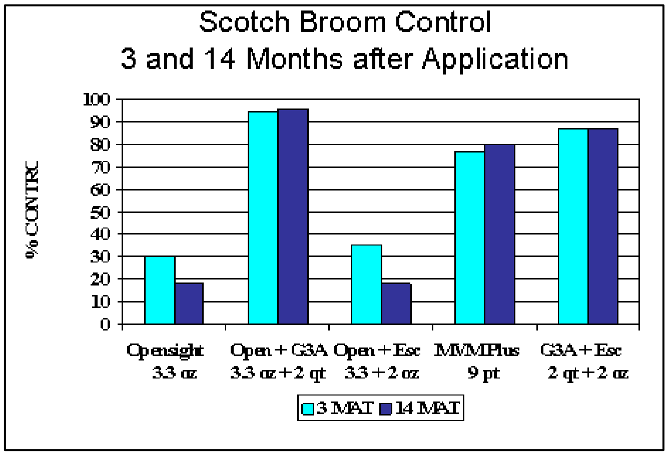


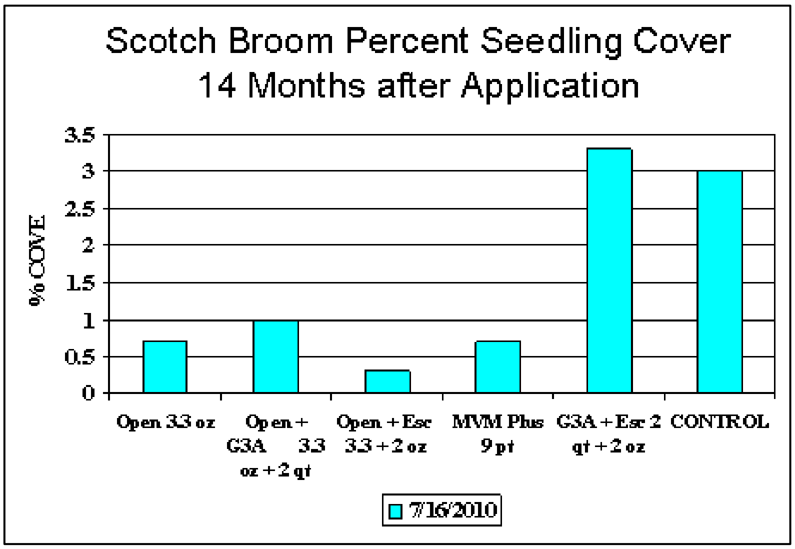




Scotch Broom Trial

- Round Mountain, CA
- 30 GPA
- Broadcast application
- Spray timing May, 15 2009
- Actively flowering when treated
- Opensight®, Milestone® Vm Plus, Escort, Garlon® 3A





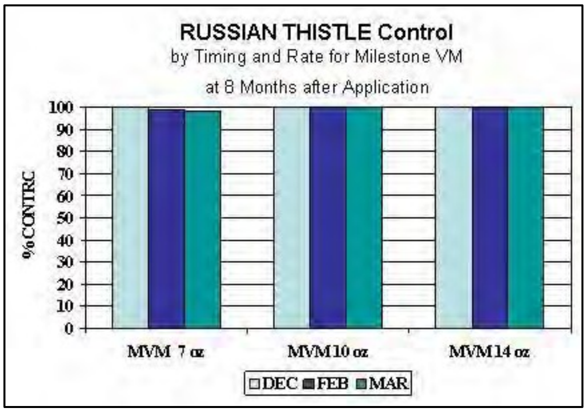
Conclusions

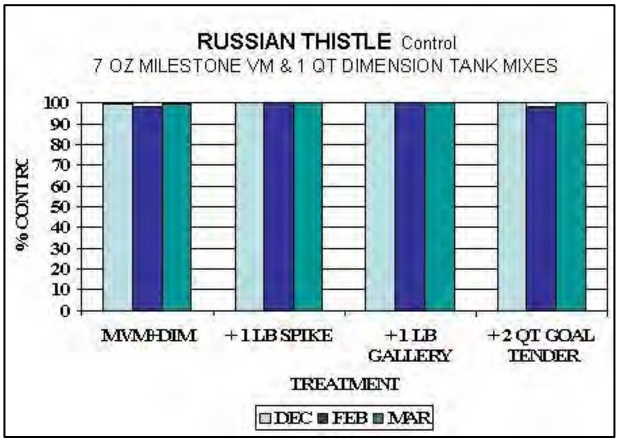
1. Best Treatment = Opensight + Garlon 3A

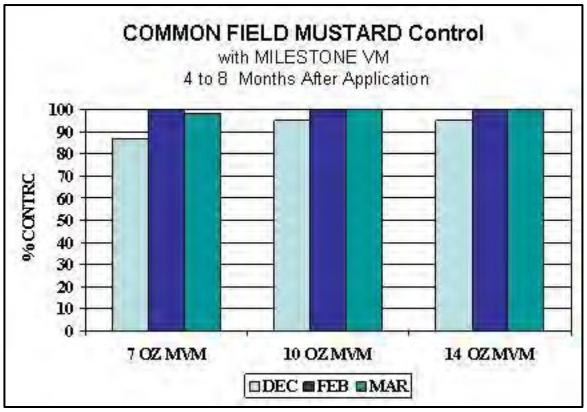
   Rate = 3.3 oz + 2 qts
2. Opensight alone is weak on Broom.
3. Control is significantly enhanced with the addition of Garlon 3A.
4. The addition of Milestone reduced seedling Broom germination.
5. Percent control was still increasing from 3 MAT to 14 MAT for treatments with Garlon 3A and decreasing for those without it.

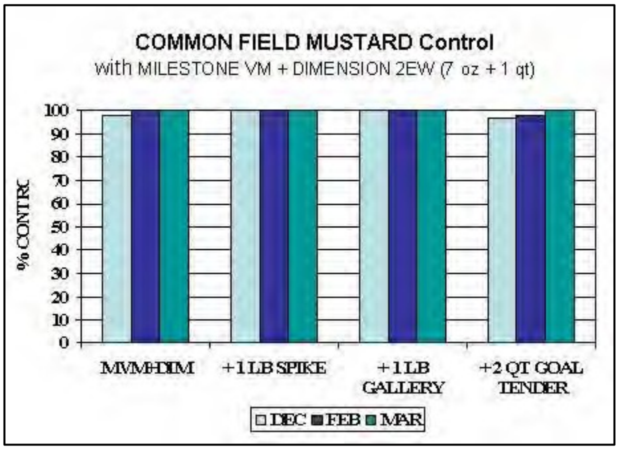
Russian Thistle and Common Field Mustard Trial

- Willows, CA
- Three spray timings: December, February and March
- 40 GPA
- Pre-emergent applications
- Broadcast
- Milestone® VM, Dimension® EW, GoalTender®, Oust, Telar, Spike® 80DF, Accord® XRT II, Gallery® 75DF, Payload
- All treatments include Accord XRT II at 2 qt/A









Conclusions

1. Overall Timing had little effect on efficacy

   Slight effect for Field Mustard and B.F. Trefoil with Milestone VM alone at the December timing.
2. Excellent control of Russian Thistle with all rates of Milestone VM
3. Addition of Dimension 2EW, Spike and Gallery to Milestone VM increased spectrum of activity and control.

Liverwort (*Marchanta polymorpha*) Biology and Recent Research Results

Cheryl A. Wilen, University of California Cooperative Extension and UC Statewide IPM Program. 5555 Overland Ave. Suite 4101, San Diego, CA 92123 cawilen@ucdavis.edu

Liverwort is a serious weed problem in ornamental plant production, particularly in greenhouses where plants are typically grown using excessive irrigation and nutrients. These lower order plants (bryophytes) spread rapidly in the greenhouse and can cover the media surface resulting in strong competition with the crop for water and nutrients. Small plants and liners cannot get good root development in upper part of media. This weed cover also impedes water from reaching the media thereby increasing runoff and water use. The presence of liverwort in the container reduces salability of crop and increases the chance that the weed will spread to other containers and other areas of the nursery. Liverworts growing on the media and greenhouse floors and under benches provide excellent habitat for fungus gnats and snails.

The plant does not have flowers, seeds, leaves, or roots. The flat green organ is the thallus or gametophyte. The single cell rhizoids act similarly to roots attaching the thallus to the soil. Liverwort can spread vegetatively and by spores. There are two alternate forms in its life cycle: a gametophytic stage and a sporophytic stage. In sexual reproduction, the gametophyte produces male and female structures that look like little palm trees (sporophytes). The female form will produce spores that are propelled into the air.

In vegetative reproduction, new plants are formed when older plant parts die at the fork of a branch of a thallus. Gametophytes also produce gemmae cups that hold gemmae, often described as looking like a nest with eggs. These gemmae can spread by water splash and produce new young plants vegetatively.

We recently completed a greenhouse study[1] examining several treatments for their pre- or post-emergent control of liverwort.

Treatments[2] in the test were:

Inoculated check (control)
Broadstar 0.25G (flumioxazine) @ 50lb/A
Ronstar 2G (oxadiazon) @ 100lb/A
Ground Mustard Seed Meal (MSM) @ 2090 and 4180 g/100ft^2
Freehand (dimethenamid-P + pendimethalin) @ 150lb/A

Eight replications were used. Treatments were applied to 4” pots that had young plants on the media surface (POE treatments) or applied after the pots were inoculated with a solution that contained a suspension of gemmae (PRE treatments). The experiments were conducted in a

[1] Funded by a grant from the California Nursery and Garden Centers
[2] Products in these tests were for experimental use only. Their mention anywhere in this document does not constitute a recommendation or endorsement.

greenhouse at the UC South Coast Research Center in Irvine, CA and irrigated twice daily with overhead sprinklers. Pots were evaluated 7, 14, 29, and 42 days after treatment (DAT).

Results

The MSM treatments were quickly infested by an unknown fungus that covered the media surface. The media remained covered with the fungus for at least 14DAT, with the higher rate lasting longer, in some cases up to 42DAT.

Nevertheless, the MSM treatments provided excellent liverwort control, superior to that of Broadstar and Ronstar in both PRE and POE tests (Figures 1 and 2). The higher rate of MSM continued to maintain excellent control for the duration of the study while the lower rate started to lose liverwort control after 4 weeks. Freehand also provided excellent PRE control of liverwort for the duration of the study. In the Freehand treated pots in the POE test, there was no reduction in liverwort cover from the time of application but they had approximately 85% less green liverwort cover than the inoculated check even 42DAT (Figure 2). That is, while Freehand did not completely control liverwort, it did inhibit the growth of liverwort in the pots such that it did not increase on coverage.

Currently, there are no selective herbicides registered for use in enclosed greenhouses. Freehand shows excellent potential and could be used in non-enclosed areas such as open nurseries and shade houses that are open on both ends. Additional work needs to be done examining MSM rates, timing of reapplication, and crop selectivity.

Figure 1. Percent green cover of liverwort as affected by preemergent treatment.

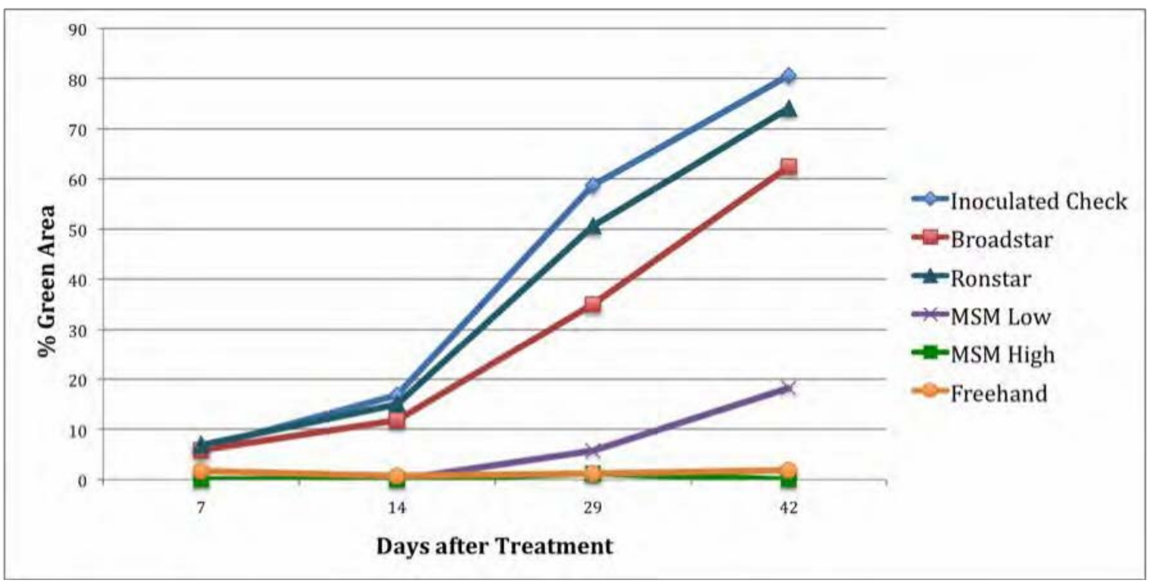
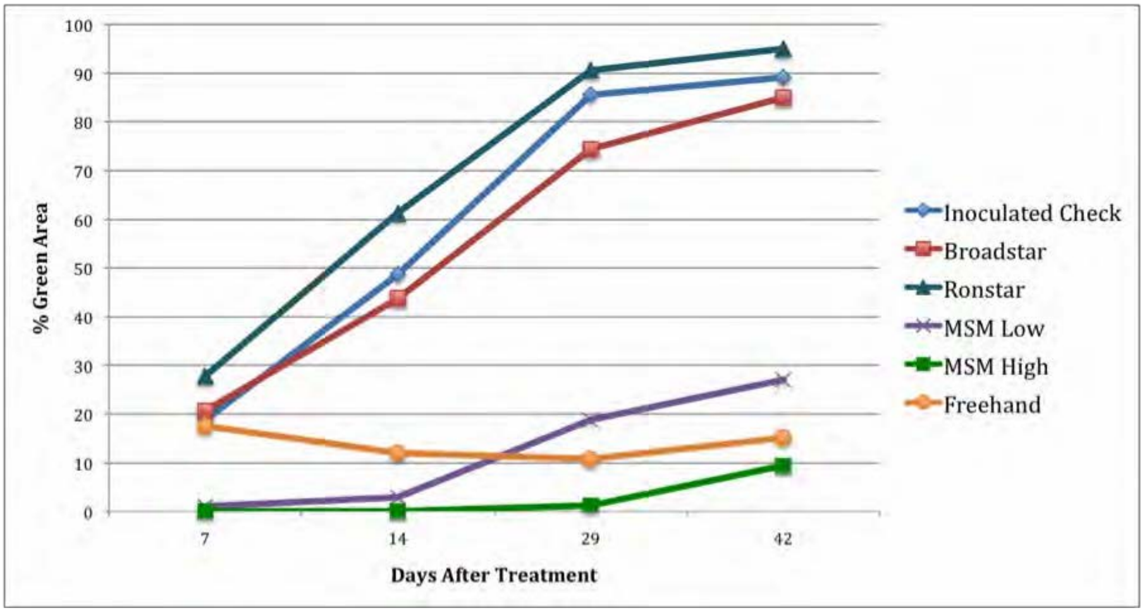


Figure 2. Percent green cover of liverwort as affected by postemergent treatment.



Post- and Pre-emergent Liverwort Control Trial

Steve Tjosvold and *Richard Smith*
University of California Cooperative Extension
Santa Cruz and Monterey Counties

Liverworts (*Marchantia* spp.) are non-vascular, primitive plants that form dense, matted, colonies (thalli) on the soil surface of containers in greenhouses and outdoor nursery stock. A mat of liverworts can impede water from overhead irrigations from entering the soil surface and sometimes liverworts can crowd slow growing ornamental crops. They are often a hard to manage nuisance. They spread by spores and are especially prolific in the cool, humid conditions of the central coast counties of California. This study was to test pre and post emergent applications of various conventional and biorational herbicides, and cocoa- shell mulch.

One gallon pots filled with Super Soil® potting mix were assembled on September 23 in the greenhouse at the UC Cooperative Extension greenhouse in Salinas, CA. Treatments included preemergent and post emergent applications of various materials (Table 1 and 2).

For pre-emergent treatments (Table 1), liverwort inoculum was prepared by blending 20 grams of liverwort thalli with 200 mls of buttermilk and 1 liter of water. All pots of pre-emergent treatments had 100 mls of this slurry added to them. They were then watered to settle the slurry and then the pre-emergent treatments were applied. In the case of the cocoa mulch treatments, the slurry was applied over the top of the mulch. The effectiveness of the treatments were determined by measuring the area of liverwort thalli that covered the pot surface 25 and 26 DAT.

For the post emergent treatments (Table 2), mature, heavily-matted, liverwort from infested propagation flats were cut into 2.5-inch diameter plugs and transplanted to 1-gallon pots on September 23 and post emergence materials were applied on October 7. In this two week period, new liverworts developed in the soil surrounding the transplanted plugs, apparently developing from gemmae that had splashed from the liverwort plug. The effectiveness of the treatments were evaluated separately on the mature plug and the young thalli by measuring the coverage of living (green) thalli 11 and 22 DAT.

The area of living (green) thalli was measured by photographing the pot surface, manipulating the color range of the image in Adobe Photoshop so that a lesion- area measurement software program (ASSESS, from the American Phytopathological Society) could be used to measure the area covered by the liverwort. All sprayed herbicides were applied at a rate of 72 gallons/acre. There were five replications of each treatment of 1-gallon pots and after the treatments were applied they were arranged in a randomized complete block design in a greenhouse bench covered with 40% shade cloth. The treated pots were misted three times per day for 2 minutes to provide a microclimate very favorable for liverwort growth.

Table 1: Pre-emergence Treatments

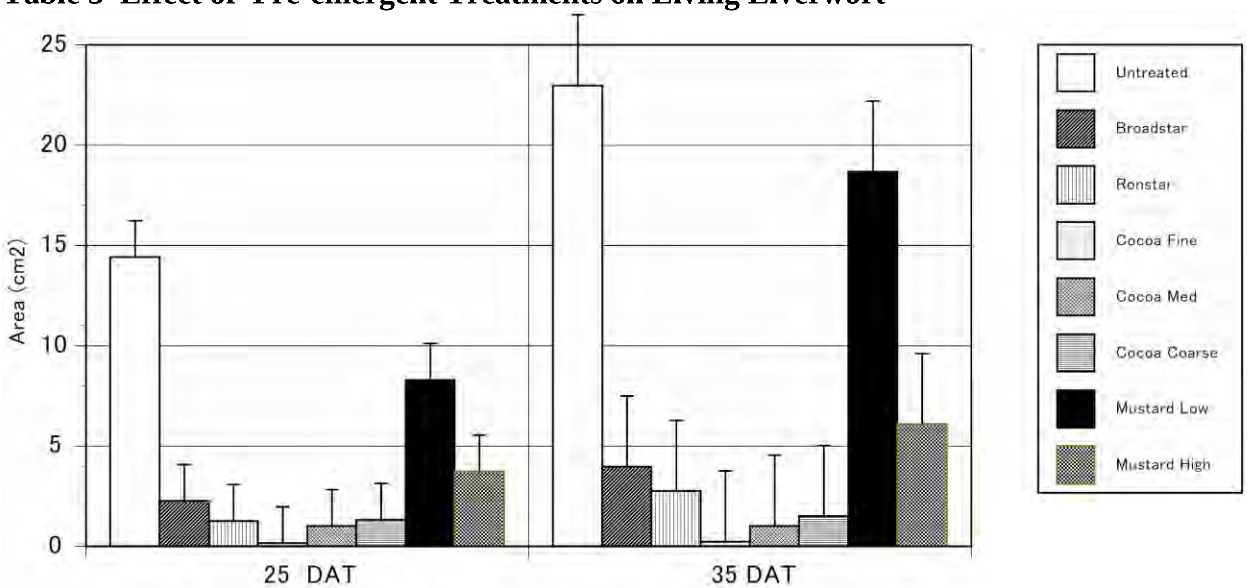
No.	Treatment	Manufacturer	A. I.	Rate	Liverwort Applied
1	Untreated			----	
2	Broadstar 0.25G	Valent Professional Products	flumioxazim	5.6 g / m^2	Before Treatment
3	Ronstar 50WSP	Bayer Environmental Science	oxadiazon	0.45 g / m^2	Before Treatment
4	Cocoa hulls – fine (2mm)	Bloomer Chocolate Company Chicago, IL		14.2 L / m^2 2 cm deep	After Treatment
5	Cocoa hulls – medium (4mm)			14.2 L / m^2	After Treatment
6	Cocoa hulls – coarse (8 mm)			14.2 L / m^2	After Treatment
7	Mustard seed meal – ground (2 mm)	MPT Mustard Products & Technologies Inc., Saskatoon, Canada		225 g / m^2	After Treatment
8	Mustard seed meal – ground (2 mm)			450 g / m^2	After Treatment

Table 2: Post-emergence Treatments

No.	Treatment	Manufacturer	Active Ing.	Rate Product / m^2	Comment
9	Untreated	----		----	
10	Mustard seed meal (2mm)	MPT Mustard Products & Technologies Inc., Saskatoon, Canada		225 g / m2	
11	Mustard seed meal (2mm)			450 g / m2	
12	Sporatec	Brandt Consolidated	botanical oils	1.15 ml / m^2	
13	Scythe	Gowan	pelargonic acid	4.41 ml / m^2	
14	Bryophyter	2% v/v	botanical oils	1.47 ml / m^2	
15	Shark 2EC	1.0 oz/A	carfentrazone	0.0075 ml / m^2	+ 0.25% Nonionic Surfactant
16	Weed Pharm	100% v/v	acetic acid	73.6 ml / m^2	

Cocoa mulch was the most effective in controlling liverwort germination, and there was a trend that the finer the mulch was more effective (Table 3). This was not expected because most mulches are most effective when they are coarse. Typically, coarse mulches dry out spores or seeds more effectively than finer mulches. Cocoa mulch may be working in a different way, perhaps leaching out toxic levels of a compound. Cocoa mulch is known to have very high levels of potassium and perhaps high levels of potassium are inhibitory to liverwort. Ronstar and Broadstar were moderately effective. MSM (mustard seed meal) at both rates provided uneven and a low level of control. The uneven and low control may have been result of the uneven application of either the inoculum or product. Perhaps the MSM was redistributed unevenly when the inoculum was applied overhead.

Table 3 Effect of Pre-emergent Treatments on Living Liverwort



MSM (low and high rates), Scythe, Bryophter, and Weed-Pharm completely killed all young liverworts, and the high rate of MSM completely killed all mature liverworts (Table 4 and 5). Sporatech and Shark were only moderately effective on young liverworts, and even less effective on mature liverworts.

There was no evaluation on plant tolerance in this study, so if the experimental products are used, insure that plant tolerances are first tested. For the registered products, consult the label for application information.

Table 4 Effect of Post-emergent Treatments on Living Young Liverwort

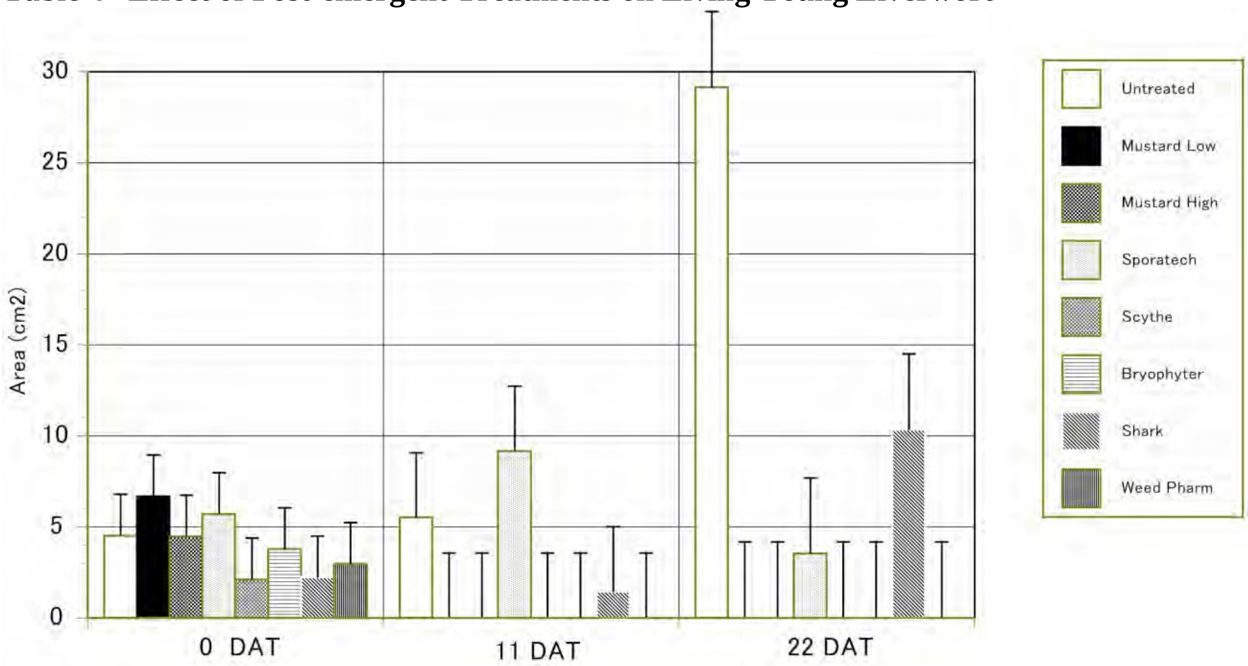
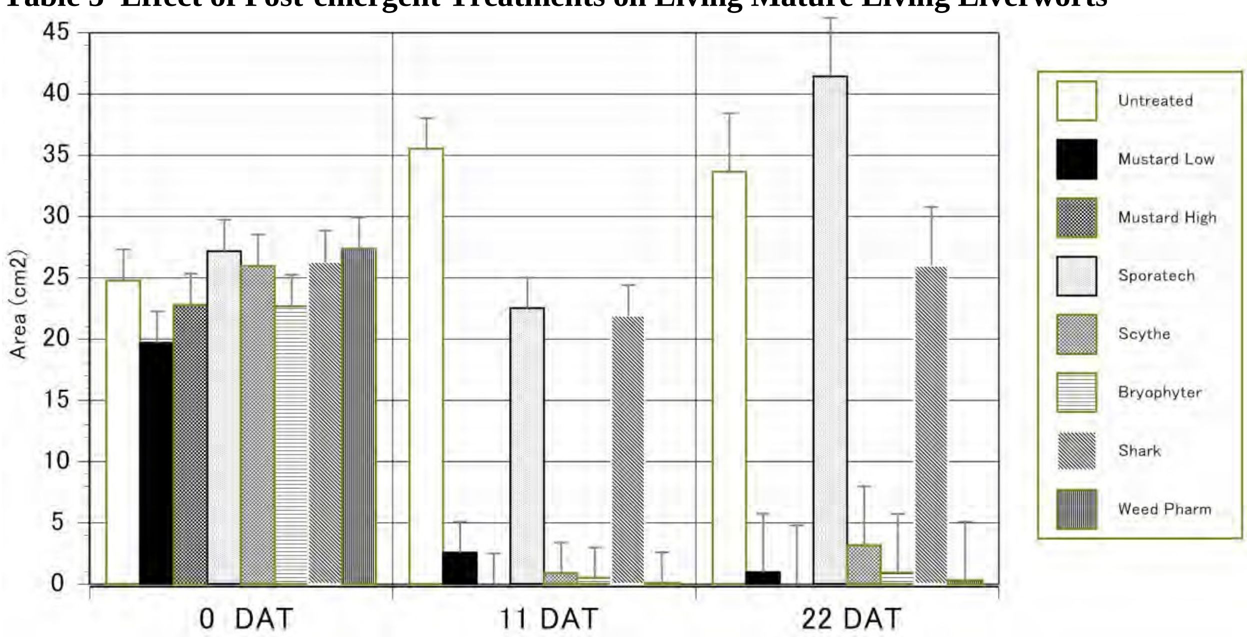


Table 5 Effect of Post-emergent Treatments on Living Mature Living Liverworts



Effects of Surface Seals on Fumigant Emissions and Pest Control

B.D. Hanson[1,2], S. Gao[2], J.S. Gerik[2], R. Qin[1,2], J. McDonald[2], and D. Wang[2]
[1]University of California, Davis and [2]USDA-ARS, Parlier, CA

Pre-plant fumigation with methyl bromide has been used for control of soil borne pests in many high value annual, perennial and nursery crops but is being phased out under the provisions of the US Clean Air Act and Montreal Protocol. Currently, 1,3-dichloropropene (1,3-D) is the only registered alternative fumigant that meets California nursery certification standards; however, this fumigant is under increasing regulatory scrutiny due to its release of volatile organic compounds (VOC). As part of a larger project, two trials were conducted to simultaneously evaluate the effects of surface treatments and two application shanks on 1,3-D emissions and soil borne pest control.

In this well-prepared field, nematodes (in a citrus nematode bioassay) were well controlled with all 1,3-D treatments regardless of application shank or surface seal technique. Pathogen control varied slightly among treatments but tended to be best with HDPE and VIF film and with a metam sodium sequential treatment. Similarly, weed control was usually slightly better in those plots sealed with either HDPE or VIF film or followed with metam sodium. Weed control efficacy with 1,3-D was reduced by intermittent water seals and the dual application technique.

There were no emission differences between the conventional shank and the Buessing shank application technique in this trial. Bare soil treatments (no film or water seal) had the earliest and highest emission flux and the highest cumulative emission (42% of the total). Intermittent water seals after fumigation delayed the peak emission flux but did not greatly reduce the peak; however, water seals did reduce cumulative 1,3-D emission to about 34% of the total applied. The conventional HDPE film reduced peak emission flux by 3-fold and cumulative 1,3-D emission by 50% compared to the bare soil plots. During the 10 d evaluation period, VIF film reduced emission flux approximately 10-fold compared to the HDPE film and reduced cumulative emission to less than 2% of the amount applied. However, results of a related study suggested that the highly retentive films such as VIF or TIF may retain fumigants so well that a surge in emissions will be observed when the film is cut for removal or planting holes. More work is ongoing to develop application techniques and timing to resolve the surging emission issue.

Tower Herbicide—New Herbicide Chemistry for Ornamentals

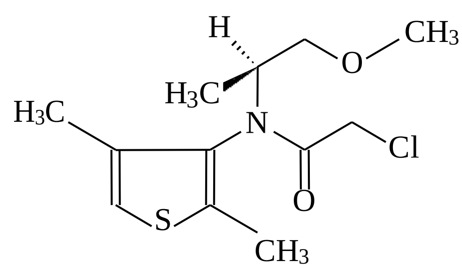
Todd Burkdoll, Turf and Ornamentals Market Development Specialist, BASF Corporation
James.burkdoll@basf.com   Email: 559-906-4641

Product Information
Pending registration in CA - ***Expected mid to late summer 2011***

- New active ingredient, broad-spectrum preemergence herbicide, for ornamentals - ***dimethenamid-p.***
- Spectrum of activity---
- Controls small-seeded broadleaf weeds, including emerging problem weed species like doveweed, eclipta, groundsel and liverwort
- Controls numerous grassy weeds and several sedges including yellow nutsedge
- Applied as a directed spray in field-grown nursery stock, landscapes and non-crop areas.
- Can be tank-mixed with Pendulum® AquaCap™ or other DNA herbicides for broader preemergence weed control

Dimethenamid-P: BAS 656H an Introduction

- **Toxicological Properties:** tech
  - Oral LD 50 rat: 1570 mg/kg
  - Dermal LD 50 rabbit: > 2000 mg/kg
  - Skin irritation (rabbit): slight
  - Eye irritation (rabbit): moderate
  - Teratogenicity: negative
  - Mutagenicity: Ames test negative
  - Reproductive: no adverse effects



Product Chemistry

- **Active Ingredient:** dimethenamid-p
- **Chemical Family:** chloroacetamide (Group 15)
- **Mode of Action:** Interferes with cell development
- **Behavior in Plants:** Inhibits seedling shoots, does not move readily in the plant
- **Control Symptoms:** Coleoptile growth is inhibited and emerged shoots are deformed
- **Half life** in soil 21-28 days

Tower Standard Information

- **Formulation:** 6.0 lb ai/gal EC (liquid)
- **Tank Mixing:** Can be tank mixed with Pendulum® AquaCap™, simazine, glyphosate, and other pre- and post-emergence herbicides (consult specific labels for uses and restrictions)
- **Reentry Interval:** 12 hours for agricultural workers

- **Caution Signal Word:** Warning

Application Timing

- Apply as a directed spray-application to the base of ornamental plants as pre emergent to weeds
- Do not apply to newly transplanted seedlings until plants have been watered and soil has settled and packed around root system
- Do not make applications at bud break, bud swell or at the first flush of new growth

Weeds Controlled by Tower Herbicide

Annual bluegrass	Hairy bittercress	Pigweeds
Barnyardgrass	Henbit	Ryegrass
Carpetweed	Fall panicum	**Sedges, annual &Yellow**
Chickweed	Florida pusley	Shepherdspurse
Crabgrass	Field sandbur	**Spurge spp.**
Dogfennel	**Fireweed (Am burnweed)**	Willowherb
Doveweed	Foxtails	Woodsorrel (Oxalis spp.)
Eclipta	**Kyllinga spp.**	
Goosegrass	Nightshades	

Use Sites

- Field Grown Nurseries
- Christmas Tree Plantations
- Landscape or Grounds Maintenance
- Mulch beds
- Ornamental Bulb production
- Noncrop Areas
- Jogging and Bike Trails
- Parking Lots
- Fence Lines
- Highway Rights-of-Way
- Golf Course Turf

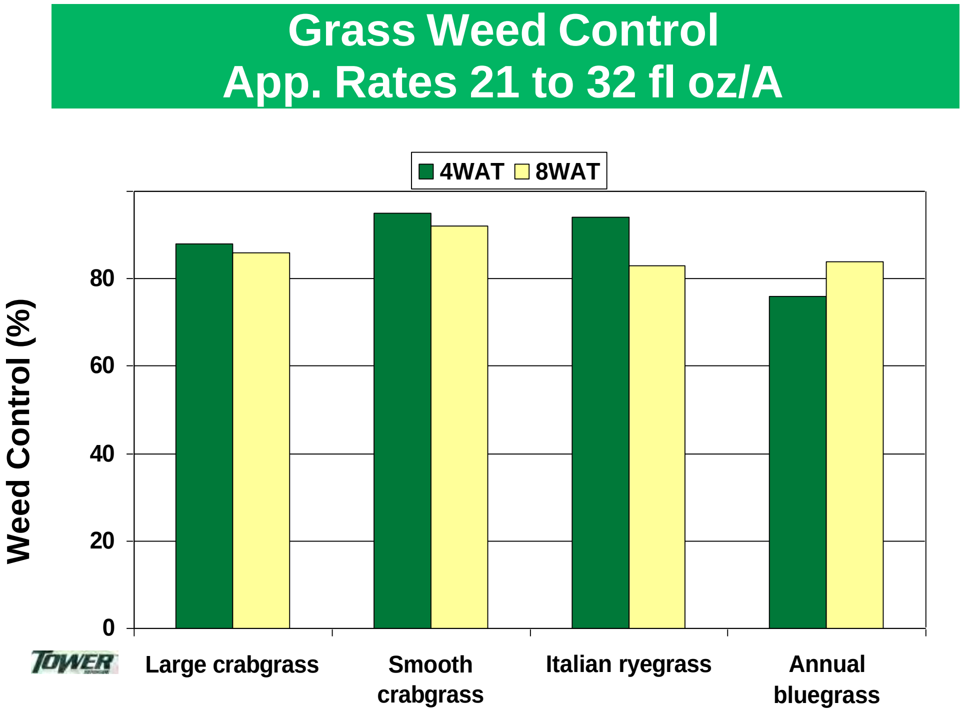
Ornamental Crops Tolerant to Tower Directed Sprays

- Red ash
- White cedar
- Crape myrtle
- Douglas Fir*
- Fraser Fir
- Southern Magnolia
- Red maple
- Western redcedar
- Azalea
- Boxwood
- Holly spp.
- Hydrangea
- Juniper
- Rhododendron
- RoseSpirea
- Yew

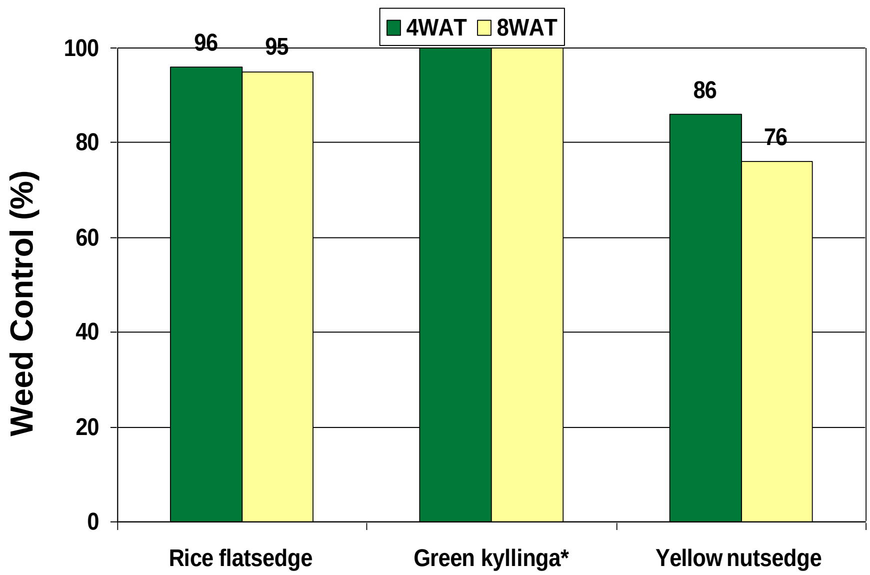
Key Features

- Excellent control of small seeded broadleaf weeds, including troublesome, new weed problems
- Controls yellow nutsedge more effectively that any available product
- Provides unsurpassed weed control when tank mixed with Pendulum AquaCap

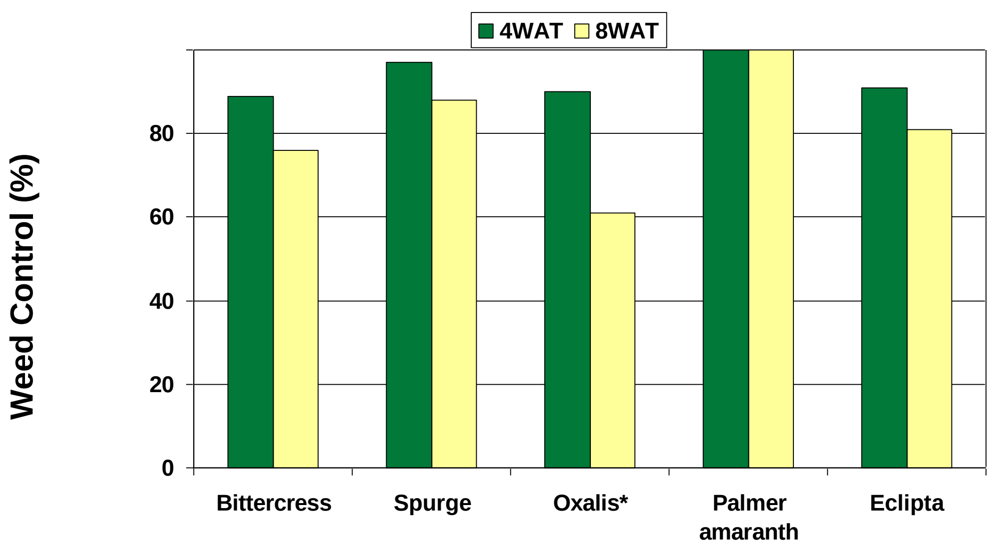
Tower Herbicide for broader spectrum Weed Control in Ornamentals and GC turf.
Pending registration in CA (*Expected mid to late summer 2011)*



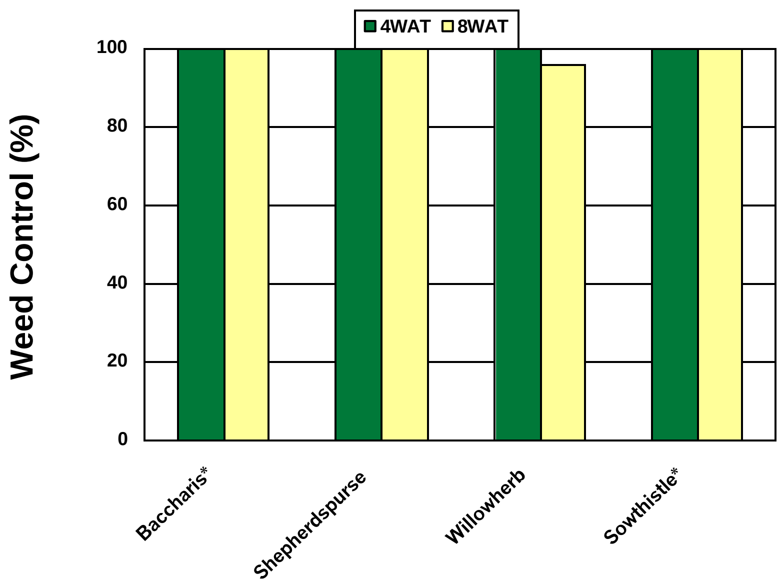
Sedge Weed Control (cont.)
App. Rates 32 fl oz/A



Broadleaf Weed Control
App. Rates 21 to 32 fl oz/A



Broadleaf Weed Control (cont.)
App. Rates 21 to 32 fl oz/A

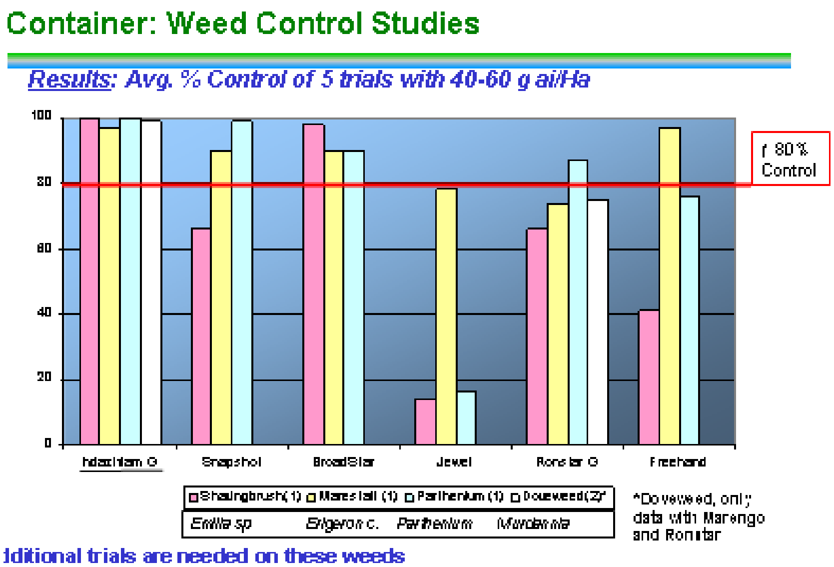

4WAT
8WAT
Weed Control (%)
100
80
60
40
20
0
Baccharis*
Shepherdspurse
Willowherb
Sowthistle*

Weed Control and Ornamental Tolerance with Indaziflam

Don Myers and Astrid Parker, Bayer Crop Science, 2 T. W. Alexander Drive
Research Triangle Park, NC 27709   don.myers@bayer.com, astrid.parker@bayer.com

Indaziflam is a new cellulose biosynthesis inhibitor (CBI) under development by Bayer Environmental Science for broadspectrum pre-emergent weed control. Indaziflam is classified as an alkylazine herbicide in WSSA group 29. It works by inhibiting crystalline cellulose deposition in the cell wall which affects cell wall formation, cell elongation and division; thus, only actively growing meristematic regions of roots and shoots of emerging weed seeds are affected.

Since 2008, indaziflam has been tested for weed control and plant tolerance in container ornamentals and around field grown nursery trees. To evaluate weed control in container ornamentals, multiple rates of indaziflam G were tested in various potting mixes. Indaziflam G was watered in following the application and weed seeds were surface-sown one to three days later. At rates of 40-60 g ai/ha, indaziflam G provided excellent weed control for 3-5 months against a large variety of weeds, including hard-to-control weeds such as Eclipta (*Eclipta alba),* prostate spurge (*Euphorbia maculata)* and common groundsel (*Senecio vulgaris).*



Ornamental tolerance studies were done by applying indaziflam G over-the-top, at rates ranging from 30-160 g ai/Ha, to mature liners transplanted into 1-3 gallon size containers. A second application was made two months later. Plant quality and marketability assessments were made throughout the studies; root quality was evaluated at the end of the studies. To date, 109 plant species/ cultivars have been tested and 40-60 g ai/Ha was safe on 100% of the conifers, 83% of woody ornamentals, 75% of herbaceous ornamentals, and on 70% of the ornamental grasses.

Indaziflam 20 WP, at 40-80 g ai/Ha, provided above 90% weed control around field grown nursery trees. Perennial weeds emerging from rhizomes or roots, such as nutsedge (*Cyperus* sp.) or encroaching bermudagrass (*Cynodon dactylon),* were not controlled. Trees were about 3 years old and 5-6 feet tall; injury to trees was not observed.

Going forward, additional efficacy and tolerance studies will be conducted.

Weed Shifts in North Coast Grapes Due to Changing Weed Control Practices

John A. Roncoroni UCCE Weed Science Farm Advisor, Napa
Email : jaroncoroni@ucdavis.edu

Weed control practices in North Coast Vineyards, particularly those in Napa County have change in the last 20 years. Many vineyards have adopted ‘no-till’ or minimum tillage practices for weed control within the vineyard. Changing from tillage using herbicide under the vine has changed the weed composition. The herbicides used in that 20 year period have also changed. Some new herbicides have been registered for use in grapes. The biggest change in herbicide use is the shift by some managers to using postemergent herbicides exclusively.

We really don’t have any new weeds in the vineyard, but there has been a shift in their occurrence and density. The ‘old’ weeds: Filaree, Prickly Lettuce, Sowthistle, Mustards, Wild Carrot, Chickweed, Annual Bluegrass, and Wild Oats are still around and important problems in many vineyards. The ‘new’ weeds: Filaree continues to be a serious weed problem and is now joined by Sharpoint Fluvellin, Horseweed, Panicle Willowherb, and Hairy Fleabane that have been around in fairly low numbers for years. Hairy Fleabane is not a problem in vineyards in the North Coast, yet. It is now found on roadsides and in areas outside of and around the vineyard, but has the potential to move into the vineyard and become a very serious problem.

The characteristics that these new weeds share is that they are not well controlled by glyphosate (Roundup). The exception is Sharpoint fluvellin. Fluvellin is controlled by glyphosate but grows at times in the North Coast when glyphosate is not normally used. Germination is in mid-to- late summer, and continuing into the fall when vines are most susceptible to glyphosate drift.

The practice of ‘RoundUp’ only has gained popularity because of the relatively low cost of glyphosate products and a reduction in cultivation because of high cost and increased erosion potential. Many growers have chosen not to use pre-emergence herbicide because of the threat of off-site movement. Many growers are now re-evaluating their weed control practices to control these new weeds.

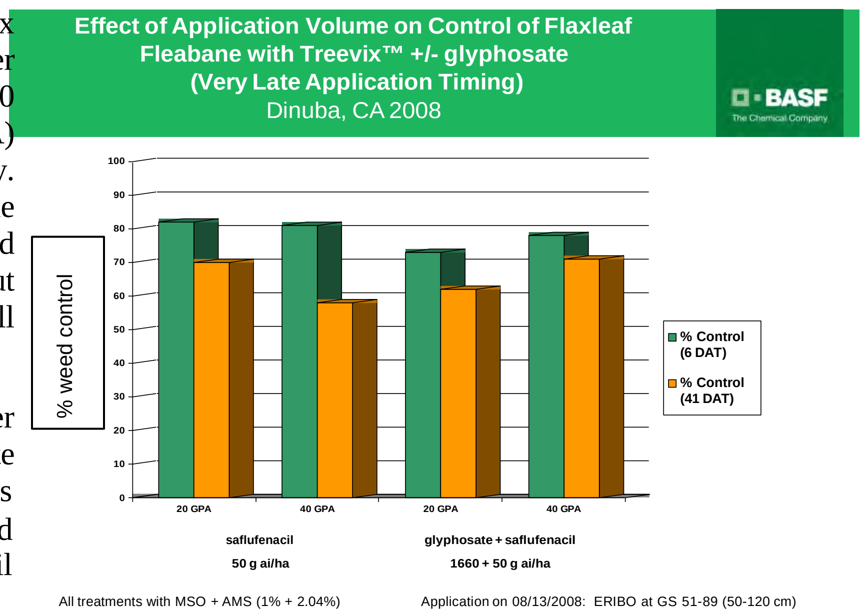
Efficacy of Treevix in Citrus and Tree Nut Crops

Curtis R. Rainbolt, BASF Corporation, Fresno, CA curtis.rainbolt@basf.com

Treevix herbicide was recently registered in California for weed control in citrus, almonds, pistachios, and walnuts. The active ingredient in Treevix, is saflufenacil (Kixor). Saflufenacil is a protoporphyrinogen-IX-oxidase (PPO) inhibitor belonging to the pyrimidinedione class of chemistry. Treevix provides postemergence burndown control of many key weeds including marestail, fleabane, cheeseweed, willowherb, sowthistle, and others. Because Treevix does not have grass activity it should be tankmixed with an herbicide that has grass activity.

Factors that influence efficacy with Treevix include weed size, carrier volume, and adjuvant selection.

- Similar to many burndown herbicides, Treevix herbicide works best on small weeds. Field trials have shown that 3 to 6 weeks after application control of flaxleaf fleabane that is less than 6 inches tall is 97% compared to only 82% when the fleabane is taller than 6 inches.
- When applying Treevix increasing the carrier volume from 5 to 20 gallons per acre (GPA) also improved efficacy. Increasing carrier volume from 20 to 40 GPA did not decrease efficacy, but did not improve it in all situations.
- Adjuvant trials over multiple years indicate that Treevix efficacy is greatest when com-bined with methylated seed oil (MSO).

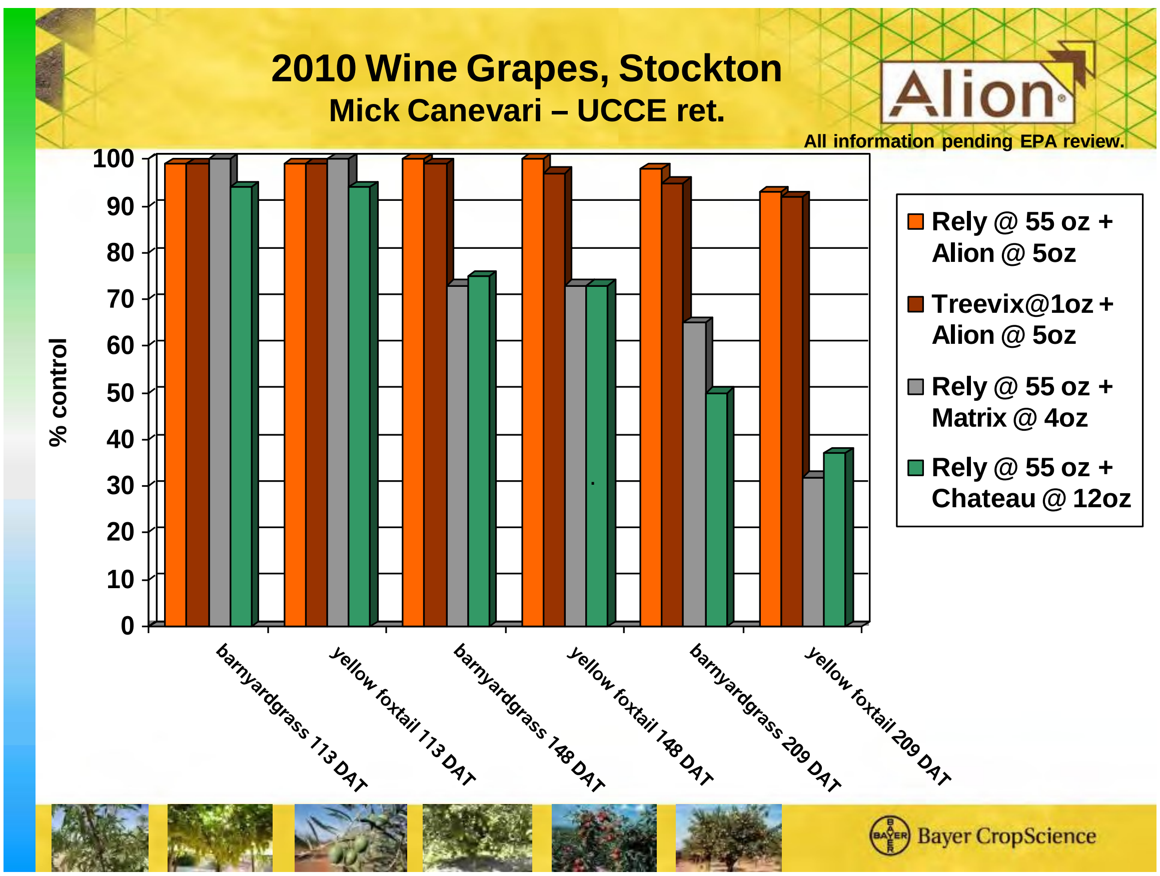


In summary, Treevix herbicide can provide excellent burndown control of broadleaf weeds when weeds are smaller than 6 inches, carrier volume is 20 GPA or greater, and MSO and AMS are used as adjuvants.

Indaziflam: A New Pre-emergent Herbicide for Residual Control in TNV Crops

Ryan Allen, Bayer CropScience, Roseville, CA.

Indaziflam, a new active ingredient from Bayer CropScience, has proven in numerous field efficacy studies to provide long-lasting residual control of many important broadleaf and grass weed species when applied preemergence. Indaziflam is a cellulose biosynthesis inhibitor, and classified by HRAC and WSSA as a group L and group 29 herbicide, respectively. Numerous rates and application timings of Indaziflam have been evaluated by University, private, and Bayer CropScience researchers, with the results confirming its broad spectrum and longevity of control. The results of these trials have also demonstrated the ability of Indaziflam to readily tank mix with most common adjuvants and herbicides. One application of Indaziflam at 73 g ai/ha (5 oz/A) can be expected to effectively control a wide range of broadleaf and grass weeds for up to 6 months, although control lasting much longer has been observed in some studies. Indaziflam will be sold as Alion™ in the TNV market upon EPA registration, which is currently anticipated in 2011.



Weed Management in Organic Vineyards and Orchards

Anil Shrestha[1], Marcelo L. Moretti[1], Kaan Kurtural[1], and Matthew Fidelibus[2].
[1]California State University, Fresno, CA 93740
[2]University of California, Kearney Agricultural Center, Parlier, CA 93648

Weed management in organic vineyards and orchards is a challenge due to the lack of registered herbicides that are available for use. Thus, growers usually have to rely on alternate tools for weed management in organic orchards and vineyards.

These tools include mechanical and thermal weed control methods, to name a few. Mechanical and thermal (flaming in particular) tools can generate dust and smoke and this can have implications associated with air quality regulations in the San Joaquin Valley (SJV).

There are a few new postemergence broad-spectrum herbicides labeled for use in organic systems. Similarly, there are new non-chemical weed control machines being designed. However, the efficacy and economics of these new tools have not been tested adequately in field studies.

Therefore, on-farm studies were conducted in 2010 in a transition-organic almond orchard at California State University, Fresno, a commercial organic raisin grape vineyard, in Selma, and in a commercial organic winegrape vineyard in Madera comparing several organic weed management options.

Treatments included

- steam (Batchen Stinger ®),
- flame (orchard only),
- French plow (raisin vineyard only),
- Bezzerides cultivator (vineyards only),
- and organic herbicides Greenmatch® (all sites), and Burnout® (orchard only).

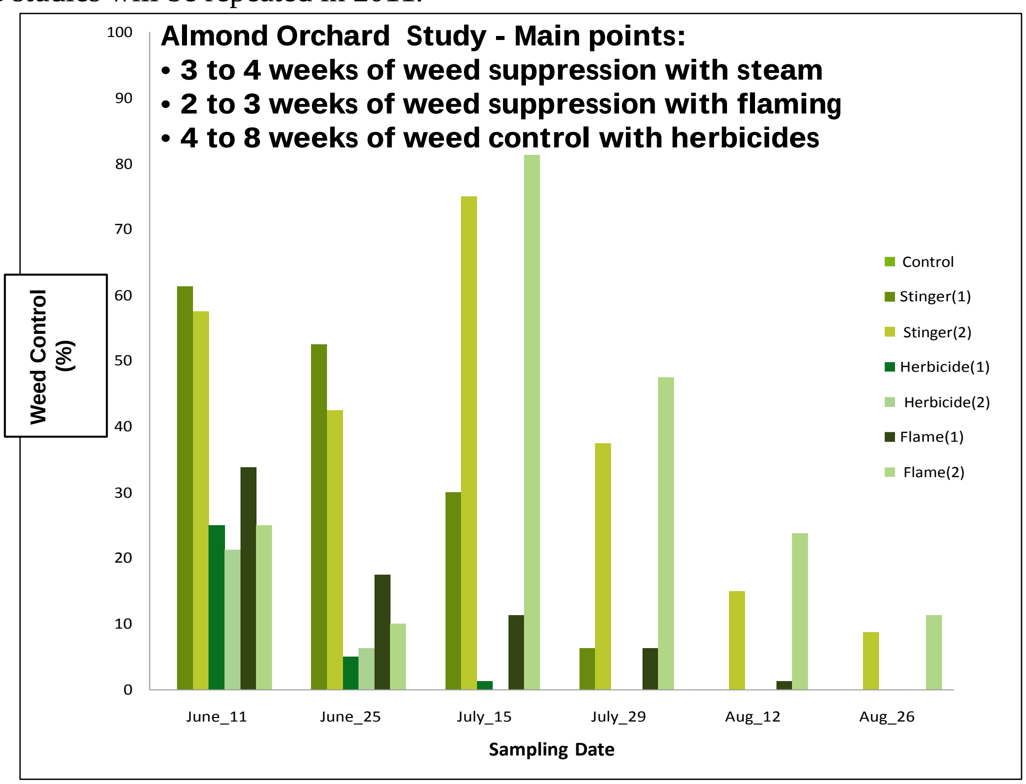
Non-treated control plots were also included at each site. The experimental design was a randomized complete block in the orchards and a split-plot in the vineyards. Each study site had four replicates of each treatment combination.

Weed densities by species, weed biomass, and visual estimates of percent weed control compared to the non-treated control were taken. In the vineyards, time required for hand weeding a month after the initial treatments were applied, and crop yield and quality parameters were also assessed. Yields were not taken for almond as it was a young non-bearing orchard.

In the almond orchard study, the steam treatment provided 3-4 weeks of weed suppression, flaming provided 2-3 weeks of weed suppression while the organic herbicides provided 4-8 weeks of weed suppression. The control with steam, flame, and organic herbicides was better when the weeds were at the seedling or early growth stages. The results were also affected by the type of weed species. For example, none of the treatments were effective against certain species such as puncturevine (*Tribulus terrestris*) and cut-leaf evening primrose (*Oenothera laciniata*), although some suppression was observed at earlier growth stages of these weeds. The *Conyza* sp. (horseweed and hairy fleabane) generally regrew soon after the thermal treatments. Therefore, monthly or bi-monthly applications of these treatments will be necessary depending on the regrowth of the weeds. It may not be safe to use a flamer in the orchards after early spring because of fire hazards in an arid environment such as that in the SJV.

In the vineyard studies, steam was less effective in the raisin vineyard but more effective in winegrape vineyards because, at the time of the treatment application, of weeds in the raisin vineyards were larger, at a later growth stage, and consisted of different weed species than weeds in the winegrape vineyard. As in the almond orchard, weed suppression by steam was limited to 2-3 weeks. Steam was not effective on nutsedge (*Cyperus* sp.). The organic herbicide provided selective bundown of certain broad-leaved weed species such as shepherd's purse (*Capsella bursa-pastoris*) but had no effect on nutsedge and other grasses. The mechanical weed control treatments (French plow and Bezzerides cultivator) provided the greatest amount of weed control (>90% control for almost 3 months). However, there may be disadvantages associated with mechanical weed control because of the soil disturbance process. For example, root injury was observed with the French plow. The mechanical treatments reduced hand weeding time by about 70% compared to the non-treated control. The steam and herbicide did not reduce hand weeding time. No effect of any of the treatments was observed in grape yield and quality.

The studies will be repeated in 2011.



Tangent™ and Pindar™ GT Herbicides for Weed Control in Tree Crops*

James P. Mueller, Dow AgroSciences, Brentwood, CA. jpmueller@dow.com

Pindar GT Herbicide (oxyfluorfen plus penoxsulam) combines two herbicidal modes of action into one product. Oxyfluorfen is a PPO (protoporphyrinogen oxidase) inhibitor in HRAC mode of action group E. For many years, it has been the standard for residual weed control in tree crops. Penoxsulam is a potent ALS (acetolactate synthase) inhibitor in HRAC group B. It provides extended residual weed control for tree crop orchards at 17.5 to 35 grams active ingredient per hectare (0.016 to 0.032 lb a.i./acre). This combination provides broad spectrum and long lasting pre-emergence and post-emergence control of difficult to control broadleaf weeds and some major grass species. Pindar GT controls weeds which are resistant to other herbicide classes, and is now registered for use in US tree nut orchards.

Tangent is an SC (suspension concentrate) formulation containing penoxsulam at 240 g/L (2 lb/gal). Like Pindar GT, Tangent is effective on a wide range of broadleaf and grass weeds. Tangent registration for tree nuts is expected in 2011. Its fit in tree crop herbicide programs is now being defined. As Tangent research currently is in progress, it will be reported next year.

More than 100 weed control efficacy trials were conducted with Pindar GT from 2004 through 2010 in US tree nuts and in open fields. These replicated experiments involved pre-emergence and early post-emergence application during tree dormancy (December through February). Based on this extensive research under a wide range of conditions, Pindar GT is known to control the most difficult broadleaf weeds infesting tree nuts: hairy fleabane (*Conyza bonariensis*), horseweed (*Conyza canadensis*), filarees (*Erodium* species) and mallows (*Malva* species). Pindar GT also controls at least 60 other weed species, including most broadleaf weeds of importance to tree nut growers. It also controls some of the major grass weeds, such as barnyardgrass (*Echinochloa crus-galli*), bromegrasses (*Bromus* species), large crabgrass (*Digitaria sanguinalis*), wild barley (*Hordeum leporinum*), wild oat (*Avena fatua*), annual bluegrass (*Poa annua*) and witchgrass (*Panicum capillare*).

From 2004 through 2010, a large and thorough research project was conducted to document the safety of Pindar GT to tree nut crops. In addition to the efficacy trials described above, Pindar GT was tested in 37 crop safety trials in all major tree nut production areas. Many of these sites received three years of consecutive applications at up to four times the maximum label rate. Tree growth, tree vigor and crop yield were assessed. Pindar GT was shown to be safe to bearing and non-bearing tree nuts when used according to label directions.

To validate these research results under commercial use conditions, Pindar GT was compared to grower standard programs in 23 large scale demonstration trials in tree nuts. Treatments were applied in the winter 2009 – 2010 dormant period in the San Joaquin and Sacramento Valleys of California. Demonstration trial participants used Pindar GT in one spray tank load and treated the rest of the orchard with flumioxazin (Chateau®) and/or rimsulfuron (Matrix® FNV) herbicides. Demonstration trial participants chose the spray adjuvant, a contact ("burndown") herbicide and a grass control product. Data collected were percent control compared to a nearby untreated area within the orchard.

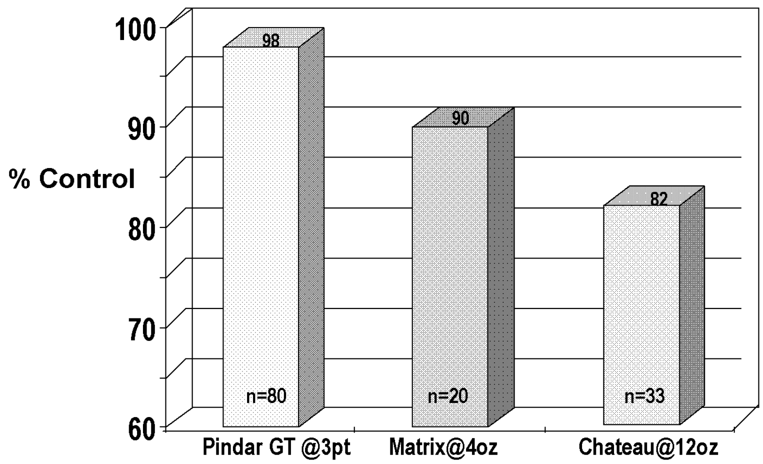
The relatively high rainfall amounts which occurred in 2010 provided a challenge for residual herbicide programs. Pindar GT was shown to deliver consistent weed control across a wide range of weed species, soil types and rainfall levels. In most trials, Pindar GT performed better than the standard residual herbicide program used by the growers. Pindar GT provided four to six months control of the major broadleaf weed species infesting tree nut orchards in California, including glyphosate - tolerant populations of *Conyza* (fleabane, horseweed). No crop safety, tank mixing or tank clean out issues occurred with Pindar GT during this commercial validation project.

Based on over 100 replicated research trials and 23 large scale demonstration trials, Pindar GT performance is consistent across soil types, geography and weather conditions. The high rate provides four to six months of residual weed control. The broad weed control spectrum and pre- and post-emergence activity of Pindar GT was illustrated in these research projects. The two modes of herbicidal action in Pindar GT will be valuable for weed resistance management. An extensive crop safety research program illustrated that Pindar GT has excellent crop safety when used according to label directions.

* The author would like to thank the many cooperators and co-workers who contributed to this project, especially Barat Bisabri, Marc Fisher, Rick Mann, Jesse Richardson Debbie Shatley, Monica Sorribas and Jagadeesh Yerneni.

Summary across trials: fleabane (*Conzya bonariensis*)

*Fleabane control 6 months after application**



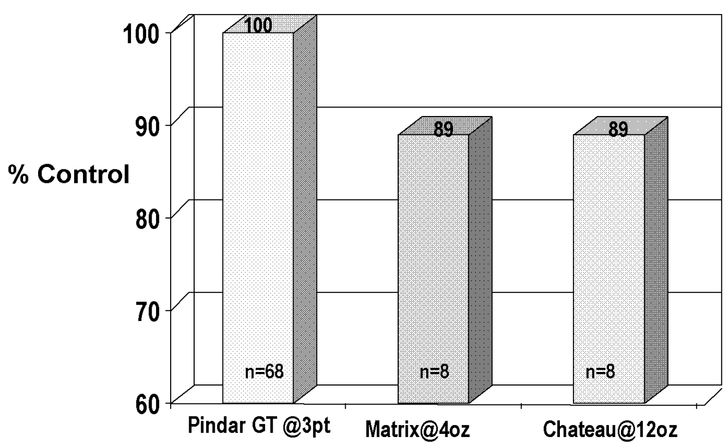
* n=number of observations

All treatments included glyphosate at 1.5 lb a.e./acre.

Summary across trials: horseweed (C*onyza canadensis*)

including glyphosate-tolerant populations

*Horseweed control 6 months after application**

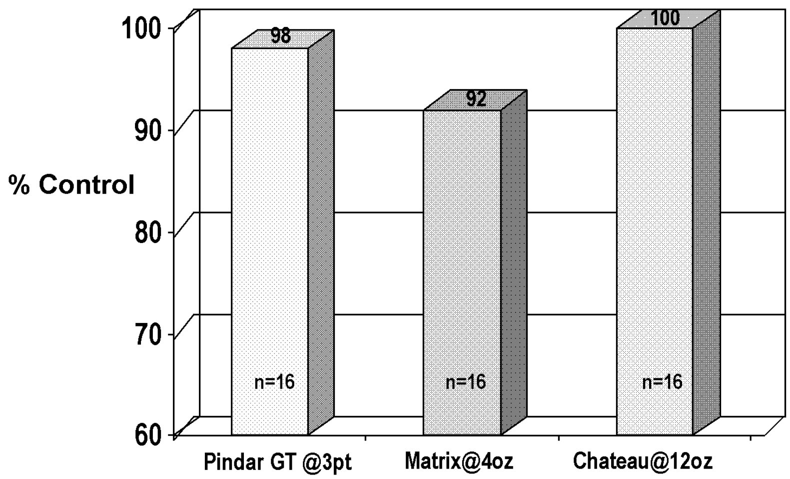


* n=number of observations

All treatments included glyphosate at 1.5 lb a.e./acre.

Summary across trials: filarees (*Erodium* species)

*Filaree control 6 months after application**

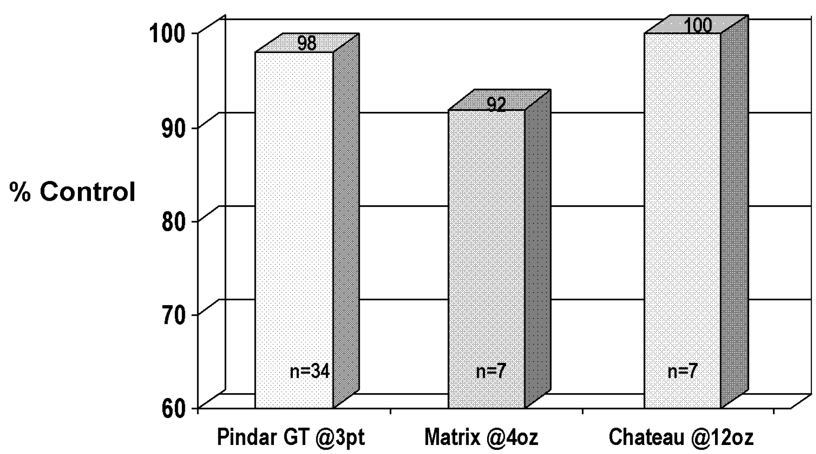


* n=number of observations

All treatments included glyphosate at 1.5 lb a.e./acre.

Summary across trials: *Malva* species

*Malva control 6 months after application**

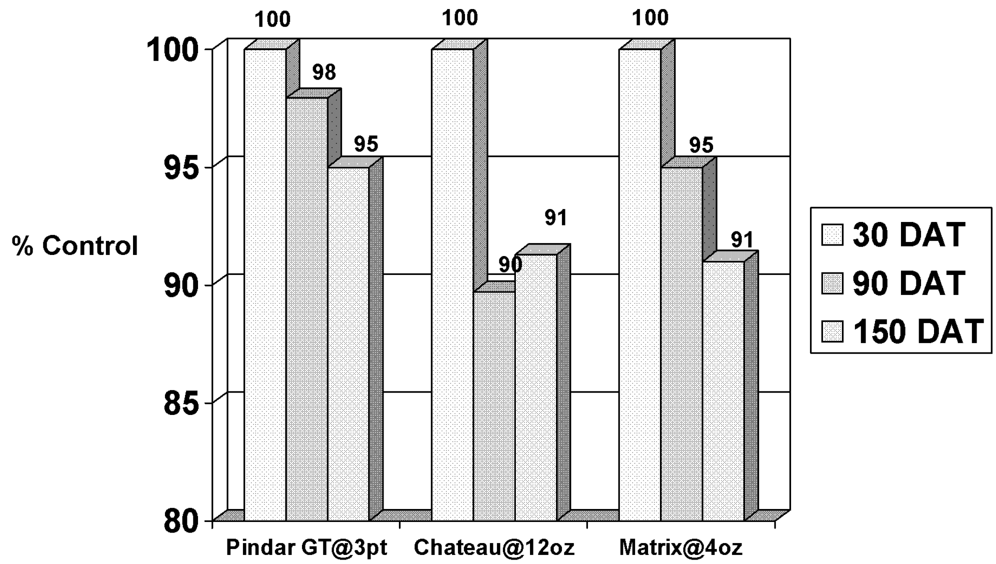


* n=number of observations

All treatments included glyphosate at 1.5 lb a.e./acre.

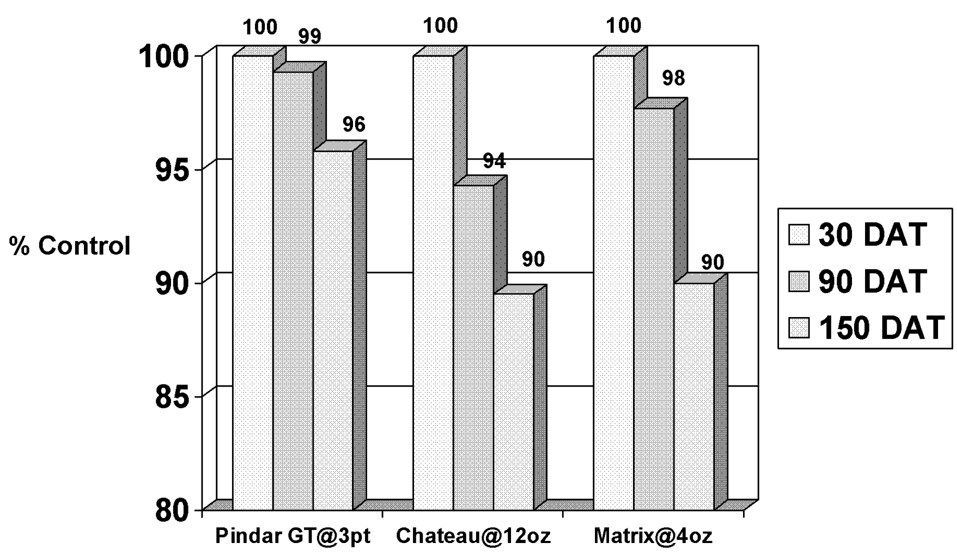
Pindar GT demonstration trials in tree nuts 2009-2010

Fleabane control 30, 90 and 150 days after application



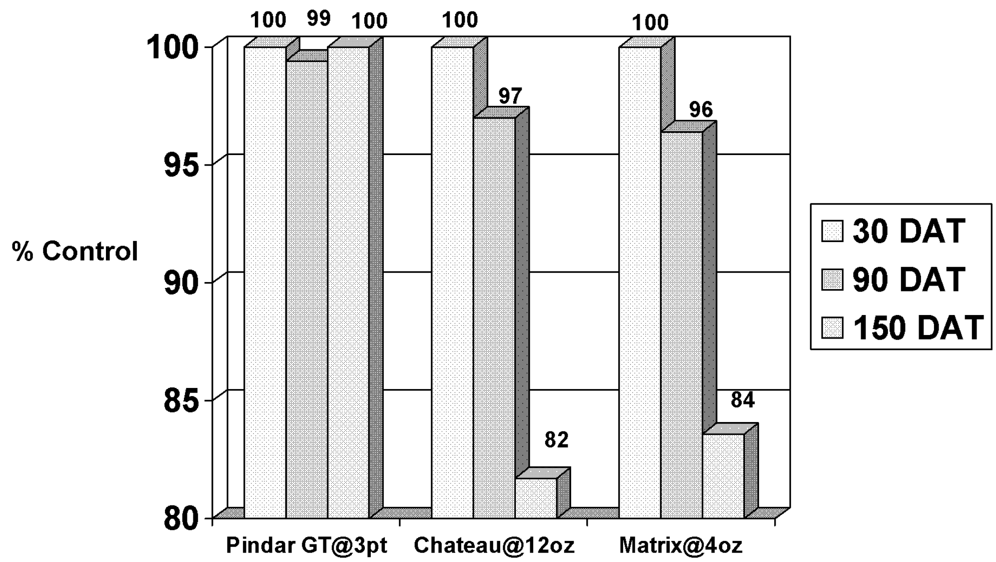
Pindar GT demonstration trials in tree nuts 2009-2010

Horseweed control 30, 90 and 150 days after application



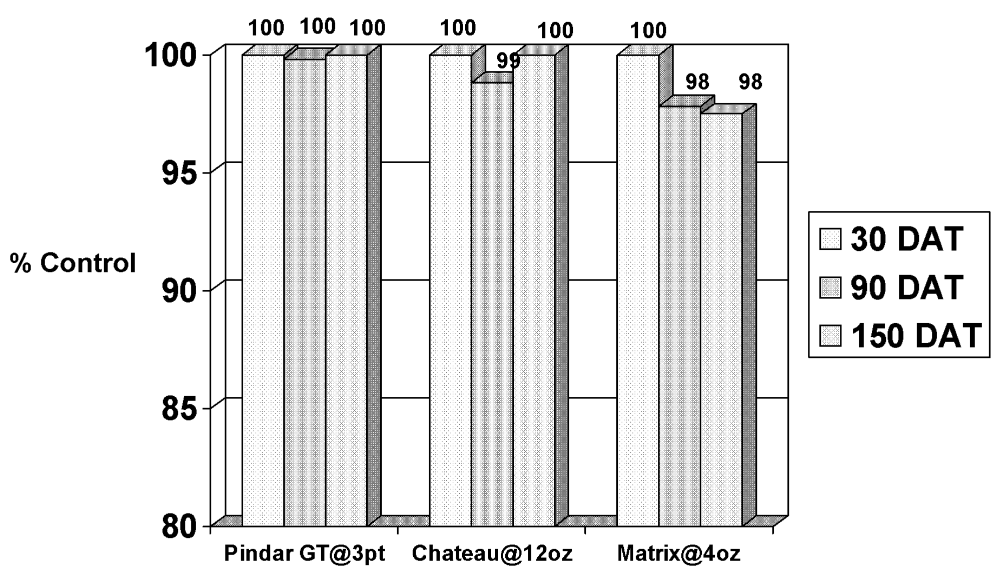
Pindar GT demonstration trials in tree nuts 2009-2010

Filaree control 30, 90 and 150 days after application



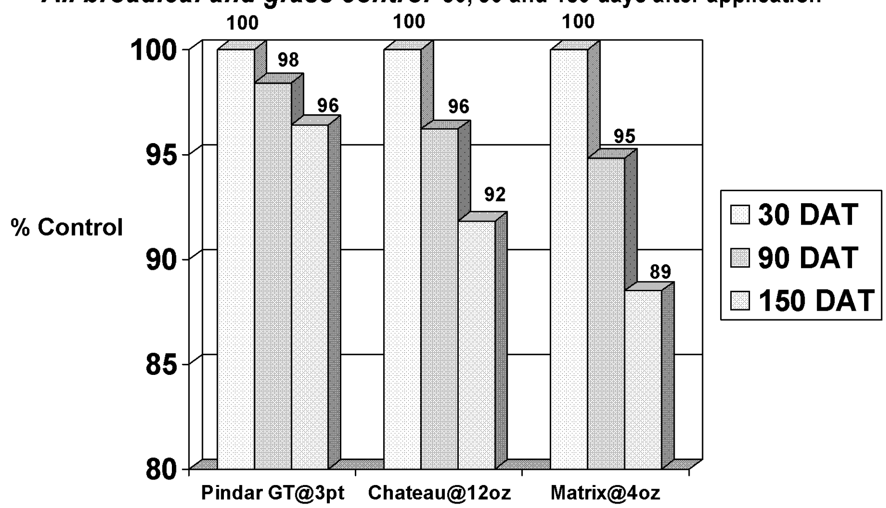
Pindar GT demonstration trials in tree nuts 2009-2010

Malva control 30, 90 and 150 days after application



Pindar GT demonstration trials in tree nuts 2009-2010

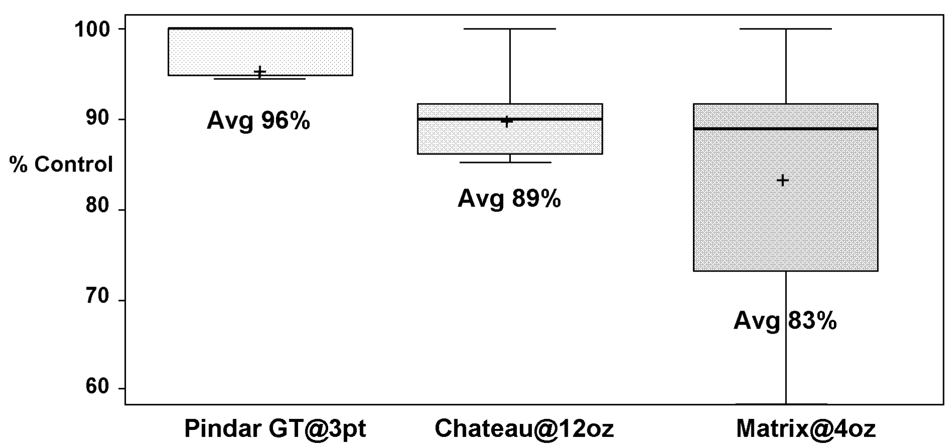
All broadleaf and grass control 30, 90 and 150 days after application



[A grass herbicide tank-mix partner was not included.]

Pindar GT demonstration trials in tree nuts 2009-2010

This box plot illustrates ***consistency of broadleaf weed control***
150 days after application, summarized across 23 locations



[A grass herbicide tank-mix partner was not included.]

New and Expanding Weeds in California

Dean G. Kelch, Plant Pest Diagnostics Laboratory
California Department of Food and Agriculture

Every year sees the introduction of new and the expansion of previously known noxious weeds in California. In 2010, the species discussed below have been chosen as notable.

Japanese dodder (*Cuscuta japonica*) is a vining parasite that attacks many woody plants. The plant is spread via humans (it is part of the Hmong pharmacopoeia) and birds. Although reproduction by seed has not been documented in California, partly mature seed capsules have been found on recently identified samples. Occurrences are widespread, but more than 90% have been in Sacramento County. Over 200 occurrences have been treated by CDFA so far. Host tree removal is the only known treatment.

Stinkweed (*Dittrichia graveolens*) is an annual, late-flowering, glandular herb first reported in California in 1984. It has spread so quickly along roads that it is now known in at least 26 California counties. Problems associated with this weed include inhibition of seed germination of other plants, toxicity to stock, and contact dermatitis in some people. Control is possible using glyphosate or repeated mowing.

Canary Island hypericum (*Hypericum canariense*) is a shrub to 2 m with large yellow flowers that is invading scrub habitat on coast. It is currently actively spreading in California. Control has been achieved with basal bark treatment with Garlon.

Capeweed (*Arctotheca calendula*) has long been confused with creeping capeweed (*A. prostrata)*, a common nursery plant sold as a ground cover. Capeweed differs in that it is an annual (vs. perennial) with dark disk flowers (vs. yellow ray flowers). It is currently known from Marin, Humboldt, San Mateo, Merced and Stanislaus Counties. Control is difficult, but there have been recent promising results using Milestone.

Star endive (*Rhagadiolus stellatus*) is an annual herb in the chicory tribe of the daisy family (Asteraceae) that prefers partially shaded habitats (although it is a grain-field weed in the Middle East). It can be distinguished from other chicory tribe weeds, such as sow thistle (*Sonchus*) and Cretan weed (*Hedypnois*) by its distinctive fruit that resembles a 6-8-pointed star. Currently, endive daisy is known only from Napa & Sonoma Counties, but it is often dominant in understory and seems to be spreading rapidly.

Figure 1. Star endive

Branched broomrape (*Orobanche ramosa*) that has been known as a parasite of tomatoes in California for many decades. In 2010 an old site was replanted to tomatoes and branched broomrape reappeared. The last known outbreak at this site occurred in the 1970s. This indicates long-term seed viability. As the seed is easily dispersed via footwear and field equipment, great care must be taken to prevent further spread. Control of large patches may not be possible, although soil fumigation has been used with some effect. The best control is to avoid planting host crops in known infestations.

Figure 2. Branched broomrape

Santa Maria feverfew (*Parthenium hysterophorus)* is a tropical annual herb. It is an important weed in Australia where it occurs in many tropical/subtropical habitats after disturbance. It is not currently established in California, but seedlings were found in a nursery greenhouse, presumably introduced via the coir component of the potting mix imported from Sri Lanka. Although most of California is not suitable for growth of this plant, it should be watched for as it is known to be toxic to stock, it inhibits germination of some crop plants, it causes contact dermatitis or pollen allergies in some people. It can be controlled via various herbicides used on broadleaf weeds.

Mexican feathergrass (*Nassella tenuissima*) is a short-lived perennial grass often used in gardens in California. It is not yet firmly established in California, but spontaneous plants in non-horticultural settings have been collected in 6 California counties.

False brome (*Brachypodium sylvaticum*) is a perennial grass in woodland in California, but it can occur in full sun in Washington and Oregon. In California, it was originally found when it was being vetted for a habitat "restoration" in redwood forest. It can be controlled with a multi-year herbicide program or by heavy grazing.

Yellow alyssum (*Alyssum murale* and *A. corsicum*) are yellow-flowered perennial members of the mustard family (Brassicaceae) from Europe. As they are metal hyperaccumulators, they were planted as possible "bio-mining" crop in Southern Oregon. They were recently discovered to have escaped into USFS land in Southern Oregon. They have a high likelihood of spread in Northern California on serpentine soils and land managers should be aware of their potential spread.

Figure 3. Yellow alyssum

CAPE IVY
US FOREST SERVICE LANDS - BIG SUR COAST

Jeff Kwasny, Los Padres National Forest, Big Sur, CA

The Big Sur coast is centrally located between San Francisco and Los Angeles. The travelers' link between these two metropolitans is Highway 1. This highway provides a major vector for invasive plants from San Francisco, the largest hub of invasive species in California. As a result, lands adjacent to Highway 1 are a menagerie of exotic plants.

Cape ivy (*Delairea odorata*) is currently the number one threat to heterogeneity and species diversity along the Big Sur coast. Alvarez and Cushman (2002) found in plots along the northern California coastal regions that habitats containing Cape ivy contained 36% fewer native plant species when compared to non-invaded areas. In addition, they found a 31% decrease in species diversity as well as 88% decrease in the abundance of native seedlings. Native to the moist mountain forests of South Africa, it was introduced in the 1850s as an ornamental in the eastern U.S. and to California by the 1950s (Elliot 1994); by the 1960s it had naturalized in Golden Gate Park, San Francisco and Marin County (Archibald 1995). Individual plants grow year-round and expand vegetatively through prolific stolon production. Cape ivy has no taproot, only shallow fibrous roots that sprout from the stolons where the vine comes into contact with soil. Typical habitat for Cape ivy is coastal scrub and riparian areas; tolerant to salt spray, it occurs along the immediate coastline right down to the high tide line.

COMPETITIVE ADVANTAGES of CAPE IVY

There are complex reasons why Cape ivy grows so well here; a few of the physiological competitive advantages discussed are: early flowering, growth form, and shading effect.

Early Flowering

Cape ivy flowers in December through February. Most native plants are dormant at this time or haven't sprouted yet. Seed is cast by March/April. This is a common advantage among many of California's nonnative invasive plant species.

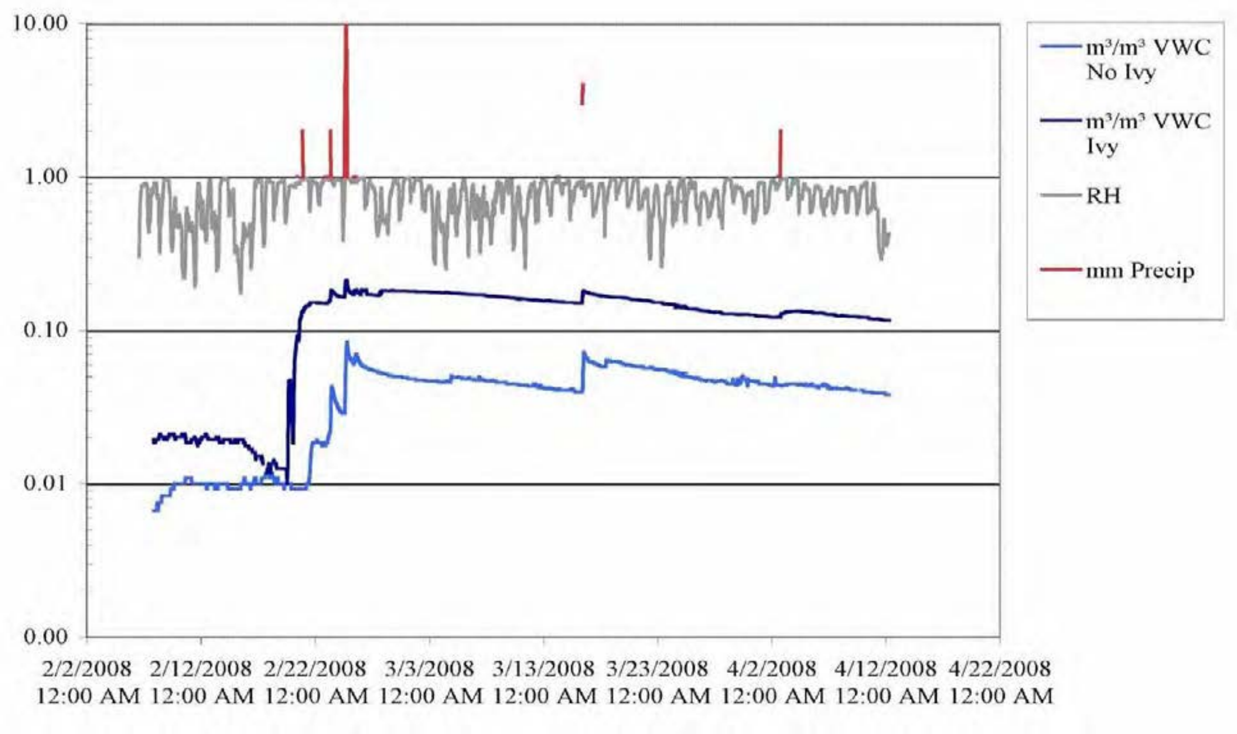
Growth Form

The invading vining growth form allows it to exploit resources by growing up shrubs and trees, while its stolons travel along the soil surface, sprouting roots on contact - a mobile and opportunistic system that is ideal for colonizing new areas.

Shading Effect

Cape ivy has the ability to protect the soil surface from loss of moisture by 'shading' the ground from sunlight and wind to keep the soil moisture higher than what is occurring naturally. This permits the soil under the ivy to store more moisture longer into the spring, and therefore give Cape ivy an advantage over natives in growing rate and seasonal growth duration. Figure 1 illustrates the results of soil moisture probes placed in the soil under Cape ivy and adjoining soil cleared of the ivy within ten meters of each other. The probes measured volumetric water content at a soil depth of 10 centimeters (Chris Potter, NASA Ames Laboratory).

Figure 1.



CONTROL METHODS

Physical

The two most common methods are: hand pull vines and stack in piles for disposal or desiccation and the "Scorched Earth" tactic of pulling and hoeing all vegetation (natives and exotics) allowing for free access to remove re-emerging Cape ivy.

Grazing with Goats

Goats have been used successfully on small sites. Recommended timing is between November and February before seeds ripen. The goats eat indiscriminately, consuming all vegetation equally, and generally leaving the root structure intact.

Green Flaming

Pioneered by Ken Moore of the Wildlands Restoration Team, Santa Cruz, a propane torch is used to heat the ivy just enough to produce wilting. Flaming is a good choice for follow-up treatment.

Chemical

Applied once a year as foliar spray in late-winter to early-spring when the ivy is photosynthesizing actively but past flowering. To achieve the desired efficacy, one to three consecutive years of treatment is necessary; three years for the older infestations and one year for spot treatment of new infestations.

In riparian areas, use 1½% solution of glyphosate (aquatic approved product) + 0.75% non-ionic nonylphenol polyethoxylate (NPE) surfactant [examples are R-11 (Wilbur-Ellis), X-77 (Loveland Industries)]. Non-target plants such as willows are dormant (some willow trees are leafless this time of year) during the winter months and are not affected by glyphosate. At Pfeiffer Beach in Big Sur the Forest Service treated Cape ivy with this solution. The first year we sprayed 600 gallons of solution, the second year we sprayed 500 gallons, and the third year we only needed to spray 18 gallons to seek and destroy new spot infestations.

In upland areas, there are two proven solutions to control Cape ivy: 1) 1½% solution of glyphosate (Roundup Pro®), or 2) a cocktail of 0.5% glyphosate (Roundup Pro®) + 0.5% triclopyr (Garlon 4®) + 0.1% silicone blend surfactant [examples: Sylgard 309 (Wilbur-Ellis), Silwet L-77 (Loveland and Helena), Freeway (Loveland Industries)]. The cocktail solution in some cases has shown to have less effect on non-target species than the glyphosate only solution. If there are no concerns about non-target species, Roundup Pro® is easier to use. Another product that I have heard is effective on upland sites is clopyralid.

Choice of control method depends on your site specific goals, strategy, issues/concerns, policy (if government agency), resource considerations, and funding/workforce.

Figure 2. Estimated cost per acre to treat Cape ivy

Manual	Goat Grazing	Chemical	Flaming
$1800	$1350	$1300	$1300

√ Manual based on actual costs incurred by USFS

√ Goat grazing based on contractor estimate

√ Chemical based on actual costs incurred by USFS

√ Flaming based on personal conversation with Ken Moore, Wildland Restoration Team (2006)

CONTROL STRATEGY

At a minimum, your control strategy should include the following:

1) Spot infestations should be first priority for treatment.
2) Funding – you must have funding and/or workforce available for a minimum of three years.
3) Establish control lines. For landscape control I recommend a map of the infestation and established control lines.

Figure 3

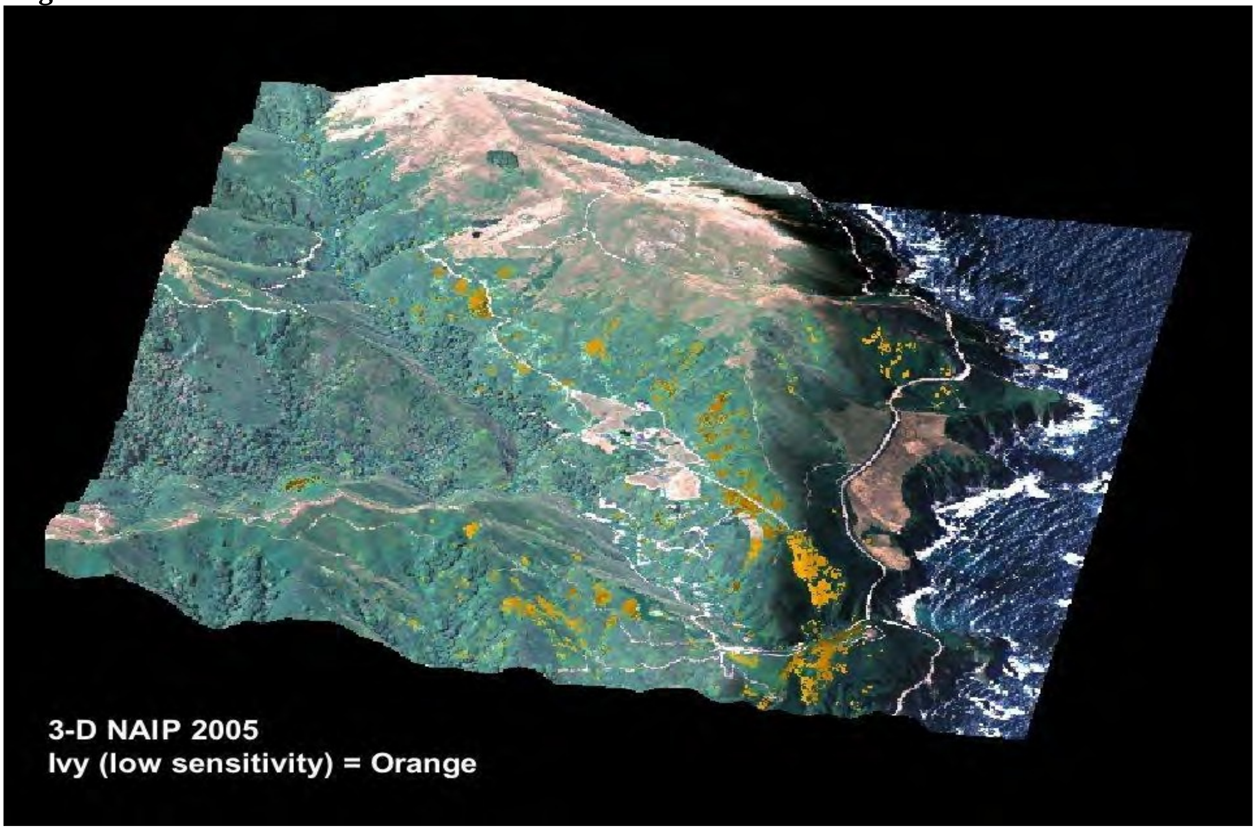


Figure 3 is an example of mapping Cape ivy infestations across the landscape using high-resolution satellite imagery (Seth Hiatt, San Francisco State University). In this example, roads are used as control lines.

Key to all non-native invasive weed control programs is persistence. Using the control strategies presented here today, the Forest Service has been and will continue to be diligent in their efforts to maintain native species diversity along the Big Sur coast.

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Weed Wars and Woes in the Far North

Carri B Pirosko, Integrated Pest Control Branch, California Department of Food and Agriculture, 37490 Toronto Avenue, Burney CA 95616 Email: cpirosko@cdfa.ca.gov

The far north end of the state is well known for land features such as: Mount Shasta, Mount Lassen and the Modoc Plateau. A lesser known story synonymous with the far north is that of the State of Jefferson. In 1941 a group of unsatisfied citizens along the southern Oregon and northern California border started a movement to create their own state, the State of Jefferson. The movement reached its peak in November of 1941 when an armed group stopped all traffic along U.S. Route 99 to distribute the group's Proclamation of Independence. These "Jeffersonians" pledged to stop traffic every Thursday there after until they were officially recognized. The movement came to an abrupt halt in December of 1941 with the bombing of Pearl Harbor. Efforts of all citizens went into the war effort. Today, the State of Jefferson is merely a state of mind.

At present, the California Department of Food and Agriculture (CDFA) has six designated weed districts across the state. Each District has a biologist that is responsible for A-rated noxious weed survey and eradication. A-rated noxious weeds are typically small, incipient populations and therefore are worked toward complete eradication. To this end, State Food and Agriculture Biologists work with County Agricultural Commissioner's Offices, Pest Boards, local Weed Management Area groups, as well ranchers and homeowners.

A large percentage of all A-rated noxious weeds are found in the State of Jefferson. The more typical central and southern California weeds such as: Arundo, pampas grass, sesbania and brooms are not found in the far north. A host of more obscure A-rated weeds that are found in the far north include:

- **Scotch thistle** (*Onopordum acanthium*)
- **Taurian thistle** (*Onopordum tauricum*)
- **Musk thistle** (*Carduus nutans*)
- **Plumeless thistle** (*Carduus acanthoides*)
- **Perennial sowthistle** (*Sonchus arvensis*)
- **Smooth (long-leaf) groundcherry** (*Physalis longifolia*)
- **Yellowspine thistle** (*Cirsium ochrocentrum*)
- **Knapweeds** [spotted (*Centaurea maculosa*), squarrose (*C. squarrosa*), diffuse (*C. diffusa*), and meadow (*C. X moncktonii*)]
- **Dalmatian toadflax** (*Linaria genistifolia*)
- **Leafy spurge** (*Euphorbia esula*)

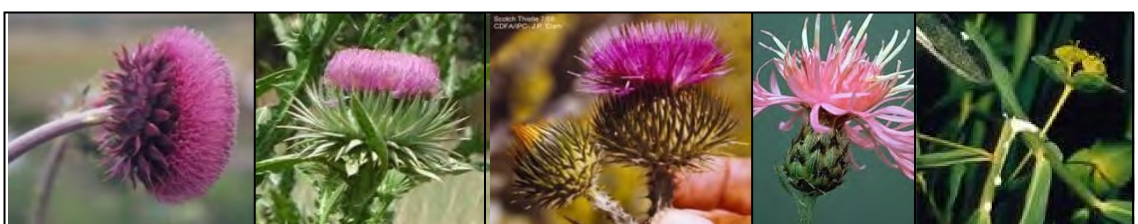
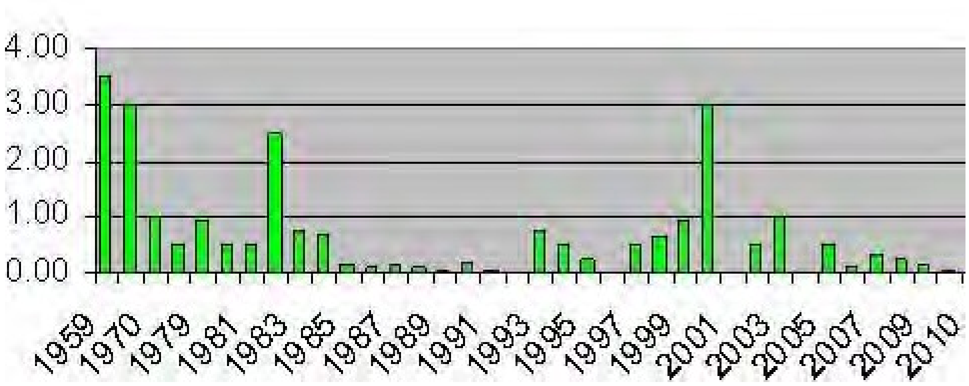


Fig 1. Musk thistle, Taurian thistle, Scotch thistle, Meadow knapweed, and Leafy spurge.

In Modoc and Lassen Counties, yellow starthistle is not widespread and therefore worked toward eradication. Perennial pepperweed is another weed that is still worked toward eradication in the State of Jefferson (currently only 2 populations exist in Susanville and Tule Lake).

Siskiyou County lies in the heart of the State of Jefferson. The County Agricultural Commissioner's Office maintains a data-set of weed acres treated (net acres) and weed acres worked (gross acres) that dates back to 1959. This data-set tells the story and exemplifies the weed wars and woes of an A-rated weed eradication program. Decades of data records for smooth groundcherry and taurian thistle show long stretches of no weeds found, a statewide eradication success story. However, on several occasions from 1959 to present, historic sites were disturbed and long-lived seed banks resulted in resurgence of these A-rated weed sites. The Siskiyou data-set establishes the importance of annual surveys when battling such long-lived seed producers, as is the case with most A-rated noxious weeds.

Figure 1. Taurian Thistle Acres Treated



Prevention is the key and therefore annual survey and detection is a high priority. Once weeds are established however the tool box for A-rated weed control in the far north is fairly simple. Herbicides include: Milestone, Transline, Telar, 2,4-D, and Perspective (Perspective or aminocyclopyrachlor has been used experimentally to date; registration expected in 2011). Milestone has become a great tool particularly in thistle and knapweed control. Milestone has been shown under high-desert conditions to provide season-long control and in some cases, control into the next season. Higher rates of Milestone can be hard on desirable grass species and therefore Transline is still a valuable tool. Telar remains the preferred tool for mustards, namely perennial pepperweed. Telar has also proven effective on thistles later in the season when thistles have already bolted and started branching out; seed development virtually stops upon application. Telar and 2,4-D are the preferred mix mid-to late summer on the tough A-rated noxious weeds like Scotch thistle.

Revegetation with Native Grasses, Sedges, Rushes, and Forbs
Competition and Control of Weeds, Soil Stabilization, and Enhancement of Biodiversity

John H. Anderson, DVM. janderson@hedgerowfarms.com
Elizabeth K. Goebel egoebel@hedgerowfarms.com
Hedgerow Farms, 21740 County Road 88, Winters, CA 95694
www.hedgerowfarms.com

Weeds impact thousands of acres of managed landscapes. These landscapes include:

- transportation corridors such as roadsides and highway interchanges
- drainage systems including ditches, swales, and sloughs
- storm water retention basins
- stream and rivers banks
- levees
- irrigation canals and reservoirs
- farmland edges and non-farmed corners
- parks and open space
- constructed wetlands and wildlife refuges

Management techniques used on these landscapes include tillage, herbicides, intensive mowing, burning, and in many instances an attempt to keep the ground free of vegetation. Left unmanaged, a huge number of exotic non-native weeds become established in a short period of time. Many miles of storm water sloughs and swales are now dominated with some of the worst weeds that have infiltrated California. These include perennial pepper weed, Johnson grass, and yellow star thistle and hundreds more.

When ground is kept bare, usually with herbicides, problems include soil erosion and the required continuous spraying. Bare ground also eliminates potential wildlife habitat for a wide variety of birds, reptiles, amphibians, small mammals, beneficial insects (including pollinators) and a host of others. The emergence of herbicide resistant weeds is another increasingly common problem.

Over the past 30 years we have been testing and implementing vegetation practices using California native plants on many of the areas listed above. After initially recognizing and using the weed-eliminating feature of some of the exotic perennial grasses (i.e. tall wheat grass, perla grass, berber orchard grass) we began exploring the potential of native perennial plants in our habitat restoration programs. Over the years we have identified a multitude of native perennials and annuals that, once established, provide excellent cover and wildlife habitat while suppressing and eliminating weeds. Most of the species are adapted to the Mediterranean climate of California and require no water during our dry season in late spring and summer.

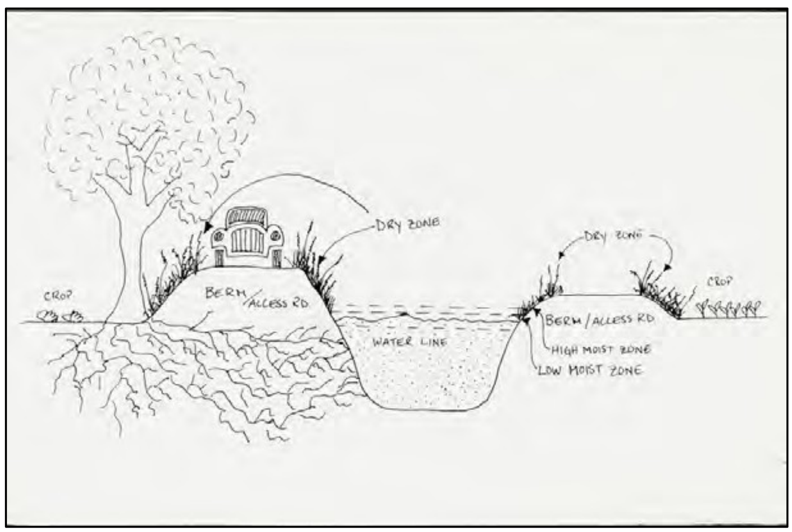
In addition, the ecosystem services they provide include:

- soil stabilization and erosion control
- enhanced water infiltration facilitated by extensive root systems that may go as deep as 6-8 feet or more
- bio-remediation of pollutants and pathogens
- carbon sequestration
- diverse habitat for many wildlife species

Over the past 10 years many of these plant species have become readily available either as seed or transplants. Now there are over 30 species of native grasses, 11 species of sedges and rushes, 40 species of forbs including many perennials available. There is also increased emphasis on using bioregional ecotypes in many projects, and origin-known seed and plants are more widely available. Included here (see end of document) is a list of the most commonly used species. For plant descriptions, see the USDA Plants Database (plants.usda.gov) or CalFlora (www.calflora.org). Information on what to use where and seed mixes can be found on some of the seed supplier web sites and on the California Native Plant Link Exchange (CNPLX) web site (cnplx.info). CNPLX also has a searchable database showing which seed companies and nurseries carry which species.

There are many implementation techniques that are beyond the scope of this manuscript. Re-vegetation sites vary considerably. A list of the practices that need to be considered include:

- tillage
- initial weed control
- seeding
  - hydroseeding
  - broadcast seeding
  - drill seeding
  - imprint seeding
- transplanting
  - plug planting
  - native sod
- follow-up management
  - herbicides
    - post emergent
    - pre-emergent
  - mowing and swathing
  - grazing



Pre-seeding tillage can be very important, especially on heavily compacted sites. Initial weed control and continued weed control during early establishment is very important. Exotic weedy species can rapidly overwhelm and eliminate slow growing native seedlings; these native perennials may take up to 3 or 4 years to become well established and provide weed control function.

While these vegetation practices are generally recognized as the right thing to do, they are only practiced on a very small percentage of the landscape. Pest Control Advisors could play a valuable role in recognizing where to establish native plant corridors and marketing the concept for the entities that can provide the design and implementation expertise.

Information on restoration and revegetation, as well as training workshops offered, are available from: the California Native Grasslands Association (www.CNGA.org), The California Society for Ecological Restoration (www.SERCAL.org), California Invasive Plant Council (www.CalIPC.org) and several of the Resource Conservation Districts (including the Yolo County RCD, www.yolorcd.org).

Commonly Used Species Common name (Botanical name, # of ecotypes available from Hedgerow Farms)

Grasses

Bentgrass (*Agrostis exarata*, 1)
Blue wildrye (*Elymus glaucus*, 12)
California barley (*Hordeum brachyantherum californicum*, 2)
California brome (*Bromus carinatus*, 3)
California Oniongrass (*Melica californica*, 5)
Creeping wildrye (*Leymus triticoides*, 5)
Deergrass (*Muhlenbergia rigens*, 1)
Foothill needlegrass (*Nassella lepida*, 3)
Idaho fescue (*Festuca idahoensis*, 1)
Meadow barley (*Hordeum brachyantherum*, 7)
Molate fescue (*Festuca rubra molate*, 1)
Nodding needlegrass (*Nassella cernua*, 6)
One sided bluegrass (*Poa secunda secunda*, 3)
Purple needlegrass (*Nassella pulchra*, 17)
Slender hairgrass (*Deschampsia elongata*, 1)
Slender wheatgrass (*Elymus trachycaulus*, 4)
Small fescue (*Vulpia microstachys*, 2)
Squirrel tail (*Elymus multisetus*, 2)

Sedges and Rushes

Baltic rush (*Juncus balticus*, 1)
Bulrush (*Scirpus americanu*, 0)
Common rush (*Juncus effusus*, 1)
Fox sedge (*Carex vulpinoidea*, 1)
Grey rush (*Juncus patens*, 2)
Santa Barbara sedge (*Carex barberae*, 1)
Slender sedge (*Carex praegracilis*, 3)
Spike rush (*Eleocharis macrostachya*, 1)
Torrent sedge (*Carex nudata*, 1)

Forbs

Bolander's sunflower (*Helianthus bolanderi*, 2)
California phacelia (*Phacelia californica*, 1)
California poppy (*Eschscholzia californica*, 1)
Common madia (*Madia elegans*, 1)
Gum plant (*Grindelia camporum*, 4)
Lupine species (*Lupinus*, 6 species carried each with 1 or 2 ecotypes)
Milkweed (*Asclepias fascicularis*, 1)
Mugwort (*Artemesia douglasiana*, 1)
Spanish clover (*Lotus purshianus*, 1)
Tomcat clover (*Trifolium willdenovii*, 1)
Turkey mullein (*Croton setigerus*, 2)
Vinegarweed (*Trichostema lanceolatum*, 1)

Herbicide Use Constraints in Vegetable Crops

Raymond A. Ratto Jr., Ratto Bros. Inc, 6312 Beckwith Rd, Modesto, CA
Email: rrattojr@RattoBros.com

Production. Ratto Bros is a vertically integrated large scale vegetable and watermelon farming operation with 40 different crops. Planting takes place continuously and an average of three to four crops per year are grown on the same parcel of ground. Weed control is essential in most vegetable crops due to their poor competitive ability with weeds and because weeds can be hosts of insect pests and pathogens affecting the crops.

Weed Management. Weed management is a challenge due to lack of registered herbicides for specialty vegetables. Kerb (pronamide) is an important component of weed control in leafy vegetables and current re-registration and potential loss of its availability is a big concern. For many vegetable crops only one herbicide is available and efficacy is poor (Table 1). Often times hand weeding is done with expenses up to $1000/acre.

Table 1. Herbicide use for specialty vegetable crops

Vegetable crop	Herbicide availability	Comments
Basil	Devrinol	Poor broadleaf control
Table Beets	Betanex, Dual Magnum	
Celeriac	None	
Daikon	Prefar, Dual Magnum	
Dandelion	Prefar	
Baby Dill	Prometryn	
Leeks	Dacthal	Potential residue issues
Lettuce	Prefar	
Parsley	Prometryn	

In the absence of effective herbicide programs for most crops, Vapam (metam sodium) fumigation has become a primary tool in weed control. After soil pre-irrigation (essential for good fumigant distribution) Vapam can be applied through the bedmulcher, blade, drench, drip, and deep shank chisel. However, restrictions on fumigant use such as increases in buffer zones, administrative requirements (preparation of management and emergency response plans) and applicator training make Vapam use difficult and costly.

IR-4 (minor use crops) Program is an important mechanism of securing herbicides for specialty vegetables and Ratto Bros. have been actively participating in it by conducting field efficacy trials. This helped the establishment of SLN (Special Local Needs) label for Dual Magnum (*S*-metolachlor) for root and tuber crops subgroups. IR-s program is especially important fit to California, since the greatest variety of minor crops is grown in the state, which produces more than 50% of the total specialty crops in the US.

About 30% of requests for IR-4 result in label development and herbicide availability (when registrant adds the material to existing labels). Table 2 provides an overview of herbicides that became available via IR-4 process from 2005 to 2010.

Table 2. Herbicides approved for minor crop use via IR-4 program, 2005-2010.

Herbicide	**Crop**
2,4-D *(Weedar 64)*	Wild rice
Clethodim *(Select Max)*	Asparagus, Bushberry subgroup 13-07B, Caneberry subgroup 13-07A, flax, globe artichoke, herb subgroup, leafy green subgroup, legume vegetable group, peach, safflower
Clopyralid *(Stinger)*	Bushberry subgroup 13-07B,Swiss chard, annual strawberry (FL)
Clorimuron-ethyl *(Classic Herbicide)*	Berry, low growing, except strawberry, subgroup 13-07H
Desmedipham *(Betanex)*	Garden beet (roots and tops), sweet corn, spinach
Dicamba *(WeedMaster)*	Sweet corn
Dichlobenil *(Casoron)*	Bushberry subgroup, caneberry subgroup, rhubarb
Dimethenamid-p *(Outlook)*	Grasses (seed), green onion, leek, pumpkin, radish, rutabaga, shallot (fresh leaves), turnip (roots and tops greens), Welsh onion, winter squash
Diuron *(Karmex)*	Mint, Prickly per cactus
Endothall *(Aquathol, Hydrotholl)*	Root and tuber vegetables group 1, Leaves of root and tuber; Bulb vegetables, Leafy vegetable (except Brassica), Legume vegetable, Fruiting vegetables, Cucurbit vegetables, Citrus fruits, Pome fruits, Stone fruits, Berry and small fruit group; Tree nuts group, Cereals grains group, Forage, fodder, and straw of cereal grains group, Grass, forage, fodder, and hay group, Non-grass, animal feed, group, grape, mint and rice
Ethalfluralin *(Curbit EC)*	Dill, mustard, potato, rapeseed
Ethofumesate *(Nortron)*	Carrot (PNW), garden beet, dry bulb onion, garlic, shallot (bulb and fresh leaves)
Fluroxypyr *(Starane)*	Dry bulb onion, millet, Pome fruit group
Fomesafen *(Reflex)*	Dry bean, snap bean
Flumioxazin *(Valor, Chateau)*	Asparagus, Bushberry subgroup, Cucurbit vegetable group, dry bean, Fruiting vegetable group, Leaf Petioles subgroup 4B, Melon subgroup, okra, strawberry, Tree nuts group

Herbicide	**Crop**
Foramsulfuron *(Equip, Tribute)*	Pop corn, sweet corn
Glyphosate *(Roundup)*	Dry pea, Indian mulberry, Legume vegetable group, safflower, sunflower
Halosulfuron-methyl *(Sandea)*	Apple, Bushberry subgroup 13-07B, Dried shelled pea and bean (except soybean) subgroup 6C, Succulent shelled pea and bean subgroup 6,Tuberous and corm vegetable subgroup 1c, okra, rhubarb
Lactofen *(Cobra)*	Fruiting vegetable group 8, okra
Linuron *(Lorox)*	Celeriac, rhubarb
MCPB *(Thistrol)*	Mint
Paraquat *(Gramoxone Inteon)*	Cucurbit Vegetable Group, dry bulb onion, ginger, okra
Phenmedipham *(Spin-AID)*	Spinach
Pendimethalin *(Prowl H2O)*	Artichoke, asparagus, Carrot, Citrus fruit Group, Fruiting vegetable group, Head and stem Brassica subgroup, grape, grasses (time-limited tolerance), green onion, juneberry, leek, mint, olive, Pome fruit group, pomegranate, shallot (fresh leaves), strawberry (perennial),Tree nut Group, pistachio, Welsh onion
Prometryn *(Caparol 4L)*	Carrot, celeriac, cilantro, coriander, Leaf petioles subgroup 4B, okra, parsley
Pronamide *(Kerb)*	Belgian endive, Berry group chicory, dandelion
Sethoxydim *(Poast)*	Borage, buckwheat, crambe, cuphea, echium, dill, gold of pleasure, hare's ear mustard, lesquerella, lunaria, meadowfoam, milkweed, mustard, okra, oil radish, poppy, sweet rocket, turnip greens, Root and tuber vegetable group 1.
S-metolachlor *(Dual Magnum)*	Bushberry subgroup 13-07B, Caneberry subgroup 13-07A, carrot, cucumber, Fruiting vegetables group 8, Head and Stem Brassica subgroup 5A, Leaf Petioles subgroup 4B, Leafy Brassica Greens subgroup 5B, Lowbush blueberry, Melon subgroup 9A, Onion bulb subgroup 3-07A, and Onion Green subgroup 3-07B, pumpkin, okra, Root vegetables (except sugar beet) subgroup 1B, Sesame, sweet sorghum, Tuberous and corm vegetables subgroup 1C, turnip greens, winter squash
Terbacil *(Sibar)*	Watermelon
Thifensulfuron-methyl *(Harnony)*	Safflower
Tribenuron-methyl *(Ally, Canopy)*	Sunflower

Requirements for
Section 18 & 24(C) Registrations for Herbicides in Vegetable Crops

Anne Downs, Senior Registration Specialist, Wilbur Ellis Company
841 W. Elkhorn Blvd., Rio Linda, CA 95673 adowns@wilburellis.com

Access to pesticides for use on minor crops may be accomplished using two different sections of law within FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act). They include Section 24(c), (aka Special Local Need) registrations and Section 18 “permits to use”.

Minor use of pesticides……

- Are those for which the total US production for a crop is fewer than 300,000 acres
- Also applies to pesticide uses which do not provide sufficient economic incentive for a registrant to support initial or continuing registrations

States have authority under Section 24(c) of FIFRA to register additional uses of a federally registered pesticide based on special local needs. A Special Local Need, or SLN, means an existing or imminent pest problem, within a state, for which the State Lead Agency (DPR), has determined that an appropriate federally registered pesticide product is not sufficiently available.

Section 24(C) SLNs

- Are for distribution and use only within a particular state.
- States may consider uses such as the following as candidates for SLNs:
    1. Adding a new method or timing of application.
    2. Adding a new crop (new site).
    3. Changing the rate of application.
    4. Application in a particular soil type.
    5. New product/different formulation.
    6. The new product will enhance resistance management.
- SLNs involving use on a food crop must have an established tolerance or be exempted from the requirement for a tolerance for that crop.
- Some crops are considered non-food/non-feed sites e.g. ornamentals and most seed crops.
- Generally SLNs are prepared and submitted by grower groups.
- SLN submission requirements vary by state.

  CA DPR’s SLN form may be found, on line, at the following web address:

  http://www. cdpr.ca.gov/docs/registration/regforms/sec24/24app02.pdf

The SLN applicant must provide the following information:

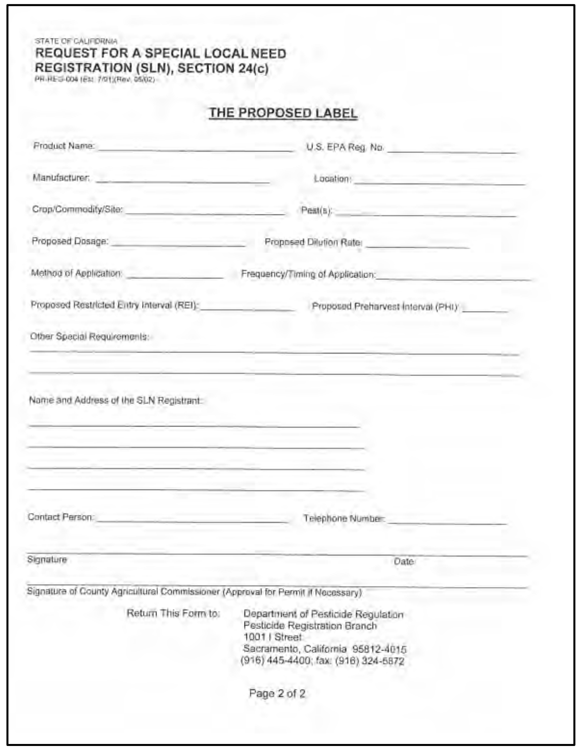
1. A complete description of the problem and submit evidence such as field data, copies of published articles, or written statements from qualified experts that a special local need exists.
2. Must list other products that are registered in California for this use and give reasons why the alternatives are not available or are not controlling the pest(s).
3. Must also report similar uses for which the product is registered.
4. Must advise whether the crop will be marketed fresh or processed and what, if any, are the anticipated hazards to bees, fish, wildlife or any non-target organisms?
5. Must estimate the total amount of acreage to be treated and whether or not a residue tolerance has been established for the food or feed crop?
6. Must submit efficacy and phytotoxicity data, as well as, a letter of authorization from the manufacturer.
7. And, finally, the applicant, in cooperation with the registrant, must develop label language.

- A state must notify EPA within 10 days of when they issue a SLN registration.
- EPA has 90 days from the date the state issued the SLN to make a final decision whether to disapprove the SLN.
- If EPA makes no objections, the SLN becomes a federal registration.
- SLN registrations remain in effect unless EPA, the State, the Registrant, or the Applicant, takes action to cancel the registration.
- Ideally, a registrant will move towards adding the SLN use to their Section 3 label as the nature of a SLN makes it vulnerable.

Common Questions

1. **Are there circumstances under which a §24(c), aka SLN, should not be issued?** Yes, if expanding the use triggers further data requirements, raises human or environmental risk concerns, etc.
2. **Can states issue SLNs which negate restrictions on §3 labels?** It depends. §24(c)s often allow new uses or new use directions which may differ from those on the §3 label. However, if the SLN provisions raise risk concerns, the use of the SLN would be inappropriate.
3. **Is offering growers a choice of products or a less hazardous formulation (to humans, NTOs, or other environmental component) an acceptable justification for a SLN registration?** Yes. This would enable pollution prevention and risk reduction as determined by the state. A clear explanation of the benefits and the data to support such a contention would be required.

4. **Can a state issue a SLN registration for the purpose of avoiding buildup of pest resistance?** Yes, however, the SLN pesticide must have a different mode of action from that already available.
5. **May a state issue a SLN registration for a use which has been voluntarily deleted?** Yes, but only if the registrant or SLN applicant submits any missing data required to register that use.
6. **Can more than one SLN registration be issued for the same use in the same state?** Yes, however, the state must ensure that the additional §24(c) registrations are necessary and adequate data have been submitted.
7. **Can a product be used up according to the SLN product label as long as it is in the possession of the user?** Yes, unless either the state or EPA has prohibited the use of the product as part of a cancellation order.


STATE OF CALIFORNIA
REQUEST FOR A SPECIAL LOCAL NEED REGISTRATION (SLN), SECTION 24(c)
PR-REG-004 (Est. 7/91)(Rev. 05/02)

THE PROPOSED LABEL

Product Name: ____________ U.S. EPA Reg. No. ____________

Manufacturer: ____________ Location: ____________

Crop/Commodity/Site: ____________ Pest(s): ____________

Proposed Dosage: ____________ Proposed Dilution Rate: ____________

Method of Application: ____________ Frequency/Timing of Application: ____________

Proposed Restricted Entry Interval (REI): ____________ Proposed Preharvest Interval (PHI): ____________

Other Special Requirements:

Name and Address of the SLN Registrant:

Contact Person: ____________ Telephone Number: ____________

Signature ____________ Date ____________

Signature of County Agricultural Commissioner (Approval for Permit if Necessary)

Return This Form to: Department of Pesticide Regulation
Pesticide Registration Branch
1001 I Street
Sacramento, California 95812-4015
(916) 445-4400; fax: (916) 324-5872

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<u>Section 18 (Permit to Use)</u>

States may also request that EPA allow use of an unregistered active ingredient, or an additional use for a registered pesticide, to respond to emergency conditions, under Section 18 of FIFRA.

- Section 18 of FIFRA, authorizes EPA to allow an unregistered use of a pesticide for a limited time if EPA determines that an emergency conditions exists.
- An “emergency condition” is an urgent, non-routine situation that requires the use of a pesticide.

Four Types of Section 18s

1. Specific
2. Quarantine
3. Public Health
4. Crisis

Requests are made for pesticides needed for pest problems that impact production of agricultural goods when there are no alternatives for controlling the pest.

- Specific or Public Health Exemptions may only be issued for a year.
- Quarantine exemptions may be issued for no more than three years.

EPA generally takes approximately 60 days, from date of receipt, to make a decision regarding a Section 18 request. If the emergency is determined to be valid and the risks are acceptable, EPA approves the request.

- The majority of requests that EPA receives are for Specific Exemptions. Most Specific Exemptions involve the treatment of agricultural goods and EPA will, therefore, establish a formal tolerance (or maximum allowable residue level) for that active ingredient on that crop.
- Current Section 18's may be found at the following link on the EPA website: http://cfpub1.epa.gov/oppref/section18/search.cfm

In 2006, EPA published a final rule that revised the regulations governing emergency exemptions. They included:

1. A streamlining of the recertification application.
2. A redefinition of what constitutes significant economic loss and revision of data requirements for documenting the loss.

Components of a Section 18

Description of the Proposed Use including:

- Method and rate of application
- Maximum number of applications
- Total acreage to be planted and treated
- Use season
- Date first and last application needed
- PHI
- REI
- Earliest harvest date
- Any additional precautions, requirements, etc.
- Address registered alternative pesticides and alternative control practices.
- Include efficacy data which should include statistical data on comparative California registered products. The data should also compare the California registered products to the proposed product. Effects on crop yield and quality should be documented.
- A letter of authorization from the registrant must also be included.

- Address registered alternative pesticides and alternative control practices.
- Include efficacy data which should include statistical data on comparative California registered products. The data should also compare the California registered products to the proposed product. Effects on crop yield and quality should be documented.
- A letter of authorization from the registrant must also be included.

COMPARISON between SECTION 24(C) and SECTION 18

Section 24(c) aka SLN	**Section 18**
Applicant: Any person or group	Applicant: Must be a third party such as grower group, county, university, etc. (cannot be the registrant)
2 Types: First Party (the manufacturer) or Third Party (other than manufacturer)	4 Types: Specific Crisis Quarantine Public Health
Tolerance or Exemption from tolerance already established	No tolerance established.
Justification and lack of alternatives must be documented	Emergency, non-routine situation must be well- documented. Economics and lack of suitable alternatives must be verified
Data Needed Includes….. Residue Efficacy Phytotoxicity	Data Needed Includes….. Residue Efficacy Phytotoxicity Economic
Letter of Authorization from Registrant	Letter of Authorization from Registrant
Post for Public Comment is Required	Post for Public Comment is not Required
Issued generally without an expiration date	When issued, always includes an expiration date. Use period cannot exceed a 12 month period
Fees: - Must pay USEPA maintenance fees on an annual basis. - No DPR fees	Fees: None to either USEPA nor DPR

Weeds as Hosts (and Non-Hosts) of Vegetable Pathogens

Steven T. Koike, University of California Cooperative Extension, Monterey County
1432 Abbott Street, Salinas CA 93901 Email: stkoike@ucdavis.edu

Introduction

It is well known that weeds (defined here as non-crop plants) can be an important part in the epidemiology of vegetable diseases. Weeds can play the following roles: reservoirs or initial inoculum sources of the pathogens; means of pathogen survival between crops; reservoir or source of the pathogen vectors; possible mechanism for effecting genetic change and variation in the pathogen. Weeds perhaps are most noted as playing a part in virus diseases of vegetables but can also be important in several fungal and bacterial problems as well. In recent years there have been some important vegetable crop disease outbreaks that include a weed component in the disease epidemiology.

Case studies: recent vegetable disease/weed host interactions in coastal California

Impatiens necrotic spot virus (INSV) in lettuce. Historically and worldwide, INSV never was found to infect lettuce. However, beginning in 2006 and continuing through 2010, significant and damaging cases of INSV were experienced on numerous romaine, greenleaf, redleaf, butter, and iceberg plantings in Monterey and San Benito counties. Researchers wondered why INSV, which had been present in coastal counties for many years on horticultural crops and landscape plants, would now infect lettuce and cause such significant losses. Hypotheses about a novel INSV strain were discounted when molecular evidence indicated that the coastal INSV outbreaks are caused by a typical strain of INSV that does not differ significantly from ornamental INSV strains. A two-year survey indicated that the vast majority of thrips present in diseased lettuce fields are western flower thrips (*Frankliniella occidentalis*), showing that the vector is the usual and expected species. The source of virus inoculum also remained a mystery as field surveys conducted in 2007 and 2008 failed to find a widespread weed or alternate host candidate that could act as a reservoir of INSV. However, the summer 2009 and winter 2010 surveys revealed that cheeseweed (*Malva parviflora*) and shepherd's purse (*Capsella bursa-pastoris*) weeds were widely infected; such weeds were collected on and around ranches having a history of INSV outbreaks. At two lettuce-producing sites having chronic INSV problems, INSV-positive cheeseweed was readily found in vineyards adjacent to and upwind from the lettuce plots. It is notable that infected weeds appear symptomless and therefore do not give visual indications of being reservoirs of INSV.

Apium virus Y (ApVY) in celery. Starting in 2007 and continuing through 2010, striking disease symptoms were detected on celery grown in various locations in Santa Clara and Monterey counties. Affected plants could show extensive yellowing and deformity of the leaves, as well as distinct, large brown to tan lesions on the petioles. Such petiole lesions prevented the celery from being marketable and resulted in direct crop loss. The new disease was caused by *Apium virus Y* (ApVY), a virus not reported previously on celery in California. The virus appears to be host specific to plants in the Apiaceae. Because the virus was proven to not be carried in celery seed, attention was focused on finding alternative Apiaceae hosts as sources of viral inoculum. An extensive survey showed that poison hemlock weed in Monterey and Santa Clara counties was commonly infected (64%) with ApVY. Anise weed (only four collected) was negative. Positive poison hemlock was also found in Santa Cruz and Ventura counties; ApVY-infected parsley was later confirmed in Ventura County. The widespread infection of poison hemlock was an important finding and demonstrates that this weed can be a significant reservoir host for ApVY. Management of ApVY in celery likely depends on control of poison hemlock and the aphids that vector the virus.

When a weed host is not a "host"

Understanding the diagnostic process and disease epidemiology in crop/weed dynamics relies on knowing which diseases affect crops and weeds. Two valuable sources of this knowledge are host range and pathogen lists. On a host range list, for any particular pathogen there is listed all the plants that are known to be susceptible to that pathogen. On a pathogen list, for any particular plant there is listed all the pathogens that are known to cause disease on that plant. These lists are found in books, journals, other printed publications, and on-line sources. While host range and pathogen lists are essential tools, such lists also have their limitations. For example, white rust (*Albugo candida*) of crucifers and downy mildew (*Peronospora farinosa*) of chenopodium plants are two diseases listed as affecting a number of crop and weed species. However, the crops and weeds are actually infected by different races, so the race colonizing a weed will not infect crops. Therefore, one needs to evaluate and use such lists carefully.

Diagnostic implications

1. The infected weed host of a pathogen (especially pertaining to viruses) may be symptomless. Therefore, surveys and studies should account for this possibility.
2. Mis-diagnosis of virus pathogens can readily occur. Therefore, reliance on symptoms is not recommended. More robust diagnostic methods (ELISA, PCR) are required.
3. Host range lists should be used carefully. If crop and weed species are listed as hosts of the same pathogen, one must define "same." The existence of races and strains means that any one particular pathogen may not cross infect both the crop and the weed.

References

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Update on Chemical and Precision Weed Control Tools in Leafy Green Vegetables

Richard Smith, University of California Cooperative Extension, Monterey County
1432 Abbott Street, Salinas, CA 93901 Email: rifsmith@ucdavis.edu

INTRODUCTION

The central coast of California is a key area for production of leafy green vegetables such as lettuces, brassica crops, spinach, cilantro and many others. Weed control in these crops is achieved by a combination of cultural, mechanical and chemical control methods. There are nearly no new herbicides in the development pipeline for these crops, and as a result, many of these crops are dependent on old chemistries to provide effective preemergent weed control (Table 1). However, recent experience has indicated that reliance on old chemistries is not without risk. For instance, Kerb was removed from the market in 2009 for leaf lettuce, the number one lettuce type in Monterey County, and is not expected to return to the market until 2012-13 (Fennimore and Smith, 2009). In addition, RoNeet, the key preemergent herbicide for use on spinach was recently off the market, but fortunately has been returned. In addition to the loss of registered herbicides, there have been issues with new registrations of old herbicides. For instance, Dual Magnum was registered for use on spinach, but the registration has a preharvest interval and plant back restrictions that severely restrict its use on the majority of spinach acreage in California (Smith and Fennimore, 2009). And finally, the registration of prometryn for use on cilantro has been at the EPA awaiting clearance for over 10 years. All of these examples illustrate the challenges to providing useful herbicides to the leafy green vegetable industry.

Table 1. Year of registration of key leafy green vegetable herbicides.

Trade Name	Chemical	Representative Crop	Year Registered
Kerb	Pronamide	Lettuce	1972
Dacthal	DCPA	Broccoli	1958
Caparol	Prometryn	Celery	1964
Dual Magnum	S-metolachlor	Spinach	1976
Devrinol	Napropamide	Broccoli	1972

Adapted from Fennimore and Doohan, 2008

To further complicate the situation, the leafy green industry has changed by the transition to high-density 80 inch wide beds for the production of baby lettuces, spinach and cilantro; this has nearly eliminated the ability to effectively cultivate the beds (Smith et al, 2006). As a result, of these challenges, growers have had to place greater emphasis on basic cultural practices such as preirrigation followed by shallow cultivation to kill the initial weed flush in the production cycle and implement weed sanitation programs (e.g. removal of weeds from fields to reduce the weed seedbank). These practices are helpful, but have limits in their ability to provide excellent weed control. For instance, in 2010 growers faced the first year without the availability of Kerb in the spring when shepherd's purse and nettle are particularly problematic weeds. In general, there were higher weeding costs in fields impacted by these weeds because the alternative preemergence herbicides available for use on leaf lettuce do not control these weeds. Increased weeding costs varied from greatly, but in some cases were as much as $400 more than normal costs (personal communication from various Monterey County growers).

Lettuce in Monterey County is predominantly direct seeded (>95%). However, the use of transplants provides opportunities to better control weeds. Prowl H2O and Dual Magnum are both in the registration process for use on transplanted lettuce. When these materials are approved growers will have an option to deal effectively with fields with high weed pressure. However, there are two key problems with the use of transplants in lettuce production that limit their use: 1) transplants cost over $200 more per acre to produce than direct seeded lettuce, and 2) there are issues with post harvest longevity of transplanted lettuce. It will be interesting to see how growers weigh the negative aspects of the use of transplants with the positive weed control that can be achieved.

Robotic weed control technology, for example the Tillet Cultivator, is now available from Garford Corporation in England (http://garford.com/). The cultivator operates best where the crop is larger than the weeds, such as in transplanted crops. It is guided by a camera that looks down on the seedline and looks for green plants; a computer analyzes the images and directs spinning blades to cultivate between crop plants (Figure 1). This technology does not eliminate the need for hand labor but is capable of reducing the weeding time of subsequent hand weeding operations (Table 2). As technology improves in the future, it is expected that this technology will also improve in efficiency and efficacy.

Figure 1. Tillet cultivator. Note blade on the right is elevated to show the pie shaped design that allows the blade to spin around the crop plant as it travels down the seedline.

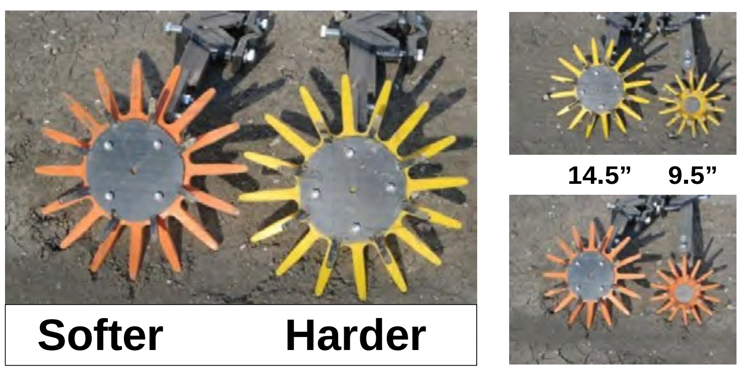
Table 2. Weeding time and yield evaluations on October 7, 2010.

Cultivation treatment	Total weeding time Aug 7&14 hr/A	Stand count Aug 7 Plant/A	Yield stand count Oct 7 Plant/A	Yield mean head Oct 7 lbs/head	Yield total Oct 7 tons/A
Standard	15.3	31,245	29,628	0.84	12.4
Tillet	11.6	30,721	29,119	0.88	12.7
Pr>F treat	<0.001	0.318	0.278	0.448	0.657
Pr>F block	0.156	0.221	0.073	0.251	0.447
LSD 0.05	**1.3**	**NS**	**NS**	**NS**	**NS**

CONCLUSIONS

Weed control in leafy green vegetables is as challenge. Using a combination of cultural, mechanical and chemical weed control strategies can provide acceptable weed control. It is critical to maintain curre ble weed control in an econo

Figure 2. Finger Weeder from Kress Co., Germany



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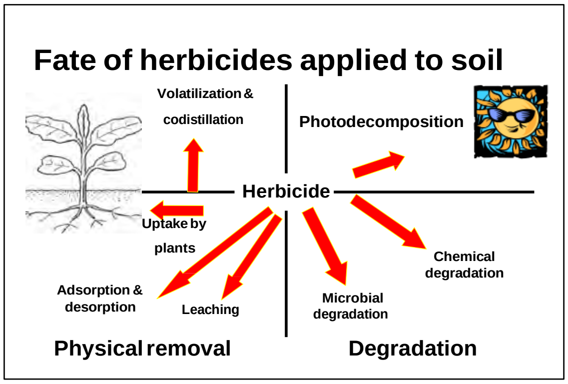
Herbicide Carryover in Vegetables

Steven A. Fennimore, U.C. Davis, 1636 E. Alisal St., Salinas, CA 93905
safennimore@ucdavis.edu

Summary. Vegetable crops are often sensitive to the presence of herbicide residues in the soil. Because of the intensive cropping system here in California, two or more vegetable crops can be grown on the same field in a given 12 month period. Some herbicides are more likely to persist than others and injure a rotational crop. Similarly, some crops are more sensitive to herbicide residues in the soil than other crops. Many of the California direct-seeded vegetable crops such as lettuce and spinach are among the most sensitive of any crops, and so special care must be taken with these and other crops. In this presentation we will examine the potential for several common vegetable herbicides to carryover, and steps that can be taken to minimize herbicide persistence such as applying herbicides in band applications.

Principal vegetable herbicides and crops. The most common vegetable herbicides used in California are Balan, Caparol, Dacthal, Devrinol, GoalTender, Kerb, Lorox, metam sodium, Poast, Prefar, Roundup, Ro-Neet, Sandea, Select Max and Treflan. Vegetable crops considered here are beans (snap), carrot, celery, cole crops, cucurbits, lettuce, onion, pepper, spinach, and tomato (fresh and processing).



Herbicide carryover and loss of herbicides. Ideally we apply an herbicide at the time of vegetable planting, and by the time of harvest the herbicide residues in the soil are gone so that we can rotate to any crop we chose. Unfortunately, not all herbicides degrade this rapidly and many rotational crops are very sensitive to the persistence of some herbicides. There are many means by which herbicides degrade in the soil, and degradation varies by herbicide chemistry. Principle means of herbicide loss are: volatilization, photodecomposition, adsorption to the soil, leaching, microbial and chemical decomposition.

Methods to minimize herbicide carryover.

1. Apply less herbicide by applying band applications over the crop seedline;
2. Apply herbicides accurately to avoid overdosing;
3. Till the field after harvest to dilute the herbicide treated soil profile;
4. After harvest keep the field moist to enhance soil degradation by soil microbes and water;
5. Maintain the soil pH near optimum levels for the crop;
6. Select herbicides that are less persistent – if a choice is available;
7. Soil additives such as activated charcoal can help adsorb excess herbicide.

Literature citations

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Pesticide Label and Container Disposal Requirements

Natalia Bahena, Agricultural Inspector/Biologist
Monterey County Agricultural Commissioner

Summary:
The pesticide label states the requirements for what Personal Protective Equipment (PPE) is required in order to mix/load and apply the pesticide. PPE required by the pesticide label must be worn by all persons handling that pesticide, as well as provided by the employer. The employer shall assure employees wear gloves unless prohibited by label when required by pesticide labeling, mixing or loading, (some exceptions) and/or adjusting, cleaning or repairing contaminated equipment.

Under California Code of Regulation, Title 3 (3 CCR) Personal Protective Equipment (PPE) is Regulated through Requirements and Exceptions, such as application by hand or using hand-held equipment, however these exemptions do not apply when the applicator is applying: vertebrate pest control baits using long handled implements that avoid actual hand contact with the bait or potentially contaminated areas of equipment.

Service Containers are defined as any container, other than the original labeled container of a registered pesticide provided by the registrant, which is utilized to hold, store, or transport the pesticide or the use-dilution of the pesticide. In no case shall a pesticide be placed or kept in any container of a type commonly used for food, drink or household products.

When Pesticides are being transported on public roads, they must be labeled with the name and address of the person or firm responsible for the container, identify of the economic poison in the container and the word "Danger," "Warning," or "Caution," in accordance with the label on the original container.

Decontamination Facility provided by the employer shall assure the applicators have available sufficient water for decontamination, single-use towels, soap, and an extra set of coveralls (even if coveralls not required by label). If the label requires the applicator to wear eye protection then 1 pint of eye wash must be immediately available. For Ag uses, the decontamination site shall be at the mixing loading site and no more than ¼ mile (or nearest point of vehicular access). For Non Ag uses, the decontamination site shall be within 100 feet of the mixing/loading site, if the applicator uses pesticides with the signal word DANGER or WARNING.

In order to dispose of Pesticide Containers applicator must triple rinse the container at the use site to be able to recycle the containers at the marina Landfill. Recycling is free, all that's required is that the containers are triple rinsed, labels are removed as well as the caps.

U.S. EPA Regulatory Updates

Patti L. TenBrook, Ph.D.
U.S. EPA Region 9, 75 Hawthorne Street, San Francisco, CA 94105
Email: tenbrook.patti@epa.gov

The U.S. EPA Office of Pesticide Programs (OPP) is currently working on many pesticide registration issues. Soil fumigants have been reregistered and OPP is now working with EPA Regions and States to implement extensive new mitigations measures which will be phased in 2010 and 2011. OPP has developed a Soil Fumigant Toolbox that provides fact sheets, fumigant labels, training materials, fumigant management plan templates, and other information that will help fumigant users understand and implement the new use restrictions (http://www.epa.gov/pesticides/reregistration/soil_fumigants/).

Beginning April 9, 2011 applications of pesticides to, over, or near water will have to be permitted under the Clean Water Act National Pollutant Discharge Elimination System (NPDES) program. NPDES permits are required for discharges of pollutants from a point source to a water of the United States, and a series of court rulings has determined that certain pesticide applications will require permitting. A draft Pesticide General Permit (PGP) was issued by EPA in June 2010 and was to be finalized by December 31, 2010, but will likely be issued in January 2011. The EPA permit will cover States, Tribes, U.S. Territories that do not have NPDES permitting authority, as well as federal facilities. Applications that will be covered by the EPA PGP include mosquito and other flying insect pest control, aquatic weed and algae control, aquatic nuisance animal control, and forest canopy pest control. States with NPDES permitting authority will have to put their own permits in place by April 9, 2011. The CA State Water Resources Control Board has permits for similar categories. It is important to note that pesticides applications that are not covered by an EPA or State general permit may still need NPDES coverage, but may require an individual permit.

In November 2009, EPA issued a draft Pesticide Registration Notice (PRN 2009-X) that proposed new label language regarding pesticide drift. The draft language included the statement, "…do not apply this product in a manner that results in spray [or dust] drift that *could cause* an adverse effect…" [emphasis added]. Many commenters noted that the term "could cause" would establish a no drift standard that was not consistent with the Federal Insecticide, Fungicide, and Rodenticide Act standard of "reasonable certainty of no harm". EPA is now proposing the following language: "…do not apply this product in a manner that results in a spray [or dust] drift that *harms* people or any other non-target organisms or sites" [emphasis added].

Registration of new pesticide chemicals or new uses of existing chemicals has historically been a process without opportunities for public participation. In 2010, EPA began a program to involve the public in registration of new chemicals, registration of first food, outdoor or residential use of an existing chemical, or in other new registration actions of significant interest.

When registration packets are received, EPA publishes a notice in the Federal Register (FR) and takes comments for 30 days. EPA then proceeds with its risk assessments and other registration processes. The completed risk assessments and proposed registration decision are posted to the public docket and a 30-day comment period is opened. No FR notice is issued when the proposed decision is posted. New registrations can be tracked at http://cfpub.epa.gov/pesticides/comments.cfm, or interested parties can subscribe to EPA Pesticide Updates at http://www.epa.gov/oppfead1/cb/csb_page/form/form.html. A final registration decision is announced in the Federal Register.

The Office of Pesticide Programs has also been working on many other issues including disclosure of inert ingredients, risk assessment for volatile and semi-volatile chemicals, and pollinator protection. The EPA Office of Water and OPP are working to develop a common approach to assessment of pesticide effects on aquatic life. If you have questions about any of these topics, please contact me.

Crop Protection Industry Assessment of EPA Spray Drift PRN and Calculation of spray drift buffers using FIFRA methodology

M.F. Leggett[1], Mark Ledson[2], Scott Jackson[3]
[1]CropLife America, [2] Syngenta, [3] BASF

Spray drift is pesticide droplet and particle movement that occurs during the initial application resulting in deposition onto non-target sites. This presentation reviewed spray drift policy, current practice in risk assessment of non-target plants exposed to drift and current research to improve exposure estimates were discussed. The EPA has sought to improve the language on labels with respect to drift. A draft PR Notice introduced in 2009 included a new standard that, if adopted, would effectively hold affected stakeholders to an unachievable "zero drift" policy.

The regulated industry opposes the proposed rule since it; undermines FIFRA, places an unreasonable burden on applicators, results in unpredictable liability, and establishes unattainable goals.

The EPA and state pesticide policies have long acknowledged that small levels of pesticide drift is unavoidable and, when used according to the product's label, does not pose a risk of 'unreasonable adverse effects' to humans or the environment. EPA's risk assessment and registration process include spray drift considerations, and label requirements include drift reduction considerations. These considerations are based on estimates of potential exposure from drift and hazard evaluation of the chemical being applied. The potential exposure from drift is estimated using models. Stakeholders are currently sponsoring research to improve model estimates so that they more accurately reflect potential for drift with consideration of available technology.

U.S. EPA Re-registration Eligibility Decision of Fumigants Pertaining to California Uses

Kevin J. Solari, Senior Environmental Scientist
California Department of Pesticide Regulation, Worker Health and Safety Branch

This presentation is an overview of new changes that apply to the use of soil-applied fumigants in California. The changes apply to fumigants that contain Metam sodium, Metam potassium and Dazomet (all Methyl Isothiocyanate-MITC producers), Methyl bromide, Chloropicrin and Methyl iodide. These changes have been implemented because of recent label revisions made by the U.S. EPA and by California Department of Pesticide Regulation (DPR) regulations, restricted material permit conditions and California only mitigation strategies.

USEPA is making these label changes to help better protect workers and bystanders while maintaining key use benefits of these fumigants across the country. Results stemming from USEPA's comprehensive re-evaluation (the RED) of these fumigants largely determined how exposure risk is mitigated through each fumigant label. USEPA labeling changes for each of the aforementioned soil-applied fumigants is being carried out in two phases. The first phase was implemented as of December 31, 2010 and effects new labeling for 2011. The second phase is currently being developed by USEPA and the states and is proposed to be implemented sometime in late 2011 or in 2012. Key components to mitigating risk for workers and bystanders required on the new labels include Respiratory Protection and Stop Work Triggers for handlers, Good Agricultural Practices and the Fumigant Management Plan (FMP).

California currently has registered products containing the active ingredients Metam sodium/potassium, Dazomet, Methyl bromide, Chloropicrin and Methyl iodide. USEPA label changes affect the use of all of these products. Additionally, DPR has other means available to mitigate the risks associated with exposure to these fumigants. For instance, DPR has developed templates for the FMP that are available on DPR's website (see below). DPR has also developed application method-specific recommended permit conditions for Metam sodium/potassium and Dazomet that are now available to County Agricultural Commissioners. DPR's Methyl bromide regulations have recently been revised to clarify respirator language, township cap limitations, and maximum work hour allowances for respirator use. DPR is currently in the process of developing interim and regionally-specific suggested permit conditions for Chloropicrin only soil-applied fumigants. For Methyl iodide, DPR determined that placing all California mitigation measures and conditions on a label for state use only is the best means of keeping the possibility of exposure to a minimum and within safe levels.

References:

California Fumigant Management Plan (CA FMP): http://www.cdpr.ca.gov/docs/enforce/prenffrm/prenfmnu.htm

Application method-specific recommended permit conditions for Metam sodium/potassium and Dazomet: http://www.cdpr.ca.gov/docs/county/cacltrs/penfltrs/penf2010/2010022.htm

Fumigant Resource Center: http://www.cdpr.ca.gov/docs/emon/methbrom/mb_main.htm

Respiratory Protection Regulations for Pesticides

Harvard Fong, Senior Industrial Hygienist
California Department of Pesticide Regulation, Sacramento, CA

The regulations concerning respiratory protection when using pesticides in California are found in Title 3 of the California Code of Regulations, Section 6739. The general information covered in this regulation are as follows:

- (a) General Requirements of the Regulation
- (b) Voluntary Use of Respiratory Protection
- (c) Selection of Respirators
- (d) Medical Evaluation of Employees Required to Wear Respirators
- (e) Fit Testing
- (f) Facepiece Seal Protection and Fitting Requirements
- (g) IDLH (Immediately Dangerous to Life or Health) Environments
- (h) Cleaning and Disinfecting
- (i) Emergency Respirators
- (j) Inspection and Repair
- (k) Breathing Air Quality for Air Supplying Respirators
- (l) Identification of filters, cartridges, and canisters
- (m) Training of Employees Required to Wear Respirators
- (n) Program Evaluation by Management
- (o) End of Service Life and Change-outs for Filters and Cartridges
- (p) Recordkeeping Requirements
- (q) Medical Evaluation Form
- (r) Voluntary Use Information Posting Form
- (s) Medical Recommendation

Must develop a ***written program*** with ***worksite-specific procedures*** when respirators are necessary or required by the employer

Written programs must incorporate all of the following elements:

Respiratory Protection Program Elements

- Selection
- Medical evaluation
- Fit testing
- Proper use for routine and emergency
- Maintenance, cleaning and care
- Ensure breathing air quality
- Training in respiratory hazards (IDLH if applicable)
- Training in donning, doffing, limitations
- Program evaluation

Stipulated Injunction and Order to Protect Red-Legged Frog (and Other Recent Injunctions)

Rich Marovich, Staff Environmental Scientist, California Department of Pesticide Regulation

Three recent injunctions have invalidated registrations of certain pesticides in certain areas that are occupied or potentially occupied by federally listed species. The injunctions are outside of FIFRA and are not enforced by EPA, DPR or county agricultural commissioners, but they could expose applicators to third-party lawsuits. The injunctions pertain to California Red-Legged Frog, Salmonids (Chinook Salmon, Coho Salmon and Steelhead); and eleven Bay Area Species collectively referred to as the "Goby Eleven." The plaintiffs are anti-pesticide groups that are exploiting a technicality in the federal Endangered Species Act. The injunctions are based on alleged failure of the Environmental Protection Agency to consult with the U.S. Fish and Wildlife Service or (for salmonids) the National Marine Fisheries Service (Services). They are not based on documented harm to listed species, only the potential for harm. Almost all federally listed species were listed because of loss of habitat, some were never abundant and are naturally limited to small geographic areas. The best defense against claims of adverse effects of pesticides (or any other stressor) is a thriving local population of listed species. Informed applicators can help to protect local populations of listed species.

Older classes of pesticides, especially the organochlorines and DDT in particular caused well documented harm to federally listed species, notably Bald Eagle, Peregrine Falcon and Brown Pelican. As these pesticides were phased out the species have recovered. These cases have influenced a generation of wildlife biologists who view even relatively benign pesticides as harmful. Whereas the U.S. Fish & Wildlife Service exhibited restraint in finding jeopardy in only 1% of all non-pesticide consultations, they found jeopardy in 99% of all pesticide consultations.

The key to protection of listed species (or any other non-target species) is selective exposure. The injunctions specify absolute buffer zones regardless of site specific conditions and measures applicators can take to control exposure. Buffer zones are essential to define distances beyond which exposure is unlikely but they are misused as indiscriminant distances within which all use is prohibited.

The injunctions rely heavily on computer models that screen pesticides against worst case exposure scenarios, even in preference to field monitoring data. These models are useful to discern pesticides that pose no threat to listed species even under worst case conditions, but failure to pass this screen does not mean that a likelihood of harm exists, only that additional precautions are warranted. The EPA Endangered Species Protection Program allows for development of local plans as alternatives to default buffer zones. Local plans present an opportunity for communities to come up with alternative measures to protect listed species. When the Services accept these proposals with a "not-likely-to-adversely-affect" determination then the injunctions end as does the threat of further injunctions. A dialogue with the Services is needed to move beyond injunctions and absolute buffer zones toward more reasonable solutions. For more information, see: http://www.cdpr.ca.gov and select "Endangered species."

Surface Water Protection Concepts for Pesticides

Mark Pepple, Staff Environmental Scientist
CA Department of Pesticide Regulation, Email: mpepple@cdpr.ca.gov

The Food and Agricultural Code requires the Department of Pesticide Regulation (DPR) "To protect the environment from environmentally harmful pesticides by prohibiting, regulating, or ensuring proper stewardship of those pesticides." DPR's Environmental Monitoring Branch samples air and water to determine whether pesticide residues are moving offsite at levels of concern, and develops pesticide use mitigation practices. Sampling conducted by DPR as well as federal, state, and local agencies, private industry, and environmental groups has shown that pesticides contaminate surface water. This contamination can primarily cause toxicity to aquatic organisms, but occasionally exceeds levels protective of human health.

Based on monitoring data, DPR adopted regulations in 2007 to reduce levels of dormant insecticides in surface water. Pesticides have also been found in surface water during the growing season, as a result of both urban and rural use. As a result, DPR is now planning to adopt regulations that address both urban and rural sources of contamination by these pesticides that can occur year-round.

California's Pesticide Use Reporting (PUR)

Larry Wilhoit, Research Scientist III
California Department of Pesticide Regulation

California regulations require that all agricultural pesticide use and some non-agricultural uses be reported to the Department of Pesticide Regulation (DPR). The data are stored in the Pesticide Use Reporting (PUR) database. Since 1990, there has been an average of 2.5 million records per year in the PUR. The PUR contains two types of records: applications in production agriculture and all other uses by commercial pest control businesses, which include postharvest and non-agricultural applications. Each production agricultural record represents a single application and includes the amount and name of pesticide applied, date and location of the application, crop or site treated, area treated, acres planted, application method, grower ID, and field ID. The second type of record represents the total use of a pesticide product by a company on each site treated in each county during each month.

Each year's data is available in a summary report giving use in pounds of active ingredient (AI) and acres treated by crop and pesticide active ingredient. To get more specific or detail information there are several interactive web sites (calpip.cdpr.ca.gov/main.cfm, www.pesticideinfo.org, and www.ehib.org/page.jsp?page_key=135,). The full database is available in text format on DPR's ftp site (/pestreg.cdpr.ca.gov/pub/outgoing/pur_archives/).

The data is extensively checked for errors, but errors, of course, still exist. Two common errors are incorrect units of measure and product registration number. When doing an analysis it is important to check for possible errors, especially rates of use because even one or two big errors can have a huge effect on results. It is also important to read the documentation since some of the meaning of some the database field names are not obvious.

The PUR is used by many different individuals and organizations for a wide range of purposes. Pesticide use reports help DPR estimate dietary risk and ensure compliance with clean air laws and ground water regulations. Site-specific use report data, combined with geographic data on endangered species habitats, help County Agricultural Commissioners resolve potential pesticide use conflicts. DPR also uses the data to analyze how, when and where pesticides are used on different crops. Reduced-risk pest management alternatives can then be developed considering the different regions of the State and the commodities grown in these regions.

California Weed Science Society
Financial Summary
July 2010 through April 2011

Ordinary Income/Expense	
Income	
4000 · Registration Income	99,663.00
4001 · Membership Income	175.00
4010 · Proceedings Income	2,299.36
4015 · Field Tour Income	1,380.00
4020 · Exhibit Income	16,500.00
4030 · Sponsor Income	12,500.00
4065 · Orchid Fundraiser	317.00
4290 · Refunds	-1,500.00
Total Income	131,334.36
Expense	
4300 · Conference Accreditation	190.00
4310 · Conference Facility Fees	660.00
4320 · Conference Catering Expense	37,282.24
4330 · Conference Equipment Expense	2,341.00
4360 · Student Awards/Poster Expense	1,800.00
4361 · Awards-Board/Special Recog.	195.71
4370 · Scholarship Expense	6,000.00
4380 · Conference Supplies	908.12
6090 · Advertising	1,462.50
6120 · Bank Service Charges	2,590.87
6130 · Board Meeting Expenses	1,060.84
6240 · Insurance - General	1,800.00
6270 · Legal & Accounting	826.00
6280 · Mail Box Rental Expense	60.00
6300 · Office Expense	30.95
6307 · Outside Services - PAPA	34,907.30
6340 · Postage/Shipping Expense	1,899.16
6345 · Printing Expense - Newsletter	4,361.81
6355 · Website Expense	999.50
6360 · Storage Rental Expense	264.00
6390 · CWSS Textbook	3,000.00
6440 · Supplies Expense	185.82
6520 · Telephone/Internet Expense	931.21
6530 · Travel - Transport/Lodging	1,033.05
6540 · Travel - Meals/Entertainment	459.02
Total Expense	105,249.10
Net Ordinary Income	26,085.26
Net Income	**26,085.26**

RBC Wealth Management Account as of 4/30/11 **256,696.04**

25% Cash and money market

68% Taxable fixed income

5% US equities

2% Other assets

CWSS HONORARY MEMBERS LISTING

Harry Agamalian (1983)
Norman Akesson (1998)
Floyd Ashton (1990)
Alvin Baber (1995)
Walter Ball *
Dave Bayer (1986)
Carl E. Bell (2010)
Lester Berry
Tim Butler (2008)
Mick Canevari (2008)
Don Colbert (2002)
Floyd Colbert (1987)
Alden Crafts *
Marcus Cravens *
Dave Cudney (1998)
Richard Dana
Boysie Day *
Nate Dechoretz (2003)
Jim Dewlen (1979)*
Paul Dresher *
Ken Dunster (1993)*
Matt Elhardt (2005)
Clyde Elmore (1994)
Bill Fischer
Dick Fosse *
Tad Gantenbein (2004)
Rick Geddes (2006)
George Gowgani
Bill Harvey *
David Haskell (2009)
F. Dan Hess (2001)*
Floyd Holmes (1979)
Nelroy Jackson (1997)
Warren Johnson (1977)*
Bruce Kidd (2009)
Jim Koehler
Harold Kempen (1988)
Don Koehler (2003)
Butch Kreps (1987)
Edward Kurtz (1992)
Art Lange (1986)
Wayne T. Lanini (2011)
J. Robert C. Leavitt (2010)
Oliver Leonard *
Jim McHenry
Bob Meeks
Bob Mullen (1996)
Robert Norris (2002)
Ralph Offutt
Jack Orr (1999)
Ruben Pahl (1990)
Martin Pruett
Murray Pryor *
Richard Raynor
Howard Rhoads *
Jesse Richardson (2000)
Ed Rose (1991)
Conrad Schilling *
Jack Schlesselman (1999)
Vince Schweers (2003)
Deb Shatley (2009)
Conrad Skimina (2003)
Leslie Sonder *
Stan Strew
Huey Sykes (1989)
Tom Thomson (1999)
Robert Underhill
Lee VanDeren (1983) *
Ron Vargas (2001)
Stan Walton (1988) *
Bryant Washburn (1988)
Steve Wright (2007)

*Deceased

CWSS AWARD OF EXCELLENCE MEMBERS LISTING

1985 June McCaskell, Jack Schlesselman & Tom Yutani
1986 Harry Agamalian, Floyd Colbert & Ed Rose
1987 Bruce Ames, Pam Jones, & Steve Orloff
1988 Bill Clark & Linda Romander
1989 Earl Suber
1990 Ron Hanson & Phil Larson
1991 John Arvik & Elin Miller
1992 Don Colbert & Ron Kelley
1993 Ron Vargas
1994 Jim Cook & Robert Norris
1995 Mick Canevari & Rich Waegner
1996 Galen Hiett & Bill Tidwell
1997 David Haskell & Louis Hearn
1998 Jim Helmer & Jim Hill
1999 Joe DiTomaso
2000 Kurt Hembree
2001 Steven Fennimore, Wanda Graves & Scott Steinmau s
2002 Carl Bell & Harry Kline
2003 Dave Cudney & Clyde Elmore*
2004 Michelle LeStrange & Mark Mahady
2005 Scott Johnson & Richard Smith
2006 Bruce. Kidd, Judy Letterman & Celeste Elliott
2007 Barry Tickes & Cheryl Wilen
2008 Dan Bryant & Will Crites
2008 Ken Dunster* & Ron Vargas*
2009 Ellen Dean & Wayne T. Lanini
2010 Lars W.J. Anderson & Stephen F. Colbert
2011 Jennifer Malcolm & Hugo Ramirez

*President's Award for Lifetime Achievement in Weed Science

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JOSEPH ACKLEY
HELENA CHEMICAL CO.
1269 E 9TH ST
CHICO, CA 95928
530-345-9969
jackley@helenaresearch.com

MICHAEL ANDREW
CLARK PEST CONTROL
555 N GUILD AVE
LODI, CA 95240
209-712-4663
mandrew@clarkpest.com

ANDREA AUSTEL
CYGNET ENTERPRISES WEST
5040 COMMERCIAL CIRCLE, STE. E
CONCORD, CA 94520
925-685-8081
aaustel@cygnetenterprises.com

DR. KASSIM AL-KHATIB
STATEWIDE IPM
ONE SHIELDS AVE
DAVIS, CA 95616
530-752-8350
kalkhatib@ucdavis.edu

MIKE ANSOLABEHERE
VALENT USA
7498 N REMINGTON
FRESNO, CA 93711
559-281-5994
MANSO@VALENT.COM

BRUCE BADZIK
NATIONAL PARK SERVICE
BLDG 201 FORT MASON
SAN FRANCISCO, CA 94123
415-561-2893
bruce_badzik@nps.gov

EDDIE ALLEN
ALBAUGH INC
284 POST AVE.
SANGER, CA 93657-3805
559-281-1125
EDDIEA@ALBAUGHINC.COM

GENE ARMOND
SAN LUIS & DELTA MENDOTA WATER AUTHORITY
P.O. BOX 2157
LOS BANOS, CA 93635
209-826-4788
gene.armond@sldmwa.org

DAVID BAKKE
USDA FOREST SERVICE
1323 CLUB DR.
VALLEJO, CA 94592
707-562-8916
dbakke@fs.fed.us

TONY ALVAREZ
GO GREEN PEST MGMT SVC
1203 CORBETT CYN RD.
ARROYO GRANDE, CA 93420
805-440-4811
GoGreenTA@aol.com

JOHN ATTAWAY
ATTAWAY RESEARCH
2121 FERN CANYON
UKIAH, CA 95482
707-463-2169
att52@saber.net

GREG BALDWIN
AG RX
PO BOX 243
LOS ALAMOS, CA 93440 805-925-
2463
gregb@agrx.com

KRISTEN ANDERSON
WILBUR-ELLIS CO.
3817 HERITAGE LN
CLOVIS, CA 93619
559-321-4146
keanderson@wilburellis.com

FRANK AULGUR
DUPONT LAND MANAGEMENT
PO BOX 92
DUNNIGAN, CA 95937
916-765-6308
l-frank.aulgur@usa.dupont.com

LALO BANUELOS
UCCE TULARE COUNTY
4437 B S. LASPINA ST.
TULARE, CA 93274
559-280-7813
gbanuelos@ucdavis.edu

DAVID ANDRADA
BAYER CROP SCIENCE
2221 WILD PLAINS CIR
ROCKLIN, CA 95765
916-969-6364
david.andrada@bayer.com

RUSSELL AURIA
RUSSELL AURIA PEST CONTROL SERVICES
P.O. BOX 265
SEASIDE, CA 93955
831-583-9155
rapcs@wildblue.net

REED L BARNES
DEPT. OF WATER RESOURCES
34534 118TH ST EAST P.O. BOX 1187
PEARBLOSSOM, CA 93553
661-944-8502
lquinter@water.ca.gov

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DON BARTEL
SIERRA CONSULTING & IPM LLC
P.O. BOX 1971
NEVADA CITY, CA 95959
530-432-7845
donald.bartel@sbcglobal.net

JOHN BATISTICH
NOR-CAL WEED CONTROL
PO BOX 2634
MINDEN, NV 89423
831-809-6118
JBATISTICH@GMAIL.COM

MIKE BATTLES
LOWER TULE RIVER IRRIGATION DISTRICT
357 E. OLIVE AVE.
TIPTON, CA 93272
559-752-5050
mbattles@ltrid.org

CARL E BELL
U.C.C.E. - SAN DIEGO
5555 OVERLAND AVE STE 4101
SAN DIEGO, CA 92123-1219
858-694-3386
cebell@ucdavis.edu

JUDY BELL
ZOOLOGICAL SOCIETY OF SAN DIEGO
PO BOX 33632
SAN DIEGO, CA 92163 619-253-
3238
judyann-bell@hotmail.com

WALTER BETSCHART
BETSCHART FARMS
18401 MILTON RD
FARMINGTON, CA 95230
209-848-1399
BETSCHARTFARM@AOL.COM

STEVE BICKLEY
MONTEREY AG RESOURCES
PO BOX 35000
FRESNO, CA 93745
559-499-2100
ALANIK@MONTEREYAGRESOURCES.COM

ALAN BISHOP
MONSANTO
2370 ERLING WAY
KINGSBURG, CA 93631
559-246-4306
alan.v.bishop@monsanto.com

DAVE C BLODGET
SEPRO CORPORATION
3300 NORD AVE
BAKERSFIELD, CA 93314
916-955-2464
daveb@sepro.com

JEFF BODDE
STATE OF CALIFORNIA
703 B ST.
MARYSVILLE, CA 95901
530-740-4940
jeffrey_bodde@dot.ca.gov

JOSE BOTELLO
AQUATIC ENVIRONMENTS, INC.
2511 CERRITOS RD
BRENTWOOD, CA 94513
510-418-6389
JBOTELLO@AQUAMOG.COM

JAMES W BRADLEY
SACRAMENTO COUNTY WATER RESOURCES
116A HOXSIE CT
FOLSOM, CA 95630
916-337-0808
jbpca@sbcglobal.net

VIKKI DEE BRADSHAW
IMPERIAL IRRIGATION DISTRICT
P.O. BOX 937
IMPERIAL, CA 92251
760-482-3610
vdbradshaw@iid.com

JACK BRAMKAMP
CROP PRODUCTION SERVICES
2622 THIRD ST
RIVERSIDE, CA 92507
909-802-4114
jack.bramkamp@cpsagu.com

GARY BRANESS
BAYER CROP SCIENCE
341 W. BLUFF AVE.
FRESNO, CA 93711
559-240-8834
gary.braness@bayer.com

JAMES BRAZZLE
GOWAN CO.
8071 LANGDALE CT.
SACRAMENTO, CA 95829
916-801-2892
jbrazzle@gowanco.com

BRIAN BRET
DOW AGRO SCIENCES
909 THOREAU COURT
ROSEVILLE, CA 95747
916-780-7477
BLBRET@DOW.COM

CASEY BRIERLEY
TARGET SPECIALTY PRODUCTS
4367 BRISTOLWOOD RD
PLEASANTON, CA 94588
559-905-2740
CBRIERLEY@COMCAST.NET

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MATTHEW BRISTOW
CROP PRODUCTION SERVICES
P.O. BOX 346
THERMAL, CA 92274
760-408-1928
WFSMATTHEW@YAHOO.COM

CHRIS BROOKS
KERN DELTA WATER DISTRICT
501 TAFT HWY
BAKERSFIELD, CA 93307
661-834-4656
TERRYS@KERNDELTA.ORG

NANCY T BROWNFIELD
EAST BAY REGIONAL PARK DISTRICT
PO BOX 5381
WALNUT CREEK, CA 94605
510-544-2343
nbrownfield@ebparks.org

DAVID BRYSON
RAINBOW FARMS
P.O. BOX 910
TURLOCK, CA 95381
209-669-5500
dbryson@vffi.com

TIM BUFFALO
BUFFALO LAND MANAGEMENT
1476 ANITA ST.
CARPINTERIA, CA 93013
805-896-1526
tbuff3@msn.com

KEITH BUNGO
WELL PICT, INC.
5201 STRONG CIRCLE
WATSONVILLE, CA 95076
831-475-1327
KBUNGO@WELLPICT.COM

DAVID BYNUM
BYNUM AG CONSULTING
1499 N. ROGERS
CLOVIS, CA 93611
559-325-3697
bynumag@sbcglobal.net

DAVID CANNELLA
BRITZ-SIMPLOT
P.O. BOX 9300
TERRA BELLA, CA 93270
559-535-4012
davec@britzinc.com

VICTOR CAVAZOS
BUENA VISTA WATER STORAGE DIST
POB 756
BUTTONWILLOW, CA 93206
661-324-1101

DAVID CHANG
SANTA BARBARA AG COMMISSIONER
263 CAMINO DEL REMEDIO
SANTA BARBARA, CA 93110 805-681-
5600
DCHANG@CO.SANTA-BARBARA.CA.US

DAVE CHEETHAM
HELENA CHEMICAL CO.
3155 SOUTHGATE LN.
CHICO, CA 95928
530-570-4070
dcheetham@helenaresearch.com

SIG CHRISTIERSON
MAJOR FARMS, INC.
P O BOX 719
SALINAS, CA 93902
831-422-9616
sig@majorfarmsinc.com

KEVIN J CHUMAN
CROP PRODUCTION SERVICES
5466 N. FELAND AVE.
FRESNO, CA 93711
559-435-4196
KCHUMAN@SPRYNET.COM

CHARLIE CHUMLEY
HELENA CHEMICAL CO.
646 E. PALO VERDE ST.
YUMA, AZ 95365
602-418-9587
charlie.chumley@runbox.com

STEPHEN COLBERT
DUPONT CROP PROTECTION
1413 SIERRA DR
ESCALON, CA 95320
559-287-3360
stephen.f.colbert@usa.dupont.com

PETER J COMPTON
VALLEY FARM SUPPLY
PO BOX 370
NIPOMO, CA 93444
805-928-7095
petevfs@yahoo.com

CHARLES CONTRERAS
BUENA VISTA WATER STORAGE DIST
PO BOX 756
BUTTONWILLOW, CA 93206
661-324-1101
CHARLES@BVH2O.COM

THOMAS COOPER
CALTRANS
7440 COLONY DR SP#19
LA MESA, CA 91942
949-517-8264
thomas_cooper@dot.ca.gov

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MICHAEL COX
BASF
1536 E. PRINCETON CT.
VISALIA, CA 93292
559-284-7555
michael.cox@basf.com

STEVE S DEITZ
SAWTOOTH AG RESEARCH
P.O. BOX 314
WOODLAKE, CA 93286
559-564-3209
STEVESDEITZ@GMAIL.COM

RANDY DODDS
MONTEREY AG RESOURCES
PO BOX 35000
FRESNO, CA 93745
559-499-2100
rdodds@montereyagresources.com

WILL T CRITES
WILL CRITES CONSULTING
649 TEAK CT.
WALNUT CREEK, CA 94598
925-938-1291
bugkiller@aol.com

GARLOCK DEWITT
DGVCS, INC.
1211 GARDEN AVE
ST HELENA, CA 94574
707-486-6118
dewitt.garlock@gmail.com

IGNACIO DOMINGUEZ
STATE OF CALIFORNIA-DTSE
7709 E. PAUL AVE.
CLOVIS, CA 93619
559-297-3959
idomingu@dtse.ca.gov

WES CROXEN
ALLIGARE, LLC
PO BOX 1175
MADERA, CA 93639
559-706-2460
wcroxen@alligare.com

TOM DEWITT
VALENT USA
7498 N REMINGTON AVE STE 102
FRESNO, CA 93711
559-269-1754
tom.dewitt@valent.com

TANYA DRLIK
CONTRA COSTA COUNTY
2313 EDWARDS ST
BERKELEY, CA 94702
925-335-3214
tdrlik@hsd.cccounty.us

KEM CUNNINGHAM
AMVAC
P.O. BOX 1580
CARMICHAEL, CA 95609
916-847-8981
kemc@amvac.net

TOM DINN
NUFARM AMERICAS INC.
837 E VOLK LN
SAN TAN VALLEY, AZ 85140
480-987-6404
tom.dinn@us.nufarm.com

DAVID C DUNGY
TESSENDERLO KERLEY
P.O. BOX 770
SHAVER LAKE, CA 93664 559-
269-3808
davidcdoubled@aol.com

DONALD D DAVIS
DAVIS FAMILY FARMS
6709 SADDLEBACK DRIVE
BAKERSFIELD, CA 93309
661-333-1952
DON7114@ATT.NET

JOE DITOMASO
U.C. DAVIS
U.C.D.-DEPT. OF PLANT SCIENCE MAIL STOP 4
162 ROBBINS HALL
DAVIS, CA 95616
530-754-8715
jmditomaso@ucdavis.edu

DANIEL DUNHAM
TESSENDERLO KERLEY
427 E. MICHIGAN
FRESNO, CA 93704
559-250-1264
DANDUNHAM123@MSN.COM

TERRY DAVIS
UNIVAR USA
1908 DENNIS DR
ANTIOCH, CA 94509
310-948-1299
terry.davis@univarusa.com

GARY DODD
GROWERS AG SERVICE
2833 KIRA CT
YUBA CITY, CA 95993
530-671-3571
gdodd@tremontag.com

JESS DURAN
SAN LUIS & DELTA MENDOTA WATER AUTHO
P.O. BOX 2157
LOS BANOS, CA 93635 209-826-
4778

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FRED ECKERT
BASF TURF & ORNAMENTAL
3604 PINE AVE.
MANHATTAN BEACH, CA 90266
310-220-9159
fred.eckert@basf.com

MATT EHLHARDT
TREMONT LYMAN GROUP
363 PICHOLINE WAY
CHICO, CA 95928
530-891-0651
mehlhardt@tremontag.com

PAUL J ESCOBAR
SSI MAXIM CO.
5199 W HOLLY HILL DR
BOISE, ID 83703
208-331-3189
PESCOBAR@SSIMAXIM.COM

DARRELL ESPE
ECO COVER LLC
16072 GOTHARD ST
HUNTINGTON BEACH, CA 92647
877-636-2404
DARRELL.ESPE@ECOCOVER.COM

DALE A EVENSON
SLO FARM SUPPLY
7455 CASEY DRIVE
SAN MIGUEL, CA 93451
805-712-2589

DUANE EWING
EWING & ASSOCIATES
1812 OLVERA DR.
WOODLAND, CA 95776
530-662-8414
duane@ewing-associates.com

LARRY L FAUSETT
3739 MERU LANE
SANTA BARBARA, CA 93105
805-705-5529
LLFAUSETT@GMAIL.COM

PHILIPPE J FAVIER
FAVIER FARMS
6049 S. LONE TREE RD.
MERCED, CA 95341
209-722-6435
favierfarms@aol.com

JONA L FEIL ABATE-A-
WEED
7104 PALM TREE CIR
BAKERSFIELD, CA 93308
661-392-9028
Joe@abateaweed.com

STEVEN FENNIMORE
UNIVERSITY OF CALIFORNIA
1636 E ALISAL ST
SALINAS, CA 93905
831-755-2896
safennimore@ucdavis.edu

JIMMY FLORES
CALTRANS
POB 2048
CALTRANS MAINT
STOCKTON, CA 95201
209-948-7259
jimmy_flores@dot.ca.gov

LOUIS FONTES
KERN DELTA WATER DISTRICT
501 TAFT HWY
BAKERSFIELD, CA 93307
661-834-4656

DAN FOREY
BIO RESEARCH
1738 N. FOWLER AVE.
FRESNO, CA 93727
559-455-5660
DAN.FOREY@BIO-RESEARCH.NET

JAMES FOWLER
CALTRANS
4821 ADOHR LN.
CAMARILLO, CA 93012
805-389-1565
james_fowler@dot.ca.gov

SALVATORE FRANCIS
DEL MESA CARMEL
500 DEL MESA DR
CARMEL, CA 93923
831-624-1853

ANTHONY FURLONG
PARAMOUNT FARMING CO.
1596 AVE A
KINGSBURG, CA 93631
559-479-9649
anthonyf@paramountfarming.com

JEFF GALLAGHER
CSU FRESNO
1199 DIANE AVE UNIT C
KINGSBURG, CA 93631
559-331-7611
jgallagher@mail.fresnostate.edu

JOSEPH GALLAGHER
VALENT USA
P.O. BOX 418
DURHAM, CA 95938
530-343-3067
jgall@valent.com

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TAD H GANTENBEIN
1608 MCCLAREN DR.
CARMICHAEL, CA 95608
916-539-6722
tadg@surewest.net

STEVEN GOULD
MONSANTO
37185 SANTA ROSA GLEN DR.
MURRIETA, CA 92562
951-894-2006
steven.d.gould@monsanto.com

GREG HALLQUIST
CERTIS USA
8889 MONTEREY OAKS DR
ELK GROVE, CA 95758
916-838-9908

NICHOLAS GIANNECCHINI
WILBUR-ELLIS CO.
1850 N. 1ST ST.
DIXON, CA 95620
916-997-3574
ngiannecchini@wilburellis.com

PHIL GRAU
PHIL GRAU CONSULTING
3064 W. WELLINGTON LANE
FRESNO, CA 93711
559-260-5959
philgrau@aol.com

BONNIE HANSEN
TARGET SPECIALTY PRODUCTS
1155 MABRY ROAD
SAN JOSE, CA 95133
408-293-6032

NEAL GIFFIN
MONTEREY AG RESOURCES
P.O. BOX 35000
FRESNO, CA 93745 559-
499-2100
NGIFFIN@BAK.RR.COM

STUART GRAY
SIERRA PACIFIC INDUSTRIES
8246 CHURN CREEK RD.
REDDING, CA 96002
530-604-1288
sjgray@spi-ind.com

MARK P HANSEN
CPS-TIMBERLAND DIVISION
328 7TH AVE
SEASIDE, OR 97138
503-703-6315
mark.hansen@cpsagu.com

CELESTE GILBERT
MARRONE BIO INNOVATIONS
4141 COWELL BLVD #8
DAVIS, CA 95616
530-400-4864
cgilbert@marronebio.com

JIM GREIL
ROCKY MOUNTAIN AGRONOMICS
5375 EASTLAKE BLVD
WASHOE VALLEY, NV 89704 775-
771-5510
jimgreil@clearwire.net

BRAD HANSON
UNIVERSITY OF CALIFORNIA DAVIS
PLANT SCI DEPT M/S4 ONE SHIELDS AVE
DAVIS, CA 95616
530-752-8115
bhanson@ucdavis.edu

BRENDAN GILBRIDE
MICHAEL WOLF VINEYARD SERVICES, INC.
P.O. BOX 3540
YOUNTVILLE, CA 94599
707-255-4084
brendan@mwvsinc.com

JOE GUERRA
DWR
4201 SABODAN RD
BAKERSFIELD, CA 93313
661-858-5534
JGUERRA@WATER.CA.GOV

RONALD HARDING
HARDING FARMING
242 N. HARDING RD
MODESTO, CA 95357
209-522-4159
rharding@bigvalley.net

RUSSELL GILLETT
TR FARMS
POB 15
LOCKWOOD, CA 93932
805-801-9051
russgillett@gmail.com

MICHAEL L HAILE
LINWOOD SUPPLY, INC.
PO BOX 463
DIXON, CA 95620
707-678-5087
michael@linwoodsupply.com

DAVE K HATTEM
COUNTY OF MARIN PARKS
40 PINETREE CIRCLE
COTATI, CA 94931
415-713-5075
DHattem@co.marin.ca.us

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CHRISTOPHER HAUSER
SANTA LUCIA CONSERVANCY
26700 RANCHO SAN CARLOS RD
CARMEL, CA 93923
831-626-8595
chauser@slconservancy.org

CLIFF HEDBERG
GROWERS AG SERVICE
325 S ALMOND ST
DIXON, CA 95620
530-681-8329
chedberg@tremontag.com

JOHN HELM
BASF
3586 N. DEL REY AVE.
SANGER, CA 93657
559-618-0865
john.helm@basf.com

KURT HEMBREE
U.C.C.E., FRESNO
1720 S MAPLE AVE
FRESNO, CA 93702
559-456-7556
kjhembree@ucdavis.edu

HANS A HERKERT
GROWERS AG SERVICE
2100 EVERGLADE RD
YUBA CITY, CA 95993
530-510-5315
hherkert@tremontag.com

MAHLON HILE
6309 N. 9TH ST.
FRESNO, CA 93710
559-284-4254
mahlon_hile@csufresno.edu

TED HUCKABY
ARVIN-EDISON WSD
PO BOX 175
ARVIN, CA 93203
661-854-5573
thuckaby@aewsd.org

JOSE HUERTA
J.G. BOSWELL COMPANY
P.O. BOX 877
CORCORAN, CA 93212
559-992-5011
jhuerta@jgboswell.com

NORMAN HUGHES
4131 WALLACE RD
SANTA ROSA, CA 95404
707-539-0140

EDWARD P HULME
COUNTY OF MARIN PARKS
3501 CIVIC CENTER DR #260
SAN RAFAEL, CA 94903
415-499-6531
ehulme@co.marin.ca.us

RICHARD HURSTAK
CROP SCIENCE SERVICES
710 RIVER OAKS DR
PASO ROBLES, CA 93445
805-459-6400
HURSTAK@CROPSCISER.COM

SHAUN HYDE
SEPRO CORPORATION
11550 N. MERIDIAN ST. #600
CARMEL, IN 46032
317-580-8097
shaunh@sepro.com

LYNDON INOUYE
VALENT USA
P O BOX 183
KINGSBURG, CA 93631
559-269-0324
lyndon.inouye@valent.com

JOHN JACHETTA
DOW AGRO SCIENCES
985 MAXWELL LN
ZIONSVILLE, IN 46077
317-337-4686
JJJACHETTA@DOW.COM

JIM M JACKSON
U.C. DAVIS
36604 CO. RD. 17
WOODLAND, CA 95695
530-752-2173
jmjackson@ucdavis.edu

CHARLES E JEFFRIES
CONTRA COSTA COUNTY PWD
2475 WATERBIRD WAY
MARTINEZ, CA 94553
925-313-2280
cjeff@pw.cccounty.us

MANUEL JIMENEZ
BAYER CROP SCIENCE
323 OLD LINE AVE.
EXETER, CA 93221
559-592-5643
manuel.jimenez@bayercropscience.com

SCOTT A JOHNSON
WILBUR-ELLIS CO.
1710 FLUETSCH CT.
STOCKTON, CA 95207
916-712-0499
sjohnson@wilbur-ellis.com

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WALT JOHNSON
AG RX
P.O. BOX 2008
OXNARD, CA 93034
805-407-9907
wjohnson@tremontag.com

TOM KELM
MONTEREY AG RESOURCES
P O BOX 35000
FRESNO, CA 93745
559-499-2100
tkelm@montereyagresources.com

MARJA KOIVUNEN
MARRONE BIO INNOVATIONS, INC.
2121 2ND ST STE. B-107
DAVIS, CA 95618
530-750-2800
mkoivunen@marroneorganics.com

RICHARD D JONES
STATE OF CALIFORNIA - DWR
34534 116TH ST EAST POB 1187
PEARBLOSSOM, CA 93553
661-944-8502
RICHJONS@WATER.CA.GOV

MATT KENNEY
TARGET SPECIALTY PRODUCTS
1059 W GENEVA DR
TEMPE, AZ 85282
480-517-0755
MATT.KENNEY@TARGET-SPECIALTY.COM

KEVIN KRAKE
ALLIGARE, LLC
26 MENINDEE CRESCENT
KIALLA VICTORIA, 3631
+61 3 5823 5059
KKRAKE@ALLIGARE.COM

SCOTT JORGENSEN
PACIFIC AGRONOMICS
44 AMBER AVE
CLOVIS, CA 93611
559-313-7929
sjorgensen@pacificagronomics.com

MARYAM KHOSRAVIFARD
CDPR
1001 I ST
SACRAMENTO, CA 95630
916-324-3530
mkhosravifard@cdpr.ca.gov

JERRY KREBS
TESSENDERLO KERLEY
8024 FOLSOM AUBURN RD
FOLSOM, CA 95630
916-719-0644
jkrebs@tkinet.com

JAY KASHETA
CLEAN LAKES, INC
PO BOX 3186
MARTINEZ, CA 94553
925-957-1905
info@cleanlake.com

KENT KIBBLE
CALTRANS
POB 2048
CALTRANS MAINT
LODI, CA 95242
209-948-7259
kent_kibble@dot.ca.gov

TIM KSANDER
CHEMINOVA, INC.
1695 GREENWOOD WAY
YUBA CITY, CA 95993 530-
218-5208
tim.ksander@cheminova.com

STEVE O KAWAGUCHI
SOUTHLAND SOD FARMS
136 COTTAGE GROVE AVE
CAMARILLO, CA 93012
805-431-2749
steve@sod.com

BRUCE E KIDD
DOW AGRO SCIENCES
39962 VIA ESPANA
MURRIETA, CA 92562-5732
951-698-3081

GUY KYSER
U.C. DAVIS
27 BLISS AVE
WOODLAND, CA 95695
530-867-2344
gbkyser@ucdavis.edu

GREG KAZARIAN
FOWLER PACKING CO.
1298 W. FREMONT
FRESNO, CA 93711
559-281-8472
greg@fowlerpacking.com

COURTNEY KITE
SILENT FIRE INC.
P.O. BOX 91001
PASADENA, CA 91109
323-244-7144
silentfirewildflowers@gmail.com

FRANKIE LAM
BRANDT CONSOLIDATED
19243 DOVEWOOD CT
SALINAS, CA 93908
831-676-6238
wkflam@brandtconsolidated.com

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BENJAMIN LAMBRECHTSEN
B & J TRADING
PO BOX 3356
CENTRAL POINT, OR 97502
541-878-5074
bjtrading@embarqmail.com

TOM LANINI
U.C. DAVIS
1 SHIELDS AVE-DEPT PLANT SCIENCES,MAILSTOP 4
DAVIS, CA 95616
530-752-4476
wtlanini@ucdavis.edu

LANE LARUE
LA RUE AG CONSULTING
PO BOX 8314
WOODLAND, CA 95776
530-681-8338
LANELPCA@SBCGLOBAL.NET

MICHELLE LE STRANGE
U.C.C.E.-TULARE COUNTY
4437-B S. LASPINA ST.
TULARE, CA 93274
559-684-3320
mlestrange@ucdavis.edu

MAC LEARNED
FMC CORP
1126 OLD PEACHY CANYON RD
PASO ROBLES, CA 93446
805-440-8445
leland.learned@fmc.com

JOSEPH LEBOW
CROP PRODUCTION SERVICES
P.O. BOX 8071
VISALIA, CA 93290
559-304-1601
joseph.lebow@cpsagu.com

CHARLES R LEEGER
6590 KAREN LANE
RIVERSIDE, CA 92509
951-212-8970
drdeermouse@yahoo.com

DAN LEMAY
DWR
4201 SABODAN RD
BAKERSFIELD, CA 93313
661-858-5541
DLEMAY@WATER.CA.GOV

ROBERT LETTERMAN
TESSENDERLO KERLEY
18570 RANCHITO DEL RIO DR
SALINAS, CA 93908
831-455-1366
rletterman@tkinet.com

LARRY D LIGGETT
WM BOLTHOUSE FARMS INC.
7200 E BRUNDAGE LN
BAKERSFIELD, CA 93307
661-889-0969
LLIGGETT@BOLTHOUSE.COM

PAUL LOFTHOUSE
PO BOX 3733
PASADENA, CA 91031
626-201-0666
manfordway@hotmail.com

EMILIO LOPEZ
COUNTY OF SAN BERNARDINO
777 E RIALTO AVE
SAN BERNARDINO, CA 92415
909-387-2105
ELOPEZ@AWM.SBCOUNTY.GOV

LARRY G MADDOX
WILBUR ELLIS CO.
5342 S FIG AVE
FRESNO, CA 93706
559-250-8017
lnm2460@aol.com

MARK M MAHADY
MARK M. MAHADY & ASSOCIATES INC.
P.O. BOX 1290
CARMEL VALLEY, CA 93924
831-274-2344
markmahady@aol.com

LAWRENCE MARAIS
MONTEREY AG RESOURCES
PO BOX 35000
FRESNO, CA 93745 559-499-
2100X130
lmarais@montereyagresources.com

LARRY MARQUES
SAN LUIS DELTA-MENDOTA WATER AUTHORI
P.O. BOX 2157
LOS BANOS, CA 93635 209-826-
4788
larry.marques@sldmwa.org

TODD MAYHEW
VALENT
1143 N ABILENE DR
GILBERT, AZ 85233
480-323-6227
tmayh@valent.com

JERRY MAYS
DWR
4201 SABODAN ST
BAKERSFIELD, CA 93313
661-858-5516
JERRYM@WATER.CA.GOV

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SUZANNE R MCCASLIN
SAN LUIS OBISPO FARM SUPPLY
224 TANK FARM RD
SAN LUIS OBISPO, CA 93401 805-543-3751
slstore@farmsupplycompany.com

BRYAN W MCCLEERY
AMVAC
5057 ABUELA DR
SAN DIEGO, CA 92124
858-874-4430
bryanm@amvac.net

MILT MCGIFFEN
UNIVERSITY OF CALIFORNIA
U.C.R.-4101 BATCHELOR HALL EXT.
RIVERSIDE, CA 92521-0124
909-560-0839
milt@ucr.edu

BRYAN MELIKIAN
J.G. BOSWELL COMPANY
6459 N TAMERA
FRESNO, CA 93711
661-599-4960
bmelikian@jgboswell.com

DENNIS K MERRILL
KILLROY PEST CONTROL, INC.
1175 DELL AVENUE
CAMPBELL, CA 95008
408-378-0441

BEAU MILLER
DOW AGRO SCIENCES
P.O. BOX 292609
SACRAMENTO, CA 95829
916-296-2811
bjmiller@dow.com

JOHN MILLER
8652 CERES AVE
KNIGHTS LANDING, CA 95645
530-437-2381

RICK MILLER
DOW AGRO SCIENCES
9854 OAKPLACE EAST
FOLSOM, CA 95630
rmiller@dow.com

PAUL MIRASSOU
B & T FARMS
P.O. BOX 1429
GILROY, CA 95021
408-968-8483

JAMES MITCHELL
COUNTY OF SAN BERNARDINO
777 E. RIALTO AVE.
SAN BERNARDINO, CA 92415
909-387-2105
jmitchell@awm.sbcounty.gov

JAMES MOLATORE
PARAMOUNT CITRUS
11266 W. JENSEN
FRESNO, CA 93706
559-846-9499
jmolatore@paramountcitrus.com

DAVID MOORE
405 CLUBHOUSE DR
APTOS, CA 95003
831-688-1905
elvismoore@sbcglobal.net

JOHN A MOORE
GROWERS CROP CONSULTING
7816 CAROL SUE CT
BAKERSFIELD, CA 93308
661-399-8813
GROWERS@BAK.RR.COM

TOM MOORE
BELLA VISTA LANDSCAPE
340 TWIN PINES DR
SCOTTS VALLEY, CA 95066
408-410-2003
tmoore@bvls.com

ED MORA
D'ARRIGO BROTHERS
PO BOX 850
SALINAS, CA 93902
831-455-4400
EMORA@DARRIGO.COM

SCOTT MOREHEAD
AGRIAN INC.
2665 N. AIR FRESNO DR. STE. 101
FRESNO, CA 93727
559-492-5550
scott@agrian.com

MARCELO MORETTI
CSU FRESNO
4909 N BACKER ST APT 116
FRESNO, CA 93726
559-681-4138
MLMORETTI1983@GMAIL.COM

DEAN K MOSDELL
SYNGENTA
501-I S. REINO RD. #183
NEWBURY PARK, CA 91320 805-480-0514
dean.mosdell@syngenta.com

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JAMES P MUELLER
DOW AGRO SCIENCES
175 MESQUITE CT.
BRENTWOOD, CA 94513
925-634-8768
jpmueller@dow.com

JEFF NULL
SOLANO IRRIGATION DISTRICT
940 SOMMER DR
DIXON, CA 95620
707-673-6993
jeffnull@earthlink.net

JOEY PALUMBO
MPM FARMING CO, INC
2435 FAIRMONT AVE
CLOVIS, CA 93611
559-285-3410
joeypalumbo@mpmfarming.com

DOUG MUNIER
U.C.C.E.-GLENN COUNTY
P.O. BOX 697
ORLAND, CA 95963
530-865-1153
djmunier@ucdavis.edu

THOMAS OLIVARES
COLLEGE OF THE REDWOODS
P.O. BOX 886
EUREKA, CA 95502
707-444-1586
THOMAS-OLIVARES@REDWOODS.EDU

SHARON O PARKER
941 HUNTINGTON COMMON
FREMONT, CA 94536-3205
510-552-3001
soparker@yahoo.com

DONALD MYERS
BAYER ES
2 T.W. ALEXANDER DR
DURHAM, NC 27709
919-845-2529
don.myers@bayer.com

CHRIS OLSEN
BAYER ES
22978 CATT RD
WILDOMAR, CA 92595
909-261-8228
CHRIS.OLSEN@BAYER.COM

CRAIG PAULY
BASF
16791 S AVE 2 1/4 E
YUMA, AZ 85365
CRAIG.PAULY@BASF.COM

WILLIAM NANTT
CALTRANS
1744 WINDJAMMER CT
LODI, CA 95242
209-663-2081
wnantt@sbcglobal.net

SCOTT R ONETO
UCCE TUOLUMNE COUNTY
1200B AIRPORT RD
JACKSON, CA 95642
209-223-6834
sroneto@ucdavis.edu

MONTE B PECKINPAH
VALENT
5444 W. GROVE CT
VISALIA, CA 93291
559-972-4419
MPECK@VALENT.COM

MIGUEL NEGRETE
RIVERSIDE COUNTY FLOOD CONTROL
1995 MARKET ST
RIVERSIDE, CA 92501
951-955-4348
manegrete@rcflood.org

STEVE B ORLOFF
UNIVERSITY OF CALIFORNIA
1655 S MAIN ST
YREKA, CA 96097
530-842-2711
sborloff@ucdavis.edu

GAIL E PEREZ
COUNTY OF SAN LUIS OBISPO
2156 SIERRA WAY STE A
SAN LUIS OBISPO, CA 93401
805-781-5910
gperez@co.slo.ca.us

ROBERT F NORRIS
UNIV OF CA-WEED SCIENCE PROGRAM
U.C. DAVIS
DAVIS, CA 95616
530-752-0619
RFNORRIS@UCDAVIS.EDU

GARY W OSTEEN
RUSH, MARCROFT & ASSOC.
P O BOX 20006
BAKERSFIELD, CA 93390
661-665-2824
gwosteen@aol.com

DON F PERRY
J.R. SIMPLOT CO.
1841 NORA DR.
HOLLISTER, CA 95023
831-229-9337
don.perry@simplot.com

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JOHN PETERS
CALTRANS
POB 2048
CALTRANS MAINT
STOCKTON, CA 95201
209-948-7259
JOHN_PETERS@DOT.CA.GOV

JOHN PETERSON
313 ROBINSON ST
SONOMA, CA 95476
707-327-7937
johnjdp@comcast.net

ROBERT PETERSON
HARVEY LYMAN CO
325 RAINIER CT
RIO VISTA, CA 94571
707-374-2102
gpeterson@citlink.net

LAURA PETRO
CDFA
935 E. DISCOVERY LN.
ANAHEIM, CA 92801
714-520-6866
lpetro@cdfa.ca.gov

NEIL PHILLIPS JR
UPI
806 LEMON AVE
PATTERSON, CA 95363
209-481-2451
neil.phillips@uniphos.com

MARK A PINHEIRO
MILLER CHEMICAL
5222 COSUMNES DR APT 126
STOCKTON, CA 95219
209-481-9063
markpnhr@yahoo.com

BARBARA J POLLOCK
PO BOX 297
DIXON, NM 87527
505-579-9199
mulchman@cybermesa.com

FAITH POTTER
TESSENDERLO KERLEY
1037 E. VARTIKIAN
FRESNO, CA 93710
559-269-1241
fpotter@tkinet.com

STEVE PYLE
SYNGENTA
P.O. BOX 18300
GREENSBORO, NC 27455
336-632-2236
steve.pyle@syngenta.com

MATTHEW QUIST
AQUATROLS
1208 24TH ST
SAN DIEGO, CA 92102
661-319-6079
MCQUIST@GMAIL.COM

JOHN RACHUY
U.C. DAVIS
1636 E. ALISAL ST
SALINAS, CA 93905
831-594-8750
jsrachuy@ucdavis.edu

CURTIS RAINBOLT
BASF
4763 N PACIFIC AVE
FRESNO, CA 93705
559-430-4418
curtis.rainbolt@basf.com

HUGO RAMIREZ
DUPONT CROP PROTECTION
28687 ROAD 148
VISALIA, CA 93292-9262
559-246-5833
hugo.t.ramirez@usa.dupont.com

HUGH RATHBUN
DELLAVALLE LABORATORY, INC.
1910 W. MCKINLEY STE. 110
FRESNO, CA 93728
559-233-6129
hrathbun@dellavallelab.com

RUDY RAYA
CALTRANS
POB 2048
STOCKTON, CA 95201
209-948-7259
RUDY_RAYA@DOT.CA.GOV

RICH RECORDS
TARGET SPECIALTY PRODUCTS
15415 MARQUARDT AVE
SANTA FE SPRINGS, CA 90670-5711
562-802-2238
rich.records@target-specialty.com

JESSE M RICHARDSON
DOW AGRO SCIENCES
9330 10TH AVE
HESPERIA, CA 92345
760-949-2565
jmrichardson@dow.com

DAVID H RILEY
PO BOX 1049
HAMILTON, MT 59840
209-993-1124
rileydavidh@gmail.com

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JASON ROBBINS
TARGET SPECIALTY PRODUCTS
9120 HUNTERS CREEK WAY
CHOWCHILLA, CA 93610
559-313-4080
jason.robbins@target-specialty.com

JOHN A RONCORONI
U.C.C.E. NAPA
1710 SOSCOL AVE STE 4
NAPA, CA 94559
707-253-4221
jaroncoroni@ucdavis.edu

ANIL SHRESTHA
CSU FRESNO
2415 E SAN RAMON AVE M/S AS 72
DEPT OF PLANT SCIENCE
FRESNO, CA 93740
559-278-5784
ashrestha@csufresno.edu

ALICE ROBERTS
BIOSAFE SYSTEMS
737 MIRAMAR DR
FULLERTON, CA 92831
714-381-8775
aroberts@biosafesystems.com

VICKI E ROSE WILBUR-
ELLIS CO.
P.O. BOX 509
WHEATLAND, CA 95692
916-813-9836
vrose@wilburellis.com

DAVE SILLS
CROP PRODUCTION SERVICES
3301 STONEHURST DR
EL DORADO HILLS, CA 95762
916-837-6800
DAVESILLS@ATT.NET

JOSEPH RODRIGUEZ
D AND D PEST CONTROL, INC.
1825 E. 21ST ST.
MERCED, CA 95340
209-383-6070

PAUL RYAN
STATE OF CALIFORNIA-DBW
823 GRIFFITH WAY
WHEATLAND, CA 95692
530-633-9494
PRYAN@DBW.CA.GOV

MICHAEL SILVEIRA
WILBUR ELLIS CO.
4553 CO. RD. RR
ORLAND, CA 95963
916-952-2468

NICK RODRIGUEZ
D AND D PEST CONTROL, INC.
1825 E. 21ST ST.
MERCED, CA 95340
209-383-6070

JOHN W SCHEIMER
P.O. BOX 248 909 pendleton
ARBUCKLE, CA 95912
530-476-2663
jwscheimer@frontiernet.net

CONRAD SKIMINA
1248 CAPRA WAY
FALLBROOK, CA 92028-9244
760-723-4227
cskimina@aol.com

RAMIRO RODRIGUEZ
D AND D PEST CONTROL, INC.
1825 E. 21ST ST.
MERCED, CA 95340
209-383-6070

JACK SCHLESSELMAN
726 E KIP PATRICK DR
REEDLEY, CA 93654
559-638-7003
rangeoflightphoto@comcast.net

PAUL K SMITH
HELENA CHEMICAL CO.
3155 SOUTHGATE LN
CHICO, CA 95928
530-864-6443
smithp@helenachemical.com

ERNIE RONCORONI
THE TREMONT GROUP, INC.
PO BOX 1818
WOODLAND, CA 95776
530-662-5442
ernie@tremontag.com

JERRY SCHMIERER
UNIVERSITY OF CALIFORNIA
PO BOX 180
COLUSA, CA 95932
530-458-0575
jlschmierer@ucdavis.edu

RICHARD F SMITH
UNIVERSITY OF CALIFORNIA
1432 ABBOTT
SALINAS, CA 93901
831-759-7357
rifsmith@ucdavis.edu

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STEPHEN SMITH
ARVIN EDISON WSD
PO BOX 212
ARVIN, CA 93203
661-854-5573
stephensmith5295@sbcglobal.net

WAYNE J STEELE
DUPONT CROP PROTECTION
2114 E OMAHA AVE
FRESNO, CA 93720-0413
559-323-5375
wayne.j.steele@usa.dupont.com

TERRY R SUTTON
KERN DELTA WATER DISTRICT
501 TAFT HWY
BAKERSFIELD, CA 93307
661-834-4656
terrys@kerndelta.org

STEVE SNIDER
L.A. COUNTY DPW
2032 BUCKINGHAM PLACE
GLENDALE, CA 91206
818-516-7845
kingdaddyrat@aol.com

JOHN STELLING
CPS
1901 SHELTON DR
HOLLISTER, CA 95023
831-637-9221
john.stelling@cpsagu.com

GLENN A SWEANY
SANTA BARBARA CO. FLOOD CONTROL
3405 DRIFTWOOD
SANTA MARIA, CA 93455 805-
934-6125

DAVID STACH
STATE OF CALIFORNIA
703-B STREET - 5TH FLOOR
MARYSVILLE, CA 95901
530-740-4882
david_stach@dot.ca.gov

FORREST STEPHANIAN
CALIFORNIA VETERAN SUPPLY INC
755 THIRD #B
CLOVIS, CA 93612
888-602-7959
forrest@veteransupply.com

CHUCK D SYNOLD
TARGET SPECIALTY PRODUCTS
2478 N. SUNNYSIDE AVE
FRESNO, CA 93727
559-291-7740
tspsynold@earthlink.net

WAYNE STANDRIDGE
J.G. BOSWELL COMPANY
PO BOX 877
CORCORAN, CA 93212
559-992-5011
wstandridge@jgboswell.com

C. SCOTT STODDARD
U.C.C.E.
2145 WARDROBE AVE
MERCED, CA 95340
209-385-7403
CSSTODDARD@UCDAVIS.EDU

TERRI THOMAS
DUPONT CROP PROTECTION
624 MERLOT AVE
MADERA, CA 93637
559-903-7171
terri.l.thomas@usa.dupont.com

STEVEN STARCHER
1420 N. FLOYD AVE.
FRESNO, CA 93723
559-289-8874
SASTARCHER@GMAIL.COM

STEVE STRINGER
MONTEREY AgRESOURCES
2475 LASSALETTE CT
RIVERSIDE, CA 92503
559-499-2100
sstringer@brandtconsolidated.com

RONALD J THOMSEN
MANA
2111 W VARTIKIAN AVE
FRESNO, CA 93711-1846
559-696-7171
rthomsen@yahoo.com

RAYMOND STARRETT
ORO AGRI, INC.
990 TROPHY CLUB DR
TROPHY CLUB, TX 76262
817-491-2057

JAMES STURGES
DOW AGRO SCIENCES
2831 ASHLAND DR
ROSEVILLE, CA 95661
916-774-9858
jesturges@dow.com

JEFF A TIENKEN
T & T AG SERVICES
P O BOX 915
LINDSAY, CA 93247-0915
559-562-6554
tienkenj@yahoo.com

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STEVE TJOSVOLD
U.C.C.E.
1432 FREEDOM BLVD
WATSONVILLE, CA 95076
831-763-8013
satjosvold@ucdavis.edu

AVELINO VALENCIA
RIVERSIDE COUNTY FLOOD CONTROL
1995 MARKET ST
RIVERSIDE, CA 92501
951-955-4348
acvalencia@rcflood.org

MARK E WANDER
SANTA CLARA VALLEY WATER DISTRICT
5750 ALMADEN EXPRESSWAY
LOS GATOS, CA 95118
408-483-9241
mwander@valleywater.org

EDWARD TOBIAS
MODESTO IRRIGATION DISTRICT
10306 RIO SOMBRA CT
OAKDALE, CA 95361
209-526-7637
edt@mid.org

RON VARGAS
RON VARGAS CONSULTING, LLC
20251 AVE 17 1/2
MADERA, CA 93637
559-395-3375
rvargasconsulting@gmail.com

RAYMOND WATJE
WILBUR-ELLIS CO.
5930 COURTLAND DR.
RIVERSIDE, CA 92506
951-682-1026
RWATJE@AOL.COM

JAMES TUTTLE
MONTEREY AG RESOURCES
P.O. BOX 35000
FRESNO, CA 93745
559-499-2100
jtuttle@montereyagresources.com

DAVID VITOLO
SYNGENTA
303 W FARRISS AVE
HIGH POINT, NC 27262
916-316-6951
david.vitolo@syngenta.com

HENRY WEAVER
CALTRANS
POB 2048
CALTRANS MAINT
STOCKTON, CA 95201
209-948-7259
henry_weaver@dot.ca.gov

BUZZ UBER
CROP INSPECTION SERVICE
31130 HILLTOP DR
VALLEY CENTER, CA 92082
760-805-3255
buzzuber@cs.com

GREG WAHL
BECKER UNDERWOOD
3329 MCCOWAN WAY
CARMICHAEL, CA 95608
925-519-2193
greg.wahl@beckerunderwood.com

JOHN WEBER
U.C. DAVIS
785 MAHER RD
WATSONVILLE, CA 95076
831-262-3206
jbweber@ucdavis.edu

JOHN USHER
17954 BERTA CANYON RD
SALINAS, CA 93907
831-214-3000
johnusherpca@gmail.com

E.T. WALGENBACH
HORIZON
25560 VIA CAZADOR
CARMEL, CA 93923
831-622-0491
WALGIES4@AOL.COM

NANCY WESTCOTT
GOAT THROAT PUMPS
60 SHELL AVE
MILFORD, CT 06460
646-486-3636
nwestcott@goatthroat.com

JOSE VALDEZ
D'ARRIGO BROTHERS
504 SAN FERNANDO
SALINAS, CA 93906
831-262-1408
JAVH02@YAHOO.COM

DOUG WALKER
SANTA BARBARA CO. FLOOD CONTROL
1312 LEONA ST
SANTA MARIA, CA 93454 805-934-
6125
DWALKER@CO.SANTA-BARBARA.CA.US

PAUL WESTCOTT
APPLIED BIOCHEMISTS
15420 N. 29TH ST.
PHOENIX, AZ 85053
800-558-5106
paulwestcott@appliedbiochemists.com

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DANIEL WICKHAM
WILBUR-ELLIS CO.
1 LOS PIONEROS
RANCHO SANTA MARGARITA, CA 92688
949-981-0945
dwickham@wilbur-ellis.com

FRANK WILLIAMS
WIND FALL FARMS 1
3009 E. CARDELLA
FIREBAUGH, CA 93622
559-659-3931

BILL YEOMAN
PERFORMANCE PEST MANAGEMENT
3958 VALLEY AVE STE D
PLEASANTON, CA 94555
510-220-5200
bill@performancepest.com

TOMMY WILDERMUTH
MILLER CHEMICAL
2798 S. PANORAMA AVE.
YUMA, AZ 85365
928-941-1657
onewapiti@gmail.com

MIKE WILLIAMS
MILLER CHEMICAL
P.O. BOX 1508
SHAFTER, CA 93263
661-201-8411

PATRICK J YOUNG
PAT YOUNG VEG MGMT CONSULTING
31665 ROCK CREEK RD
MANTON, CA 96059
530-474-1041
MANTONMAN1@YAHOO.COM

CHERYL WILEN
U.C.C.E.
5555 OVERLAND AVE STE. 4101
SAN DIEGO, CA 92123
858-694-2846
CAWILEN@UCDAVIS.EDU

ROB WILSON
U.C.C.E.
P.O. BOX 850
TULELAKE, CA 96134
530-667-5117
rgwilson@ucdavis.edu

DAVID ZACHARY
DWR
9502 TAMPICO CT
BAKERSFIELD, CA 93312
661-588-9082
DZACHARY@WATER.CA.GOV

LARRY WILHOIT
CDPR
1001 "I" ST PO BOX 4015
SACRAMENTO, CA 95812
916-324-4271
lwilhoit@cdpr.ca.gov

RON WOLFE
DWR
3906 VIA LA MADERA
BAKERSFIELD, CA 93314
661-316-8525
RONALDW@WATER.CA.GOV

ANN ZEMKE
CHASE HORTICULTURAL RESEARCH
BOX 529
MT AUKUM, CA 95656
530-391-3068
archase@chaseresearch.net

MICHAEL WILKINS
DWR
4517 SIAM CIR
BAKERSFIELD, CA 93307
661-303-3449

STEVEN D WRIGHT U.C.C.E.-
TULARE COUNTY 4437-B
SOUTH LASPINA ST TULARE,
CA 93274
559-685-3315
sdwright@ucdavis.edu

CYNTHIA A WILLIAMS
CALTRANS
9201 S. 7TH AVE
INGLEWOOD, CA 90305
310-990-5281
cynthia_williams@dot.ca.gov

HENRY C WU
CHEMTURA
1320 E EVERGLADE AVE
FRESNO, CA 93720
559-213-8274
Henry.wu@chemtura.com

CALIFORNIA WEED SCIENCE SOCIETY
Conference History

CONFERENCE	DATE HELD	LOCATION	PRESIDENT
1st	February 16, 17, 1949	Sacramento	Walter Ball
2nd	April 4, 5, 6, 1950	Pomona	Walter Ball
3rd	January 30, 31, Feb. 1, 1951	Fresno	Alden Crafts
4th	January 22, 23, 24, 1952	San Luis Obispo	Murray Pryor
5th	January 20, 21, 22, 1953	San Jose	Bill Harvey
6th	January 27, 28, 1954	Sacramento	Marcus Cravens
7th	January 26, 27, 1955	Santa Barbara	Lester Berry
8th	February 15, 16, 17, 1956	Sacramento	Paul Dresher
9th	January 22, 23, 24, 1957	Fresno	James Koehler
10th	January 21, 22, 23, 1958	San Jose	Vernon Cheadle
11th	January 20, 21, 22, 1959	Santa Barbara	J. T. Vedder
12th	January 19, 20, 21, 1960	Sacramento	Bruce Wade
13th	January 24, 25, 26, 1961	Fresno	Stan Strew
14th	January 23, 24, 25, 1962	San Jose	Oliver Leonard
15th	January 22, 23, 24, 1963	Santa Barbara	Charles Siebe
16th	January 21, 22, 23, 1964	Sacramento	Bill Hopkins
17th	January 19, 20, 21, 1965	Fresno	Jim Dewlen
18th	January 18, 19, 20, 1966	San Jose	Norman Akesson
19th	January 24, 25, 26, 1967	San Diego	Cecil Pratt
20th	January 22, 23, 24, 1968	Sacramento	Warren Johnson
21st	January 20, 21, 22, 1969	Fresno	Floyd Holmes
22nd	January 19, 20, 21, 1970	Anaheim	Vince Schweers
23rd	January 18, 19, 20, 1971	Sacramento	Dell Clark
24th	January 16, 17, 18, 19, 1972	Fresno	Bryant Washburn
25th	January 15, 16, 17, 1973	Anaheim	Howard Rhoads
26th	January 21, 22, 23, 24, 1974	Sacramento	Tom Fuller
27th	January 20, 21, 22, 1975	Fresno	Dick Fosse
28th	January 19, 20, 21, 1976	San Diego	Jim McHenry
29th	January 17, 18, 19, 1977	Sacramento	Les Sonder
30th	January 16, 17, 18, 1978	Monterey	Floyd Colbert
31st	January 15, 16, 17, 18, 1979	Los Angeles	Harry Agamalian
32nd	January 21, 22, 23, 24, 1980	Sacramento	Conrad Schilling
33rd	January 19, 20, 21, 22, 1981	Monterey	Lee Van Deren
34th	January 18, 19, 20, 21, 1982	San Diego	Dave Bayer
35th	January 17, 18, 19, 20, 1983	San Jose	Butch Kreps
36th	January 16, 17, 18, 19, 1984	Sacramento	Ed Rose
37th	January 21, 22, 23, 24, 1985	Anaheim	Hal Kempen
38th	January 27, 28, 19, 30, 1986	Fresno	Ray Ottoson
39th	January 26, 27, 28, 29, 1987	San Jose	Ken Dunster
40th	January 18, 19, 20, 21, 1988	Sacramento	George Gowgani
41st	January 16, 17, 18, 1989	Ontario	Ed Kurtz
42nd	January 15, 16, 17, 1990	San Jose	Dennis Stroud

(Continued on inside back cover)

(Continued from inside front cover)

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CONFERENCE	DATE HELD	LOCATION	PRESIDENT
43rd	January 21, 22, 23, 1991	Santa Barbara	Jack Orr
44th	January 20, 21, 22, 1992	Sacramento	Nate Dechoretz
45th	January 18, 19, 20, 1993	Costa Mesa	Alvin A. Baber
46th	January 17, 18, 19, 1994	San Jose	James Greil
47th	January 16, 17, 19, 1995	Santa Barbara	Nelroy Jackson
48th	January 22, 23, 24, 1996	Sacramento	David Cudney
49th	January 20, 21, 22, 1997	Santa Barbara	Jesse Richardson
50th	January 12, 13, 14, 1998	Monterey	Ron Vargas
51st	January 11, 12, 13, 1999	Anaheim	Scott Johnson
52nd	January 10, 11, 12, 2000	Sacramento	Steve Wright
53rd	January 8, 9, 10, 2001	Monterey	Matt Ehlhardt
54th	January 14, 15, 16, 2002	San Jose	Lars Anderson
55th	January 20,21,22, 2003	Santa Barbara	Bruce Kidd
56th	January 12,13,14, 2004	Sacramento	Pam Geisel
57th	January 10,11,12, 2005	Monterey	Debra Keenan
58th	January 16,17,18, 2006	Ventura	L. Robert Leavitt
59th	January 8,9,10, 2007	San Diego	Deb Shatley
60th	January 28, 29, 30, 2008	Monterey	Carl Bell
61st	January 12,13,14, 2009	Sacramento	Stephen Colbert
62nd	January 11,12,13, 2010	Visalia	Stephen Colbert
63rd	January 19, 20, 21, 2011	Monterey	David Cheetham

Proceedings

63rd ANNUAL

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Theme: Weed Control: Balancing Biology, Reality And Sustainability

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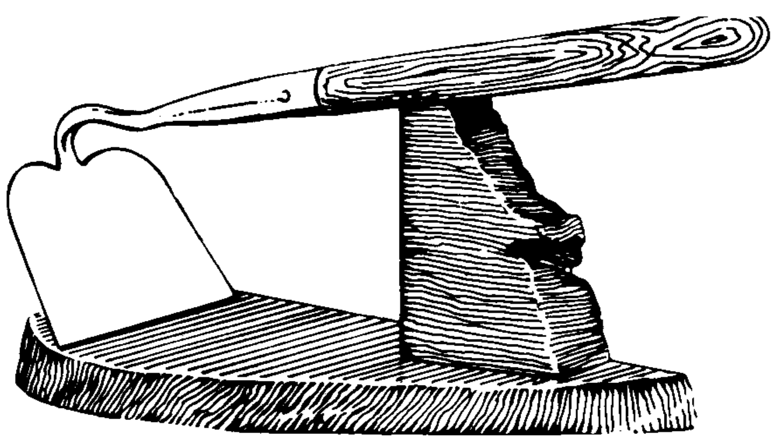
January 19, 20, & 21, 2011



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Website: www.cwss.org

Mode of Action of the Growth Regulator Herbicides

Joseph M. DiTomaso, University of California, Davis, Dept of Plant Sciences, Davis, CA 95616, jmditomaso@ucdavis.edu

Early Discovery of IAA and 2,4-D

Although IAA (indole acetic acid) has been know to chemists as long ago as 1904, the first isolation of an active auxin occurred in 1931 by two Dutch biochemists. They isolated a compound called "auxin A" from 33 gallons of human urine. The first generally accepted report of IAA in a higher plant was published by A.J. Haagen-Smit and coworkers in 1946.

The discovery of 2,4-D, and related chemicals, occurred independently by four research groups in Britain and the U.S. during World War II. This discovery revolutionized modern agriculture.

Since the synthesis of 2,4-D, a number of other synthetic auxins have become commercially available. Although these products are referred to as growth regulators or phytohormones (previously known as plant hormones), they really represent only one group of growth regulators, the auxins. Auxins can be divided into six major groups; indole acids, naphthalene acids, phenoxy carboxylic acids, benzoic acids, picolinic acid derivatives (also called pyridine carboxylic acids) and the quinoline carboxylic acids. The first group contains the natural product IAA, and does not contain any herbicides. IAA is highly unstable in plants and metabolizes too fast to be an effective synthetic herbicide. The naphthalene acids (NAA) are used in research but are not commercially available as herbicides. The other groups contain many well known herbicides; phenoxy carboxylic acids (2,4-D, 2,4,5-T, 2,4-DB, dichlorprop, MCPA, MCPB, mecoprop), benzoic acids (dicamba, chloramben), picolinic acids (aminopyralid, clopyralid, picloram, triclopyr), quinoline carboxylic acids (quinclorac), and one yet to be named family (aminocyclopyrachlor). These compounds are often called auxinic herbicides. Quinclorac has also been shown to have growth regulator activity on broadleaf species, although it is not typically considered to be an auxinic herbicide on grasses.

Mode of Action of the Auxins

IAA influences nearly every aspect of plant growth and development, it is thought to act as a ‘master hormone’ in the complex network of interactions with other growth regulators. Shoot tips, including the young leaves, are the center of most abundant naturally occurring auxin synthesis in higher plants. Other rich sources are root tips, enlarging leaves, flowers, fruits and seeds. One of the difficulties in studying the mechanism of auxin action is the multitude of different kinds of physiological processes that they appear to control. Recent evidence indicated there are IAA receptor sites (auxin-binding proteins) which unleashes a cascade of events. Auxins seem to be involved in a number of developmental functions, including phototropism, apical dominance, senescence, cell growth and differentiation, and root formation.

The initial response of plants to auxin treatment can be categorized into three phases. First, there is a rapid response (within minutes), simulated by low pH and perhaps due to auxin stimulating the pumping of protons into the cell wall and loosening it. During this phase ethylene synthesis is also increased. The second phase of the response occurs 35-45 min after treatment, and involves the synthesis of nucleic acids. The third phase is when the plants senesce and tissue decay occurs. During this phase chloroplasts are damaged and chlorosis develops, membranes are destroyed and the plant loses its vascular system integrity which leads to wilting, necrosis and finally death.

Acid-growth hypothesis

According to the acid-growth hypothesis auxins initiate an acidification mechanism, possibly a membrane-bound H^+ pump (ATPase), with the result that proton efflux occurs and the pH of the solution in the matrix of the cell wall decreases. The resultant lowering of the pH of the solution bathing the cell walls has been suggested to activate enzymes, called expansins, capable of hydrolyzing wall polysaccharides, thereby softening the wall and allow cell extension. Movement of the sugar chains along the cellulose microfibrils occurred by a mechanism (enzymatic or non-enzymatic) which catalyzes breakage and reformation of the hydrogen bonds, allowing the glucan structures to creep inchworm-fashion along the cellulose microfibrils. The rate at which the sugar polymers moved increased at lower pH. This is due to a weakening of the hydrogen bonds. The loosening of the bonds decreased the resistance of the wall to turgor pressure. More water would move into the cell causing an increase in cell volume and irreversibly stretching the cell wall.

The acid-growth hypothesis was supported by evidence showing that an exogenous acid solution can induce short term growth, which could be stopped with the addition of more basic buffers. In addition, an inhibitor of acid-induced growth was also shown to inhibit auxin-induced growth. This suggests that the growth responses evoked by both auxin and acid involve some common step. It could also be argues that acidification is not just a result of growth, but is a necessary part of the growth phenomenon.

Cell elongation after 30 to 60 min does not involve acid-induced elongation, but is due to auxin turning on genes which help cells elongate by other mechanisms (i.e. synthesis of new cell wall material).

Nucleic acid metabolism

Plant tissues respond to auxin treatment by dramatically increasing nucleic acid and protein synthesis, and this effect is closely correlated to auxin-induced growth. However, this response may be independent of the cell wall loosening phenomenon, although this is by no means conclusive.

The action of auxin appears to involve specific gene activation at the transcriptional level. Auxin may interact with a binding protein and the auxin-protein complex then interacts with chromatin (filamentous complex of DNA, histones and other proteins constituting chromosomes) to cause an increase in DNA template available for transcription. The result of this action could be altered DNA transcription and quantitative and qualitative changes in RNA synthesis. These RNAs would then serve as templates for the synthesis of the proteins required for the observed physiological responses.

The changes in DNA transcription in auxin-treated chromatin were shown to cause a substantially higher RNA polymerase activity than control chromatin. It was subsequently shown that the major influence of auxin was to increase the endogenous RNA polymerase of chromatin. The DNA-directed RNA polymerase functions in mRNA synthesis. It was demonstrated that auxins increased a specific set (at least 10) of translatable messenger RNAs that encode for a variety of proteins.

Auxinic Herbicides

The auxinic herbicides are still the most widely used herbicides in the world. They are used to selectively control broadleaf weeds in grass crops, including corn, wheat, barley, oat, sorghum, rice, sugarcane, pasture, rangeland, and turf. These compounds are all weak acid herbicides (see chapter on herbicide absorption) that are primarily applied postemergence and translocate via the phloem to the growing points and other sink regions in the plant.

At low doses, the growth regulator herbicides have a stimulatory effect on plant and cell growth similar to that of IAA. However, phytotoxic concentrations of the auxinic herbicides elicit a variety of symptoms in plants. Among these include, leaf chlorosis, altered stomatal function, stem tissue proliferation, root initiation in stem tissue, disintegration of root tissues, leaf cupping, stunted leaves, and abnormal apical growth. Many of these are secondary effects. In addition, auxin herbicides cause plugging of the phloem, growth inhibition, and tip and stem swelling.

The mechanism of action of these herbicides is thought to be the same as that of naturally occurring auxins. The primary effect of low levels of growth regulator herbicides on nucleic acid synthesis appears to be a stimulation of RNA polymerase followed by stimulation in RNA and protein synthesis. However, in meristematic tissues, high levels of auxins (typical of herbicidal concentrations) inhibit RNA synthesis and growth. In contrast, high auxin levels stimulate RNA and protein synthesis is mature tissues. This stimulation in the more mature stem regions causes parenchyma cells to divide in mature tissues. This often leads to uncontrolled growth and the production of callus tissue. Volume expansion of mature tissues is somewhat restricted by the presence of secondary cell walls and thickened cells, such as collenchyma and fibers.

Consequently, excessive cell division in these tissues can cause stem swelling and eventually cellular collapse. This occurs because the newly developed callus tissues crush the phloem and cortex, eventually resulting in rupturing of the epidermis of stem tissues. Symptoms normally appear within a few hours or days although death may not occur for several weeks or months.

A characteristic twisting symptom known as epinasty occurs following treatment with all of the auxin-like herbicides. This response is the result of an auxin-induced stimulation in ethylene production. It is thought that these herbicides stimulate ethylene production by promoting the synthesis of RNA and the enzymes involved in ethylene synthesis. More specifically, auxin activates transcriptional genes that encode for the enzyme 1-aminocyclopropane-1carboxylic acid synthase (ACS). Although ethylene is induced in most broadleaf species after exposure to auxinic herbicides, some broadleaf species (i.e. chrysanthemum, chickweed, tobacco, yellow starthistle) are tolerant to exogenous ethylene itself and phytotoxic symptoms induced by the herbicide are unaltered in the presence of ethylene biosynthesis inhibitors, suggesting ethylene plays no role in plant death. There are other broadleaf species (i.e. tomato) where auxin-induced ethylene induces the production of ABA (abscisic acid) and ABA which results in stomatal closure.

The characteristic symptoms of auxinic herbicides include rapid internode and petiole expansion due to the cell wall loosening response, and epinasty caused by the stimulation in ethylene. In addition, the inhibition in cell division in meristematic regions occurs at the same time as abnormal stimulation of cell division in mature tissues. Auxin-induced ethylene production leads to stimulation in ABA biosynthesis by up to 70 times the normal level. Together with ethylene, ABA functions as a hormonal second messenger in the mode of action of auxin herbicides. Increased ABA causes stomatal closure which photosynthesis and sugar production. In addition, ABA directly inhibits cell division and elongation and promotes, together with ethylene, leaf senescence with chloroplast damage and destruction of membrane and vascular system integrity. Another byproduct of the ethylene synthesis pathway is cyanide which injures sensitive grasses. Growth inhibition, tissue desiccation and decay and finally plant death are the consequences.

Phenoxy Carboxylic Acids

Phenoxy herbicides are formulated as either salts or esters. Esters are more volatile than salts and are more susceptible to vapor drift, particularly under warmer ambient conditions. However, ester formulations are more readily absorbed through the leaf cuticle and therefore, tend to be more active than salt formulations. This is especially true for waxy-leaved broadleaf species.

The phenoxy herbicides are widely used in many grass crops and in forestry and other non-crop areas. In California, phenoxy herbicides registered for use include 2,4-D, 2,4-DB, dichlorprop, MCPA, and mecoprop. 2,4-D is the oldest and most widely used of these compounds. MCPA is similar to 2,4-D, but is considered somewhat safer on grain crops and legumes. It is less effective on many weeds, such as borages (Boraginaceae), but may be more effective on some thistles and members of the carrot (Apiaceae) and buttercup (Ranunculaceae) families. Dichlorprop is primarily used for controlling brush. Mecoprop is generally used in combination with other auxinic herbicides for control of broadleaf weeds in turf. It is more effective than 2,4-D on chickweeds and clovers, and is safer on bentgrass turf. 2,4-DB is selective in legumes. It must be metabolically converted, through a oxidation reaction, to 2,4-D within the plant in order to be active. Many legumes crops, such as soybeans, peanuts, and seedling forage legumes (clover, alfalfa, and trefoil), as well as mints, metabolize 2,4-DB very slowly and, thus, are fairly tolerant to the herbicide.

Benzoic Acids

Among the benzoic acid herbicides, only dicamba is registered for use in California. It acts in plants the same way as the phenoxy herbicides and other auxins. The selectivity of dicamba is similar to 2,4-D, but it is generally considered to the more active than 2,4-D on perennial broadleaf weeds, legumes, and members of the smartweed (Polygonaceae) and pink (Caryophyllaceae) families. In contrast, it is less effective on mustards (Brassicaceae) and borages. Although the soil activity of dicamba is short, it does persist longer than 2,4-D. Dicamba is often used in combination with other phenoxy herbicides for control of turf and brush weeds.

Picolinic Acids

Four major herbicides belong to the picolinic acid group; aminopyralid, clopyralid, picloram, and triclopyr. Picloram is the only one that is not registered in California. Another herbicide that is very similar to aminopyralid is the new compound called aminocyclopyrachlor. It has not been classified in a chemical family as of yet. The action of these herbicides is similar to other auxinic herbicides. Triclopyr is very active on most shrub species, but also provides excellent control of most broadleaf species. It is one of the most important herbicides in non-crop areas. It has very little soil activity and tends to be somewhat weak on members of the mustard family (Brassicaceae). Aminopyralid and clopyralid are registered for use in rangelands, pastures, and wildlands. Aminocyclopyrachlor will also be registered in the same areas, but is likely to only be available as a premix with other sulfonylurea herbicides. These compounds are effective both post- and preemergence on susceptible species, but have a relatively narrow spectrum of selectivity. They are highly effective against plants in the Asteraceae (sunflower family). Fabaceae (pea family), Solanaceae (potato family), many members of the Apiaceae (carrot family) and Polygonaceae (smartweed family), and have activity on teasel (*Dipsacus* spp.). They are particularly effective for the control of thistles, including yellow starthistle, purple starthistle, Canada thistle. Aminocyclopyrachlor seems to also have good activity on a number of invasive shrubs.

Quinoline Carboxylic Acid

Quinclorac can stimulate ethylene production and cause symptoms in sensitive broadleaf species very similar to that of other auxinic herbicides. However, it is also selective for control of many grasses by a mechanism that appears to involve inhibition in cell wall synthesis. Thus, it is possible that this herbicide possesses two different mechanisms of action in plants.

Auxinic Herbicide Selectivity between Broadleaf and Grass Species

It is thought that no single aspect of herbicide behavior could completely explain auxin herbicide selectivity between broadleaf (dicotyledon) and grass (monocotyledon) species. Although a number of factors may be involved in selectivity, there is no evidence for differences in the target auxin binding sites between monocotyledons and dicotyledons. This may account for resistance in some dicot species.
Some of the possible explanations include:

1. The arrangement of the vascular tissue in bundles surrounded by protective tissue in monocotyledons seems to prevent the destruction of the phloem by the disorganized

growth caused by the herbicides. Furthermore, there is no auxin-sensitive layer of cells capable of cell division in the vascular bundles of monocotyledons.

2. Translocation of foliar-applied auxins from the site of application is less in monocotyledons than in susceptible dicotyledons. Differences in translocation also exist among species of dicotyledons.
3. There are differences in metabolism between monocotyledons and dicotyledons that could also contribute to selectivity. Differences in metabolism can also account for selectivity among dicotyledons. It has even been suggested that cucumbers compartmentalize 2,4-D in the vacuoles and this affords the species a greater degree of tolerance.

Although grass crops are tolerant to auxinic herbicides, they can be injured if these herbicides are applied during rapid cell division (tillering or flowering) or during rapid growth (high temperatures and high soil moisture). Corn and sorghum stems may become brittle after auxinic herbicide application. Wheat and rice may exhibit buggy-whipping and malformed seed heads after 2,4-D treatment.

Herbicide Resistance

A total of 28 weed species in 15 countries have developed resistance to the auxinic herbicides, with the first case appearing in 1957. In the United States and Canada, the dicot species yellow starthistle (*Centaurea solstitialis*), spreading dayflower (*Commelina diffusa*), field bindweed (*Convolvulus arvensis*), wild carrot (*Daucus carota*), kochia (*Kochia scoparia*), prickly lettuce (*Lactuca serriola*), and wild mustard (*Sinapis arvensis*) have been reported to be resistant to one or more of the auxinic herbicides (weedscience.org). The mechanism of resistance has not been identified in most cases, but may to be due to either differential binding to the target receptor site, as appears to be the case with wild mustard, or enhanced metabolism of the herbicide to non-phytotoxic metabolites.

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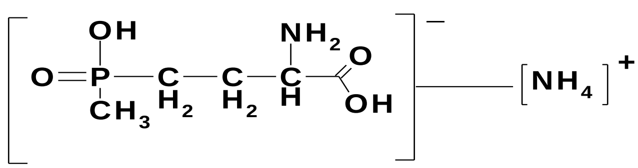
AMINO ACID BIOSYNTHESIS INHIBITING HERBICIDES

John Jachetta, Ph.D., Dow AgroSciences LLC, jjjachetta@dow.com

The identification of herbicide families that act through the inhibition of amino acid biosynthesis has resulted in revolutionary progress in agricultural practices. This review describes three herbicide classes which act through this mode-of-action; including glufosinate (also called phosphinothricin, Liberty®, Ignite®, or Finale®) which inhibits ammonia assimilation, glyphosate (Roundup®, Touchdown®, Glyphomax®) which blocks aromatic amino acid biosynthesis, and several chemical families of acetolactate synthase (ALS) inhibitors (sulfonylureas, imidazolinones, triazolopyrimidines, pyrimidinyl thiobenzoates and sulfonyl-aminocarbonyltriazolinones). These herbicide families share several characteristics including, a single plant-specific biochemical target site (with the exception of glufosinate) and low mammalian toxicity.

Inhibitors of Ammonia Assimilation and Glutamine Biosynthesis: Glufosinate:



Glufosinate-ammonium

Ammonia and Amino Acid Metabolism:

Ammonia is present in plant cells by direct uptake, photorespiration, and nitrate reduction or by the turnover of N-containing compounds in the cell. In all cases, glutamine synthetase (GS) is the essential enzyme employed in the incorporation of ammonia into glutamine. In this pathway (figure 1), glutamine is formed from glutamate by the addition of ammonia through the action of GS. Plant cell aminotransferases enable GS assimilated ammonia to move into many other amino acids and nitrogen-containing products.

The production of glutamine from glutamate is initiated with the binding of ATP to the catalytic domain of GS, followed by the binding of glutamate. Glutamate is subsequently phosphorylated within the active enzyme site to produce a glutamyl-phosphate intermediate. This intermediate reacts with ammonia to form a tetrahedral transition-state; release of PO_4 from this transition-state results in the formation of glutamine (Figure 3)(Lea and Ridley, 1989).

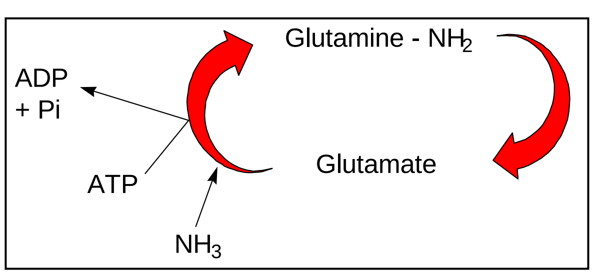


Figure 1. Reaction catalyzed by glutamine synthetase.

Glufosinate Mode-of Action:

Glufosinate (also known as phosphinothricin) is a non-selective ammonia assimilation inhibitor isolated from the bacteria *Streptomyces viridichromogenes.* This inhibitor is a phosphinic analog of glutmate and occurs naturally as one component of a small herbicidal tripeptide called bialaphos (Boger and Sandyman, 1990). The commercial product is the isolated herbicidal peptide component; this product is currently produced by chemical synthesis. Glufosinate is an inhibitor of the enzyme glutamine synthetase (GS) (reviewed by Ray, 1989, and Lea, 1991). At this site-of-action, glufosinate competes with glutamate binding at the GS catalytic domain (figure 2). Once bound to GS, glufosinate is phosphorylated to form a transition-state mimic. This mimic is then irreversibly bound to GS, resulting in deactivation of the enzyme (Lea and Ridley, 1989). The herbicidal result of GS inhibition is the rapid accumulation of ammonia in plant chloroplasts. Ammonia is a known uncoupler of photosynthetic electron transport in plant cells. Ammonia accumulation can occur within 1 hour of glufosinate treatment, with initiation of photosynthetic inhibition following in as little as 4 hours; complete photosynthetic inhibition can occur within 8 hours; free ammonia can increase within the treated cell by 10-fold within this period. This activity is light dependent, as are glufosinate induced visible symptoms of herbicide injury. Light dependency is likely the result of the inhibited ammonia reassimilation from photorespiration-produced ammonia or light-dependent nitrate reduction.

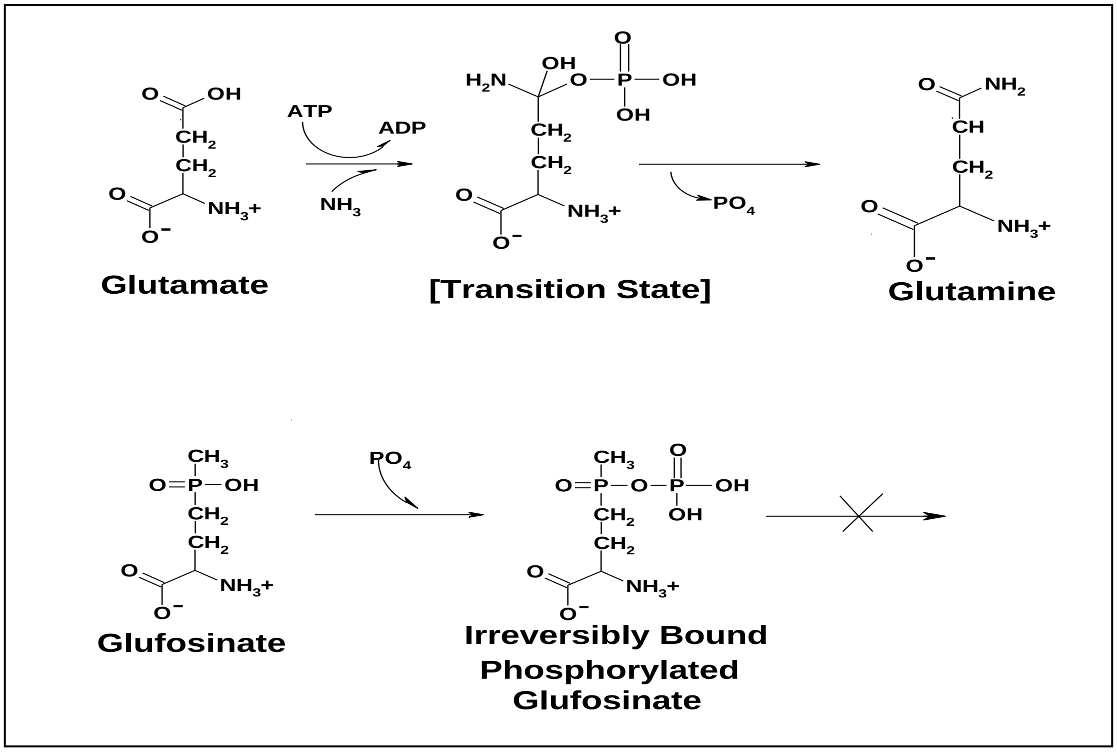


Figure 2: Incorporation of ammonia into glutamine by glutamine synthetase (GS). Glufosinate is a transition-state mimic of glutamate and binds irreversibly to GS

There is strong evidence that the inhibition of photosynthesis by glufosinate is not due to ammonia accumulation alone (Lea P.J. 1991; Gonzalex-Moro *et al.*, 1995). A second mechanism for photosynthetic inhibition results from the depletion of amino acids as a downstream effect of GS inhibition; this action may be the primary cause of glufosinate herbicidal activity (figure 3). In this scenario, amino acid depletion due to GS inhibition results in a depletion of amino (NH_2) donors for the glycolate pathway during photorespiration. The glycolate pathway mediates the oxidation of glycolate to produce glyoxylate for the ultimate production of the amino acid glycine. Since the conversion of glyoxylate to glycine is prevented by the depletion of amino donors, several metabolic intermediates accumulate, including phosphoglycolate, glycolate and glyoxylate. Several studies (most recently, Gonzalez-Moro *et al.*, 1995) have shown that glyoxylate inhibits photosynthesis by preventing the activation of RuBP, a key enzyme involved in photosynthetic CO_2 fixation. Inhibition of photosynthesis results in membrane damage, chlorophyll bleaching, and ultimately in tissue necrosis. Glufosinate induced plant necrosis normally occurs in 1 to 5 days.

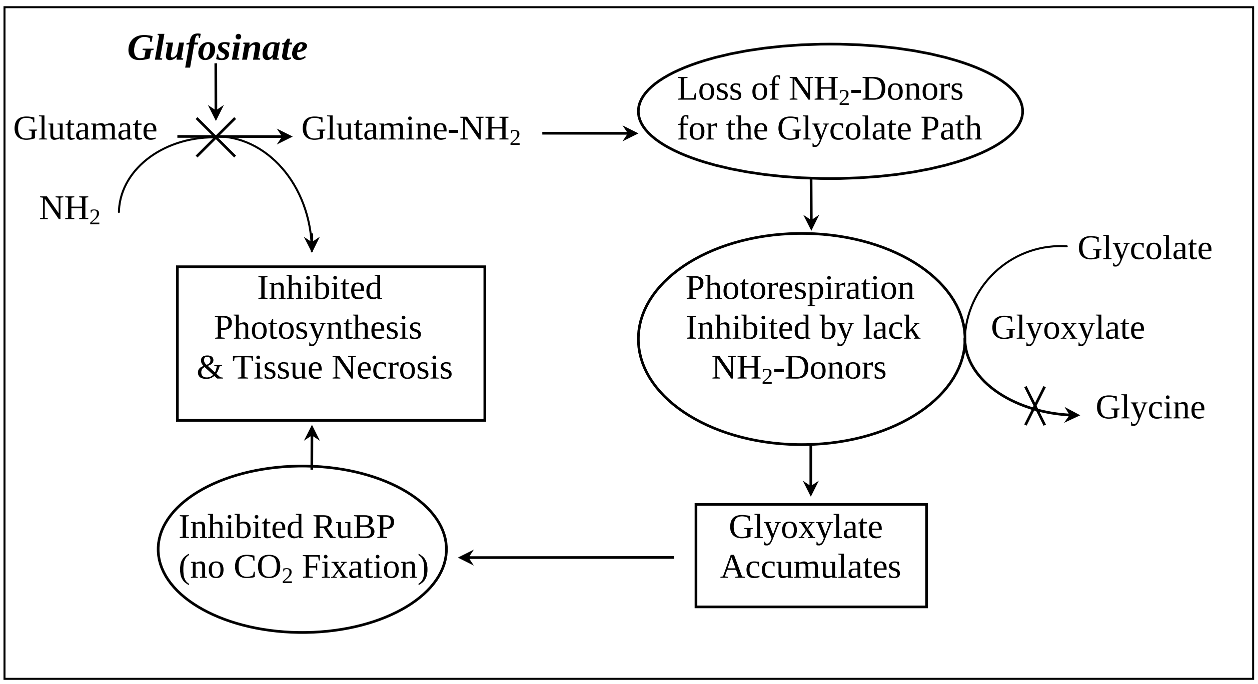


Figure 3: Glufosinate Mode-of-Action

Activity:

Glufosinate is a non-selective herbicide used at 1 to 1.5 lb./A. This inhibitor has non-systemic contact activity, is not active by root uptake, and has minimal translocation within the whole plant. Glufosinate is rapidly degraded in soil.

Glufosinate Resistant Crops:

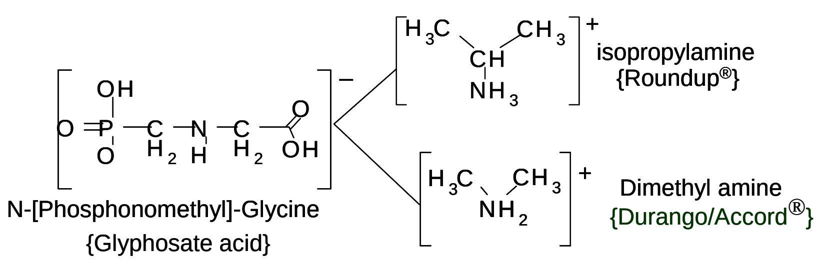
Several crops (corn, soybeans and canola) have been genetically engineered to possess resistance to glufosinate. The glufosinate resistance gene, (called *bar* for bialaphos resistance) was also isolated from *Streptomyces viridichromogenes* (Thompson *et al.*, 1987). This gene encodes a metabolizing enzyme (phosphinothricin acetyltransferase) that prevents autotoxicity in the bacteria. Plants transformed with the *bar*-gene are highly resistant to glufosinate (De Block *et al.*, 1987, De Greef *et al.*, 1989). Introduction of *bar*-transformed crop plants is proceeding quickly. Gene transfer through out-crossing is an issue for glufosinate resistant canola, as the *bar* gene appears to be able to pass to closely related plants, such as wild radish in as few as four generations (Brown *et al.*, 1996) .

Inhibition of Aromatic Amino Acid Biosynthesis: Glyphosate

Biosynthesis of Aromatic Amino Acids:

Phenylalanine, tyrosine and tryptophane are aromatic amino acids essential for protein synthesis. Biosynthesis of these amino acids (figure 2) is initiated with the condensation of a 4 carbon sugar, eythrose-4-PO_4, with a 3-carbon sugar, phosphoenylpyruvate, to form a 7-carbon sugar, deoxyarabino-heptulosonate-7-PO_4 (DAHP), via the enzyme 3-deoxy-D-arabino-heptulosonic-7-phosphate synthase (DAHP synthase). DAHP undergoes a series of reactions, including ring closure, dehydration and reduction to produce shikimic acid. Through the action of the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (ESPS), shikimic acid combines with a second phosphoenylpyruvate, followed by the loss of a PO_4 group, to produce chorismic acid (chorismic is Greek for “fork”). This pathway has two branches following chorismate formation: one into the formation of anthranilic acid leading to the amino acid tryptophane, and the other fork leading to the biosynthesis of phenylalanine and tyrosine. Tryptophane can also be formed from serine and indolglycerol.

Two primary glyphosate salts



Glyphosate Mode-of-Action:

Glyphosate was identified in the late 1960’s in a Monsanto discovery program that initially produced the sugar cane ripener glyphosine (which was originally identified from a Monsanto program to identifying new water softening agents). This herbicide was introduced in 1971 at the North Central Weed Science Conference. Glyphosate is a biosynthesis inhibitor of the aromatic amino acids phenylalanine and tyrosine, and these amino acids can reverse glyphosate-induced plant growth inhibition (Gresshoff, 1979). Specifically, glyphosate inhibits the enzyme 3-phospho-5-enoylpyruvateshikimate (EPSP) synthase (figure 4), thus, preventing the conversion of shikimate to chorismic acid (reviewed by Duke, 1988, and Ray, 1989). Inhibition of this biosynthetic pathway results in an unregulated accumulation of shikimate. Following glyphosate treatment, as much as 10 to 20% of the plant's total soluble carbon can be found to accumulate in shikimate. Plant death is apparently the result of the unregulated accumulation of carbon in that intermediate. As the rate of plant death is dependent on the amount of stored carbon in plant tissues, small plants may die relatively quickly (1 to 4 weeks) whereas larger shrubs or small trees may require a year or more to be fully controlled.

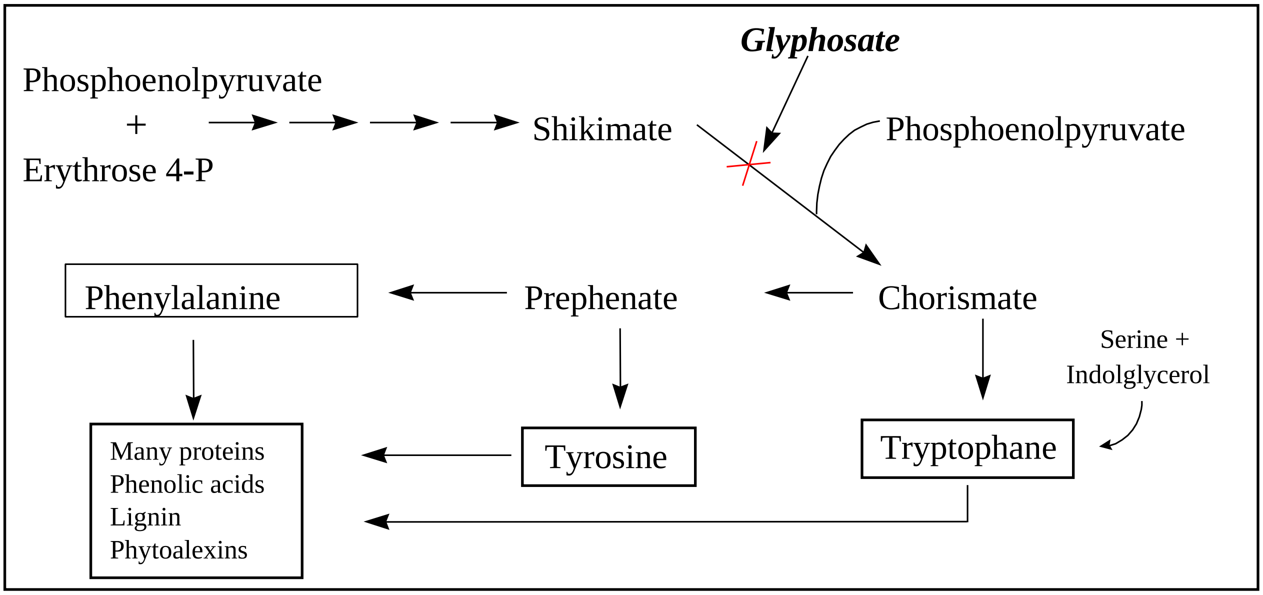


Figure 4: Aromatic amino acid biosynthesis and inhibition by glyphosate

The structure of the active site of EPSP synthase (EC-2.5.1.19) has been determined by co-crystallization of EPSP synthase from bacteria (*E. coli*) with its substrate shikimate- and glyphosate or with shikimate alone. This has allowed a determination of the structures of the enzyme-inhibitor complexes by X-ray crystallography at resolutions of 1.5 and 1.6 angstroms, respectively. Upon binding of shikimate, the two-domain enzyme closes to form an active site in the interdomain cleft. Glyphosate appears to occupy the site of the 2nd substrate, phosphoenyl pyruvate.

Two additional sites-of-action for glyphosate have been described; however, both are inhibited at far higher concentrations (mM) than required for EPSP. These sites include DAHP synthase, an earlier enzyme in the shikimate acid pathway, and the biosynthesis of 5-amino-levulinic acid (ALA), a chlorophyll precursor (reviewed by Duke, 1988). While glyphosate does inhibit chlorophyll synthesis and the whole-plant symptoms do include interveinal chlorosis, these affects appear as a result of the buildup of the shikimate (an organic acid) in the chloroplast. Accumulation of this organic acid destroys the pH balance of the plastid, causing membrane degradation and the bleaching symptomology. Young chloroplasts appear much more susceptible to glyphosate induced pH imbalance than mature plastids[1]. Fairly decisive evidence

[1] Personal communication, Dr. Douglas R. Sammons, Project Leader for Resistance Mechanisms, Monsanto Co.

that EPSP is the sole site of herbicide action can be inferred from the fact that plants genetically transformed with a glyphosate insensitive form of EPSP synthase have been shown to possess commercial levels of tolerance to the herbicide.

Activity:

Glyphosate is a non-selective broad-spectrum herbicide that is highly phloem mobile in plants. Use rates range between 0.25 and 2 lb./A. Glyphosate is not metabolized in treated plants and has no soil activity.

Glyphosate Resistant Crops

Table 1: Glyphosate Resistant Crops

CROP	STATUS
Soybeans	Commercial
Cotton	Commercial
Corn	Commercial
Sugarbeet	Commercial
Wheat	Target~?
Alfalfa	Commercial
Canola	Commercial

Resistance to Glyphosate has been engineered into a number of crops (table 1). In these crops, glyphosate resistance is the result of plant transformation with a gene (*aroA*) coding for an insensitive form of EPSP synthase. Monsanto engaged in a significant, multi-year search to locate an EPSP synthase enzyme which both bound poorly with glyphosate, but was still biochemically efficient. Many variants of plant, yeast and bacteria EPSP synthases were characterized; a useful gene was ultimately isolated from an *Agrobacterium* bacteria. As aromatic amino acid biosynthesis occurs primarily in the plant chloroplast, it was critical to target the gene product, EPSP synthase, to that organelle. To accomplish this, the *aroA* gene was fused to a chloroplast transit peptide sequence derived from *Arabidopsis thaliana*. The protein produced from this gene fusion product liberates bacterial EPSP synthase upon processing in the plastid. This mechanism of resistance is employed in Roundup Ready soybeans.

A second gene for glyphosate resistance has also been developed, this time coding for glyphosate metabolism via glyphosate oxidoreductase (*GOX*). The *GOX* gene was isolated from an *Achromobacter* bacteria collected from a glyphosate waste stream treatment facility. In a manner similar to *aroA*, glyphosate oxidoreductase was targeted to the chloroplast by fusing the *GOX* sequence with an *Arabidopsis thaliana* chloroplast transit peptide sequence. This gene construct has also been introduced into crop plants. Plants transformed with both the *aroA* and *GOX* gene constructs show excellent vegetative and reproductive glyphosate tolerance with little impact on yield.

Transgenic crop plants expressing glyphosate resistance have had a significant impact on US agriculture. Ninety percent or more of US soybeans and 95 percent or more of the cotton in the Southeast are glyphosate-tolerant; glyphosate-tolerant corn is catching on fast with 60% of the US acreage expressing this trait[2]. In the first year of introduction, canola resistant to glyphosate was planted nearly 200,000 acres, or about 20% of the total canola crop. Much of these uses

[2] Service, R.F. 2007. Newsfocus: A growing threat down on the farm. Science 316; 1114-1117

were by growers who traditionally apply a soil treatment and then follow up with a post-emergence spray, with glyphosate now serving as the latter treatment. Glyphosate tolerant alfalfa was de-regulated by USDA in June, 2005, but use was halted under injunction ordered by the Ninth Circuit in September 2007 based on an appeal by non-GM alfalfa growers and environmentalist groups over fears that the GM alfalfa would cross-pollinate with conventional crops. Monsanto appealed to the Supreme Court after a divided three-judge panel on the 9th U.S. Circuit Court of Appeals upheld the ban for the second time on June 24, 2009. In its first ruling on genetically engineered crops, the Supreme Court on June 21, 2010, overturned the lower court's decision, stating that "An injunction is a drastic and extraordinary remedy, which should not be granted as a matter of course".

Monsanto had stated that the injunction was unfair to the 5,500 growers who chose to plant Roundup Ready alfalfa on some 263,000 acres (106,000 ha) of the approximately 23 million acres of alfalfa planted in the US. A very similar, if not identical situation has occurred with glyphosate-tolerance sugar beets. Sugar beets were deregulated by the Agriculture Department in 2005 following an environmental assessment and planted widely. However, in September, 2009, the Federal District Court in San Francisco ruled that the Agriculture Department should have done a more comprehensive environmental impact statement and assessed the consequences from the likely spread of the genetically engineered trait to other sugar beets or to the related crops of Swiss chard and red table beets[3]. However, in this case, the Federal District Court allowed plantings of glyphosate-tolerance sugar beets to continue in 2010, but warned of a potential block on the use in future seasons while an environmental review takes place. The June 21, 2010 decision for glyphosate-tolerant alfalfa may affect this case as well.

<u>*Glyphosate Resistant Weeds:*</u>

A significant number of examples of glyphosate resistance have been documented since 1996, including goosegrass (*Eleusine indica)* in Malaysia and rigid ryegrass (*Lolium rigidum*) in Australia and the United States (California)[4]. In resistant goosegrass, EPSP has been determined to be an altered enzyme with two apparent point mutations[5]. One is mutation (glycine →alanine) is known to inhibit glyphosate binding, but also decreases binding of EPSP to the natural substrate, PEP; the second mutation is not yet fully characterized, but may compensate for the negative fitness effects of the first. Multiple sprays at high rates still appear to provide control of the resistant goosegrass biotype. In the case of Australian rigid ryegrass, a 3X increase in the enzyme EPSP appears to be the only observed difference between resistant and wild type plants (Gruys *et al.* 1999), glyphosate-resistant annual ryegrass populations have now been confirmed at 87 sites across Australia[6]. The resistance trait itself may be polygenic, as a full range of tolerant and sensitive plants are found in outcross breeding events. It has been speculated that these plants contain a mutation in a chloroplast PO_4-transporter that is putatively involved in glyphosate import into plastids. This hypothesis was developed from an observation of cross-

[3] Judge Rejects Approval Of Biotech Sugar Beets; New York Times via NewsEdge Corporation, 24-Sep-2009
[4] http://www.weedscience.com
[5] Mintein Tran and Scot Baerson *et al.*1999, Southeast Asia Weed Science Society in Bangkok.
[6] Dr Chris Preston, Stock and Land Journal, July 2, 2009

resistance between glyphosate-resistant ryegrass and a Zeneca AG Product's phosphonate compound that inhibits histidine biosynthesis (IUPAC, 1999). While this may be possible, the exact mechanism of glyphosate import into chloroplasts in yet unknown[7]. More recently, marestail with tolerance to 10 quarts/A of Roundup has been identified in the Mid-Atlantic States of Delaware, New Jersey and Maryland; waterhemp in Missouri also has at least one, but probably more, biotypes with resistance to glyphosate[8]. In 2003, a highly resistant population of Buckhorn Plantain (*Plantago lanceolata*) was discovered in South African vineyards with a history of poor control with glyphosate[9]; no mechanism has yet been postulated for this resistance. A University of Missouri weed scientist (Reid Smeda) has documented a 20-acre field in which common ragweed (*Ambrosia artemisiifolia*) has shown itself to be resistant to 10 times the rate of glyphosate that normally controls it[10], this biotype is now widespread in the south. In West Tennessee, cotton producers have had to re-introduced residual herbicides into their weed control programs to combat glyphosate-resistant horseweed (*Conyza canadensis*), which now comprises between 80 percent of 90 percent of the horseweed infesting the region[11]. The difficulty in controlling glyphosate-resistant horseweed is exacerbated by its biology; horseweed has an extended period of germination and can emerge in all but the coldest months of the year. Glyphosate-resistant horseweed was first documented in the Mid-South in 2002 by University of Tennessee weed scientist, Bob Hayes, after it appeared in one field in west Tennessee in 2001; over the years, glyphosate-resistant horseweed has become widely distributed in Southern no-till cotton and soybeans where it has caused significant reductions in yield (Zelaya *et al*. 2007; Steckel & Gwathmey, 2009). Zelaya *et al*. (2007) has evaluated the possible occurrence of interspecies transfer of the glyphosate resistance within the genus *Conyza* and observed that hybridization and transfer of herbicide resistance can occur between C. *canadensis* and *C. ramosissima*. The researchers have determined that approximately 3% of ova were fertilized by pollen of the opposing species and produced viable seeds. The interspecific hybrids were found to have intermediate phenotype between the parents but exhibit superior resistance to glyphosate compared to the herbicide resistant *C. canadensis* parent. This fact may be responsible for the 2007 first occurrence of glyphosate resistance in the *Conyza bonariensis* that has recently been identified in California[12].

There have also been confirmed reports of "Palmer pigweed" (*Amaranths palmeri*) resistance in several states including Arkansas (Norsworthy *et al*., 2008), Georgia[13] and Tennessee[14]. Since pigweed species are know to hybridize, glyphosate resistance in the pigweed family is of especially serious concern for if resistance in this key agronomic weed family becomes broadly entrenched across the Unites States, it has potential to seriously affect entire weed management and cultural systems and necessitate wide-scale changes in farming practices. In *Amaranthus*

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[7] Personal communication, Dr. Douglas R. Sammons, Project Leader for Resistance Mechanisms, Monsanto Co.
[8] Soybean Digest via NewsEdge Corporation, January 11, 2002
[9] WSSA International Survey of Herbicide Resistant Weeds; http://www.weedscience.org/in.asp
[10] Personal communication, Dr. Reid Smeda, University of Missouri
[11] Delta Farm Press, July 18, 2005
[12] AGROW - World Crop Protection News - http://www.agrow.co.uk, (A00970440) , Filed 12 September 2007
[13] Monsanto Imagine (weedresistancemanagement.com/layout/press_releases/09-13-05.asp)
[14] The University of Tennessee Institute of Agriculture (agriculture.tennessee.edu/ news/releases/0509-pigweed.htm)

palmeri populations collected from Georgia, the molecular basis of resistance has been identified as EPSPS gene amplification where genomes of resistant plants contained from 5-fold to more than 160-fold more copies of the EPSPS gene than did genomes of susceptible plants (Gaines *et al.*, 2010). Interestingly, in this population, EPSPS genes were present on every chromosome; therefore, gene amplification was likely not caused by unequal chromosome crossing over.

Johnson grass resistance to glyphosate would be an agronomic problem of similar magnitude. Recently, a Johnson grass (*Sorghum halepense*) glyphosate resistant biotype has been noted in Argentina (Salta province), estimates of the effected area are 10,000 hectares and the area is increasing (De La Vega *et al.*, 2006); confirmed glyphosate resistant Johnson grass has been observed in the states of Arkansas and Mississippi; though in both cases, resistance was confined to individual farms[15]. Glyphosate resistance in barnyardgrass (*Echinochloa crusgalli*) is being investigated in the Lower Namoi area of Australia at the University of Adelaide where the summer fallow weed control program relied solely on glyphosate with 15 to 20 applications over a 5-year period; initial greenhouse test results have demonstrated resistance, confirmative testing is now underway[16]. The perennial weed, sourgrass (*Digitaria insularis*), has recently infested Paraguay's glyphosate-tolerant soybean crops and many farmers are considering a return to planting conventional seeds[17]. Most recently, Kansas State University scientists identified five Kochia weed populations in western Kansas with confirmed resistance to glyphosate[18]. Kochia, also called fireweed, is a drought-tolerant weed commonly found on land in the western United States and Canada where crops are grown and cattle are grazed.

Additionally, there have also been scattered reports of glyphosate "nonperformance" on lambs-quarters (C*henopodium album*), with the first reports appearing in South Dakota and Western Minnesota and moving east. If true, a potential mechanism of lambsquarters tolerance could be an alteration in emergence pattern in response to glyphosate-mediated selection of earlier germinating biotypes and encouragement of later germinating biotypes through reduced tillage.

A unique insect-mediated mechanism leading to reduced glyphosate performance has been reported for glyphosate in common ragweed, giant ragweed, and tall waterhemp via the disruption of vascular translocation pathways by feeding insect larva tunneling within the plant stem[19]. Researchers at the University of IL reported on the distribution and impact of insect tunneling on herbicidal control caused by *Lepidoptera*, *Coleoptera*, *Lixus*, and *Dectes* species. Researchers at Purdue, Michigan State and Ohio State Universities have also investigated a tunneling phenomenon in the weed species mentioned above as well as marestail. While not true resistance or tolerance, this phenomena may mimic either situation and result in misdiagnosis of the phenomena.

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[15] AGROW - World Crop Protection News - http://www.agrow.co.uk, (A00989414) Filed 17March 2008 Agrow News Update

[16] Glyphosate Resistance in Barnyardgrass, January 30, 2007. Cotton Tales. Vol. 6. www.dpinsw.gov.au

[17] AGROW News Update, Published Online: 07-May-2008

[18] Associated Press via NewsEdge Corporation 1-Mar-2010

[19] Notes from NCWSS Herbicide Resistance Committee Meeting – Monday, December 1, 2003

Weed or volunteer populations with increased herbicide resistance are also possible due to genetic contamination of non-GM crops by glyphosate-resistant and other herbicide-resistant GM-crops. Field studies of *Brassica* pollen dispersal have indicated that most pollen falls near the release point, but some has been found up to 120 m or more from the point of release. Cultivate rape pollen is capable of fertilizing the weeds *Raphanus raphanistrum* and *Hirschfeldia incana* (Champolivier, Messean and Prunier, 2001) and the transfer of glyphosate resistance to cultivated mustards has been observed in Canada and elsewhere.

While weed population shifts to more tolerant species due to herbicide selection pressure is not true resistance, shifts to indigenous weed species with a higher natural tolerance to glyphosate and/or later emerging species has been observed following continuous use of glyphosate in crop rotation schemes limited to glyphosate-resistant crops. The grower should consider the wisdom of this type of herbicide use pattern on the long-term composition of weed populations in any agroecosystem under continuous cultivation (Miller et al., 2003).

Inhibitors of Branched Chain Amino Acid Biosynthesis: Acetolactate Synthase Inhibitors

Acetolactate synthase (ALS) catalyzes the first committed step in branched-chain amino acid biosynthesis (figure 6, reviewed by Kishore and Shah, 1988). This enzyme facilitates the condensation of two molecules of pyruvate to form acetolactate, which is converted through a series of reaction steps into valine and leucine. ALS also catalyzes a similar reaction, producing acetohydroxybutyrate for the production of isoleucine, when 2-ketobuterate and pyruvate are used as substrates. Biosynthesis of branched-chain amino acids takes place in the chloroplasts.

Branched Chain Amino Acid Biosynthesis Inhibition:

Five families of herbicides with remarkable activity have been discovered over the last 25 years, including the sulfonylureas, imidazolinones, triazolopyrimidines, pyrimidinyl thiobenzoates, and sulfonylaminocarbonyltriazolinones (figure 5). These herbicides inhibit the production of branched chain amino acids by the inhibition of acetolactate synthase (ALS) (see reviews by Pesticide Science, 1990, and Stetter, 1994). Several commercial examples of these herbicide families are listed in table 2 with representative structures in figure 6.

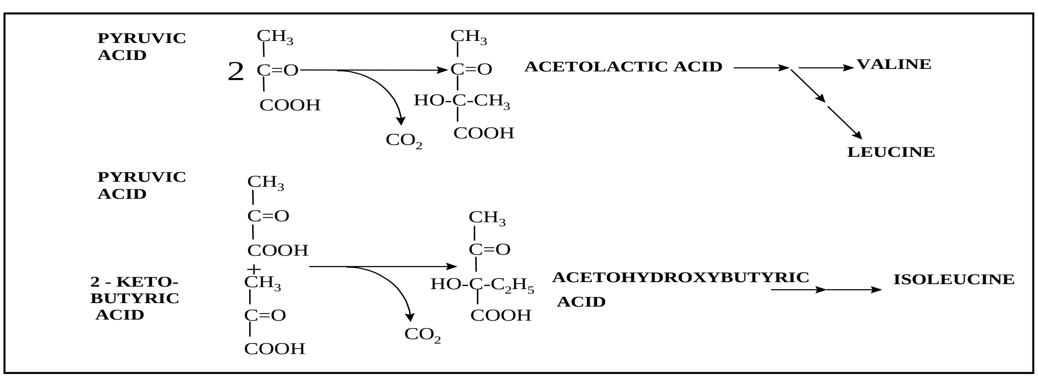
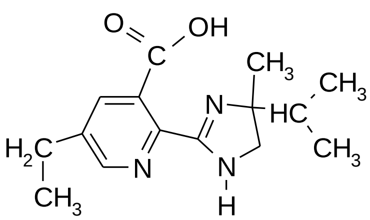


Figure 5. Reactions catalyzed by Acetolactate Synthase.

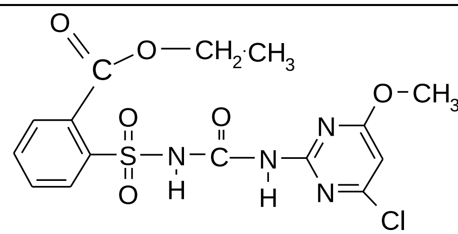
Table 2: Commercial Examples of Acetolactate synthase Inhibiting Herbicides:

Chemical Class	Trade Name	Target Crop	Common Name
Sulfonylureas	Londax® Classic® Oust®	Rice Soybean Non-Crop	Bensulfuron-methyl Chlorimuron-ethyl Sulfometuron-methyl
Imidazolinones	Pursuit® Scepter®	Soybean Soybean	Imazethapyr Imazaquin
Triazolopyrimidines	Broadstrike® FirstRate® Strongarm®	Soybean Soybean Peanuts, Soybeans	Flumetsulam Cloransulam-methyl Diclosulam
Pyrimidinyl thiobenzoates	Staple®	Cotton	Pyrithiobac-sodium
Sulfonylaminocarbonyl-triazolinones	Everest®	Wheat	Flucarbazone-sodium

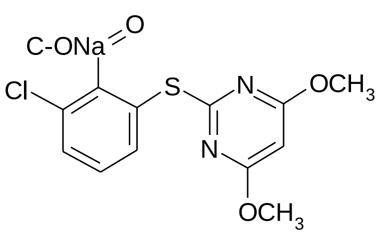
Figure 6: Representative Structures of ALS-Inhibitor Chemical Families



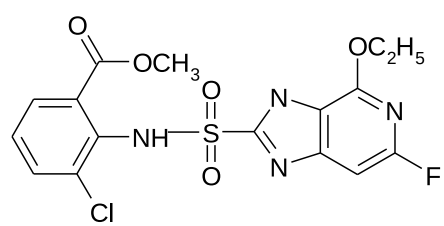
Imidazolinone
Ex: Imazethapyr



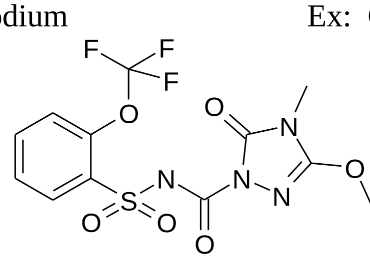
Sulfonylurea
Ex: Chlorimuron-ethyl



Pyrimidinyl Thiobenzoate
Ex: Pyrithiobac-sodium



Triazolopyrimidine Sulfonylanilids
Ex: Cloransulam-methyl



Sulfonylaminocarbonyltriazolinones Ex: Flucarbazone-sodium

ALS-Inhibitor Mode-of-Action:

ALS-inhibiting herbicides prevent the biosynthesis of branched chain amino acids, including valine, leucine, and isoleucine through the specific inhibition of ALS (figure 5). Under laboratory conditions, ALS-inhibitor induced plant growth inhibition can be reversed by supplementing the growth medium with these amino acids. The exact mechanism-of-action resulting in plant death is unknown. Some evidence points to the buildup of one of the substrates of ALS, ✓-ketobuterate, which may cause a general imbalance in 2-ketoacid metabolism and interfere with a variety of biosynthetic processes involved in the utilization of glucose as a carbon source (via glycolysis and the TCA cycle) (LaRossa and T.K. Van Dyk, 1987). However, more recent evidence indicates that the elevation of ✓-ketobuterate occurs only at herbicide concentrations well above the dose required to inhibit growth in plants (Epelbaum *et al.*, 1992; Schloss, 1994). An imbalance in 2-ketoacid metabolism may be important in the inhibition of bacterial ALS and appears to be associated with intracellular acidification and the induction of a stress response (Van Dyk *et al.*, 1998). Whatever the mechanism-of-action, the suppression of branch chain amino acid biosynthesis does results in a rapid inhibition of cell division at the G1 or G2 phases of interphase in the absence of any direct affect on mitosis (reviewed by Brown, 1990). Plant growth can be inhibited within 2 hours following treatment. While cell division and growth are quickly arrested, ultimate plant death is slow. Since plant growth stops almost immediately, the competitive potential of treated weeds is not significant and the presence of affected plants in the field is of no agronomic concern. The rate of plant death is likely related to the total pool of branched chain amino acids available. Thus, small plants will succumb much more rapidly than larger species with more reserves. ALS inhibitor symptomology includes the rapid inhibition of root and shoot growth, vein reddening, chlorosis, and meristematic necrosis.

ALS-Inhibiting Herbicide Resistant Crops:

Several herbicide resistant crops have been engineered through the mutation of the gene encoding ALS. Crops include sulfonylurea tolerant (STS) soybeans and imidazolinone resistant or tolerant (IR/IT) corn, imidazolinone tolerant (Smart®) canola, imidazolinone tolerant (Clearfield®) wheat and rice.

ALS-Inhibiting Herbicide Resistant Weeds:

Unlike most herbicidal enzyme inhibitors, ALS-inhibiting herbicides do not bind to the catalytic domain of the target enzyme (Schloss 1990, 1994). Instead, ALS inhibitors appear to bind to an evolutionary vestige of pyruvate oxidase contained within ALS. Both pyruvate oxidase and ALS apparently share a common evolutionary origin. Since ALS inhibitors do not bind to the catalytic domain of the enzyme, some mutations in the herbicide-binding site are not lethal and have minimal selective disadvantage. This has allowed for the rapid selection of herbicide resistance by compounds with this mode-of-action.

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Free Radical Generators

Kassim Al-Khatib, UC IPM Program, University of California, Davis, kalkhatib@ucdavis.edu

Free radicals are atoms, molecules, or ions with unpaired electrons. In general, the unpaired electrons cause radicals to be highly chemically reactive. Radicals are believed to be involved in the aging process, degenerative diseases, a range of disorders including cancer, arthritis, athero-sclerosis, Alzheimer's diseases, and diabetes. The free radical theory of aging implies that antioxidants such as vitamin A, vitamin C, vitamin E, and superoxide dismutase will slow the process of aging by preventing free radicals from oxidizing sensitive biological molecules or reducing the formation of free radicals.

Free radicals are frequently denoted by a dot placed immediately to the right of the atomic symbol or molecular formula as follows:

$$Cl_2 \Rightarrow Cl. + Cl.$$

$$O_2 \Rightarrow O. + O.$$

Plants naturally have free radicals that are by-products of several chemical processes. However, under normal conditions plants have the ability to mitigate free radical injury by utilizing enzymatic system and antioxidants.

Several herbicide groups can injure plants by generating massive amounts of free radicals. Free radicals are unstable and must obtain an electron from some other chemical to become stable. By taking an electron from another chemical, the other chemical now becomes a free radical and its chemical structure is changed. It must then steal an electron. Thus the chain reaction (of atoms stealing electrons) continues and can be thousands of events long. These events can result in serious damage to cells including lipid periodation, protein damage, and DNA lesions.

In broad terms, there are three groups of herbicides that generate massive amounts of free radicals including those that:

1) Inhibit photosystem II (PSII inhibitors): triazines, triazinone, pyridazinone, phenyl-carbamate, amide, Nitrile, benzothiadiazinone, phenyl ureas, and uracils.

2) Capture electrons in photosystem I (PSI disruptor): bipyridiliums.

3) Inhibit protoporphyrinogen oxidase (Protox inhibitors): diphenyl ethers, phenylpyrazole, N-phenylphthalimide, thiadiazole, oxadiazole, and triazolinone.

The following discussion is about the herbicides under (2) and (3) above, which are often grouped together as free radical generators.

Common properties:

Bipyridiliums (diquat and paraquat, Figure 1), the diphenyl ethers (Figures 2 and 3), and the N-phenyl heterocycles (oxadiazon, carfentrazone, and sulfentrazone, Figures 3) share several properties. Signs of injury to susceptible plants are very similar for all of these herbicides. Symptoms appear a few hours after treatment as dark green areas on foliage, followed by wilting. Necrosis follows, and in a few days the characteristic browning or "burned" appearance is evident. Susceptible species are killed within a few days. Death of tissue is so rapid that none of these herbicides are appreciably translocated. Because of a lack of systemic action, complete coverage is important to prevent weed regrowth. Activity is greater on sunny days, although applications at night that are followed by a bright day may have greatest efficacy.

None of these herbicides are susceptible to leaching from the soil, but for different reasons. Diquat and paraquat are strongly adsorbed by clays and other inorganic soil colloids; thus they are rarely active in the soil (Figure 4). Oxadiazon and the diphenyl ethers are strongly adsorbed by soil organic matter; when applied preemergence, most activity occurs near the soil surface as seedlings emerge. Soil incorporation greatly decreases the activity of oxadiazon and diphenyl ethers.

Principal uses:

Paraquat and diquat are nonselective herbicides. Paraquat is widely used to control vegetation prior to crop emergence, as a dormant season treatment in alfalfa and other perennial crops, and as a directed spray. Diquat is mostly used for aquatic weed control. Application is either postemergent for cattail control, or water-run to control algae and submersed and floating weeds.

Diphenyl ethers and the N-phenyl heterocycles are selective herbicides that must be carefully applied to avoid injury. Sensitivity to these herbicides often varies with crop age, and most crops can outgrow minor, early-season damage. Avoiding contact with crop foliage helps to prevent crop injury, as in directed applications of oxyfluorfen under dormant fruit and nut trees and grapes, or granular applications of oxadiazon in woody ornamentals and turf.

Mode of Action

The mode of action for free radical generators involves membrane degradation. Paraquat and diquat accept electrons from photosystem I (Figure 5) to form free radicals. These free radicals rapidly produce a superoxide radical from molecular oxygen that then undergoes enzymatic dismutation to form hydrogen peroxide (Figures 6 and 7). Hydrogen peroxide and the superoxide radicals interact to produce hydroxyl radicals, which quickly degrade membranes.

The diphenyl ethers and the N-phenyl heterocycles affect the enzyme protoporphyrinogen oxidase (Protox, Figure 8). Protox is found in the chloroplast envelope and in mitochondria (Figure 9). Protox converts protogen IX into protoporphyrin IX (proto IX). Diphenyl ethers and oxadiazon inhibit Protox (Figures 10 and 11). As a result, excess protogen IX moves out of the chloroplast and into the cytoplasm. Enzymatic oxidation of protogen IX into proto IX results in an accumulation of proto IX. The excess proto IX interacts with oxygen and light to form singlet oxygen ('02), which begins the process of lipid peroxidation (Figures 12 and 13). Both lipids and proteins are oxidized, destroying chlorophyll, carotenoids, and rupturing membranes.

Lipid Peroxidation

All of the free radical generators destroy cell membranes, ultimately leading to the death of plant tissue. A major component of cell membranes are lipids. Lipid peroxidation by free radicals involves three steps: initiation, propagation, and termination (Figure 12). The lipid peroxidation initiation factor varies with the herbicide group and includes: triplet chlorophyll from photosystem II inhibitors, singlet oxygen from Protox inhibitors, and hydroxyl radicals from bipyridylium herbicides. All of these initiating factors remove a methylene group from near the double bond (the unsaturation site) of polyunsaturated fatty acids (Figure 13). This is the initiation reaction. The propagation reaction occurs when the peroxidized lipid radical reduces to lipid peroxides when they extract hydrogen from other polyunsaturated fatty acids in the plant cell membranes. The termination reaction occurs because the lipid peroxides are not stable and undergo degradation to small hydrocarbons such as pentane and ethane.

Bioassays

Diphenyl ethers: *Chlorella* (Kratky and Warren 1971), *Chlamydomonas* (Hess 1980), and sorghum seedlings (Fadayomi and Warren 1977).

Paraquat and diquat: *Lemna* spp. (Funderburk and Lawrence 1963; Damanakis 1970).

Toxicology

Diphenyl ethers and oxadiazon: low avian and mammalian, low to moderate fish toxicity.

Paraquat and diquat: fish toxicity is low for both. Mammalian toxicity is moderate for diquat but HIGH for paraquat. Paraquat is often used in suicide attempts, and can be fatal if enhaled, swallowed, or absorbed through the skin. If ingested, drink fluids and induce vomiting immediately. Flush affected skin areas immediately with water. Respirators are required for many paraquat application situations.

Herbicide Resistance

There are no reports of resistance to diphenyl ethers. At least twenty-seven weed species are resistant to paraquat.

Information on Usage

Paraquat is often used for postemergent control of small weeds, or to destroy foliage of larger weeds. Killing above ground tissue to set back the growth of larger weeds ("burndown") allows crops to form a canopy that shades out weeds. Penetration of paraquat through the plant cuticle is critical, so the use of nonionic surfactants is recommended. Paraquat is rapidly absorbed through plant foliage, and rain occurring 30 minutes or more after application has no effect on activity.

Diquat use is restricted to waters with little outflow to reduce risk of accidental poisoning.

Acifluorfen-sodium is used on more acres than any other diphenyl ether because it is registered in three high acreage crops: soybeans, peanuts, and rice. Soybean and rice use is strictly postemergent, and control is effective for many broadleaf weeds that are missed by other herbicides. Use a nonionic surfactant with postemergent treatments. Peanut use is only as a pre-emergent application. Do not plant root crops (e.g. carrots) for at least 18 months into any soil treated with acifluorfen-sodium.

Oxyfluorfen is used in a number of crops for pre-emergent control, or as a directed postemergent treatment. It will injure most crops if applied over-the-top, but can be safely applied over-the-top in onions. Pre-emergent applications will injure direct-seeded cole crops, but can be safe for transplants. Transplanting breaks through the surface barrier of herbicide-treated soil, allowing the crop to grow without contacting herbicide, but still controlling weeds that emerge through the undisturbed surrounding soil.

Oxadiazon is used on warm season turf grass to control annual grasses and in many ornamentals to control grasses and annual broadleaves.

Selected References

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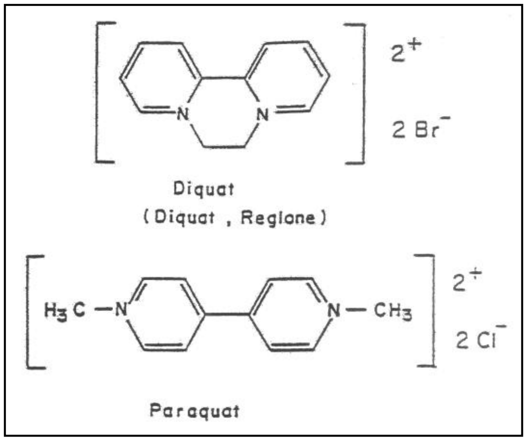


Figure 1. Structure of the two most common bipyridiliums, paraquat and diquat. Note the characteristic herterocyclic rings that contain both carbon and nitrogen atoms. When in solution with water, both paraquat and diquat are bivalent cations, i.e. have two positive charges.

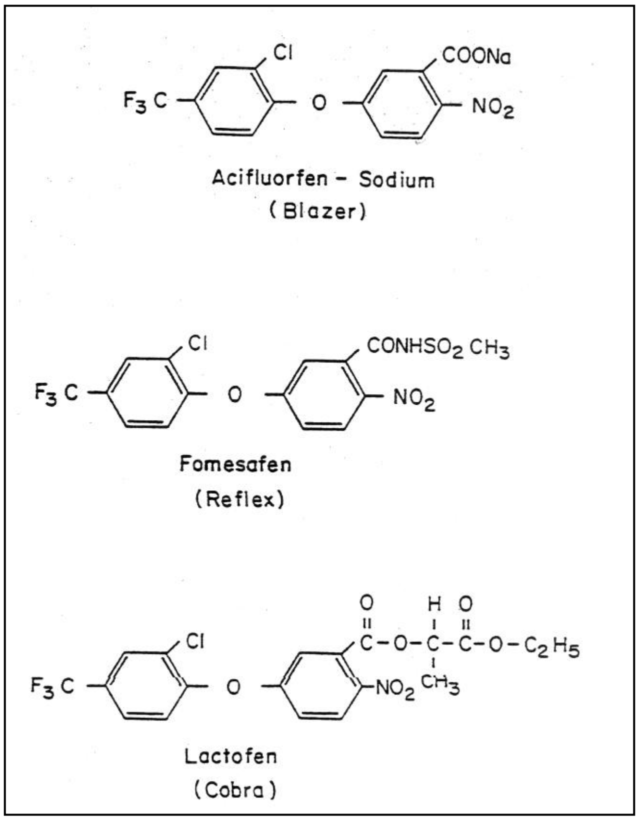


Figure 2. Chemical structure of widely used diphenyl ether herbicides. Diphenyl ethers contain two benzene rings ("phenyl" groups) connected by an ether linkage.

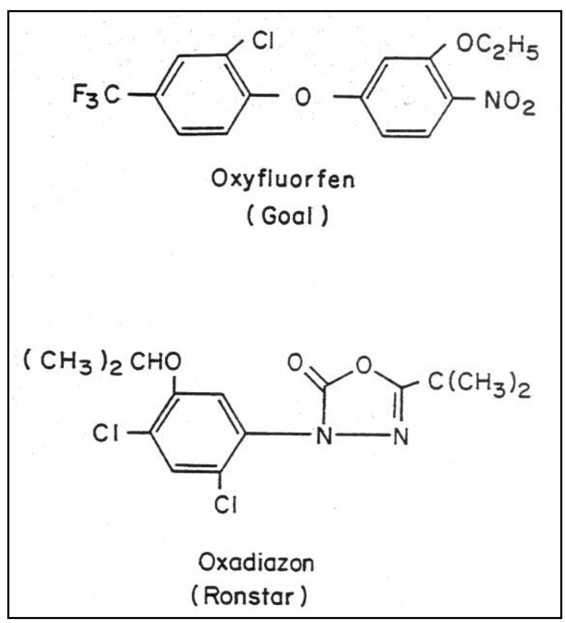


Figure 3. Structure of oxyfluorfen, a diphenyl ether; and oxadiazon, an N-phenyl heterocyclic herbicide. The N-phenyl heterocycles consist of a phenyl group bonded to a nitrogen atom in a heterocyclic ring. Both diphenyl ethers and N-phenyl heterocycles have benzene rings and extensive resonance structures.

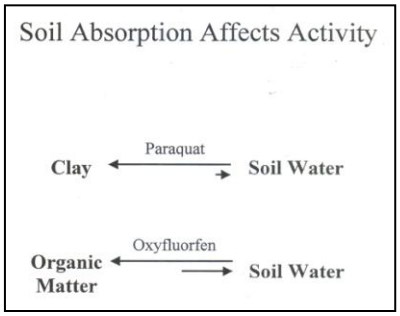


Figure 4. Dynamic equilibrium between soil components and herbicides. Paraquat is so strongly adsorbed onto clay particles that the equilibria is almost completely shifted toward the clay particles, and very little paraquat enters into the soil water solution. As a result, there is usually no injury to plants in soil following paraquat application.

Oxyfluorfen is absorbed onto soil organic matter, which usually prevents significant leaching of oxyfluorfen. However, enough oxyfluorfen enters the soil water solution to injure or kill seedlings that emerge through the surface of oxyfluorfen-treated soil. Thus, oxyfluorfen acts as a barrier to weed emergence. Breaking the barrier, e.g. by digging a hole to plant transplants, prevents injury to plants growing where the soil was disturbed.

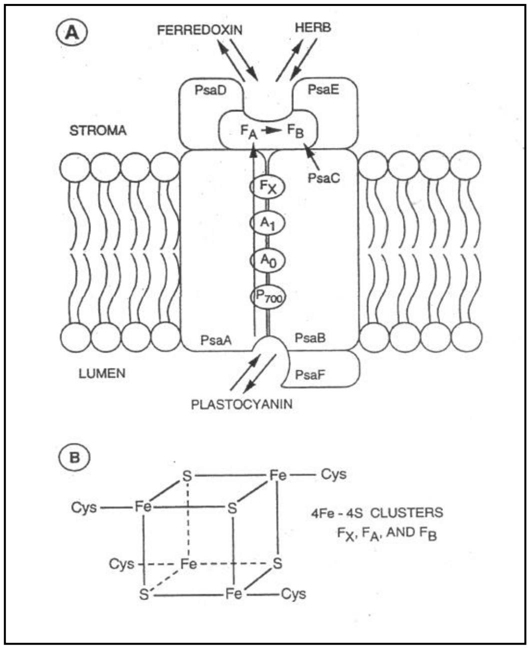


Figure 5. Electron transport in the photosystem I (PS I) complex embedded in thylakoid membranes of chloroplasts. Arrows within the PS I complex represent electron flow. P700, a dimer of chlorophyll a, accepts light energy from the chlorophylls and carotenes associated with PS I. Other electron carriers are: Ao, a chlorophyll a molecule; A1, a phylloquinone; and FX, FA and FBare iron-sulfur clusters (4Fe-4S). Plastocyanin and ferredoxin are soluble electron carrier proteins that dock to PS I. Plastocyanin gives up an electron to PS I (photooxidized) and ferredoxin accepts an electron from PS I (photoreduced). The structural proteins of PS I are termed Psa. PsaA and PsaB make up the core of PS I and are embedded in the thylakoid membrane, whereas PsaC is a peripheral protein housing the iron-sulfur clusters FA and Fe. PsaD and PsaE assist with the docking of ferredoxin, while PsaF assists with the docking of plastocyanin. The bipyridilium herbicides compete with ferredoxin for a binding site at or near PsaC.

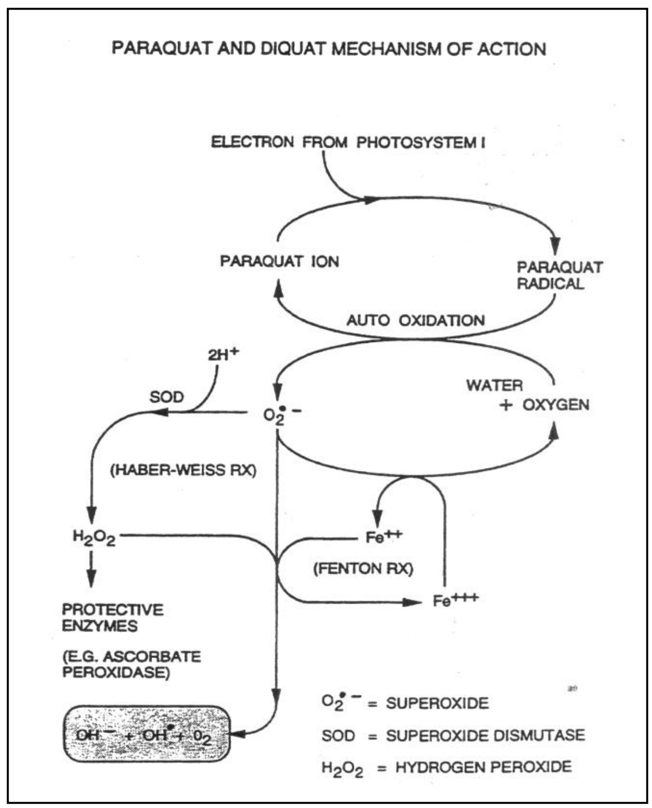


Figure 6. Paraquat, a di-cation bipyridilium herbicide, captures electrons from PS I during electron flow in photosynthesis and becomes a free radical (mono-cation). The paraquat free radical is unstable and rapidly undergoes

auto-oxidation back to the parent ion. During the auto-oxidation process, superoxide radicals (02') are produced from molecular oxygen. Superoxide can undergo enzymatic dismutation (superoxide dismutase - SOD) to form hydrogen peroxide (H202). As hydrogen peroxide and superoxide accumulate in the cell after paraquat treatment, they react to produce hydroxyl radicals (OH') via the Haber-Weiss reaction. The reaction is catalyzed by transition metals, iron or copper, in the Fenton reaction. Hydroxyl radicals efficiently initiate lipid peroxidation in polyunsaturated fatty acids in membranes.

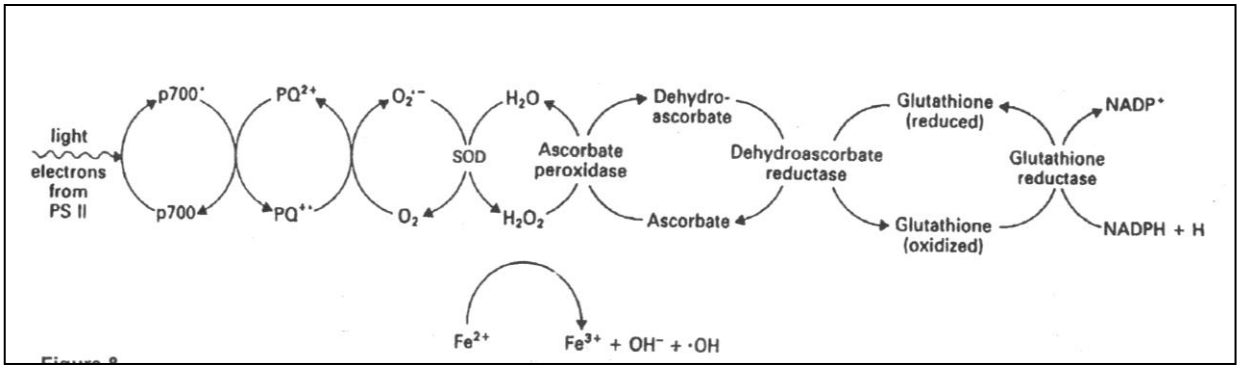


Figure 7. Superoxide generation and detoxification at Photosystem I. PO, paraquat; SOD, superoxide dismutase (after Shaaltiel & Gressel 1986).

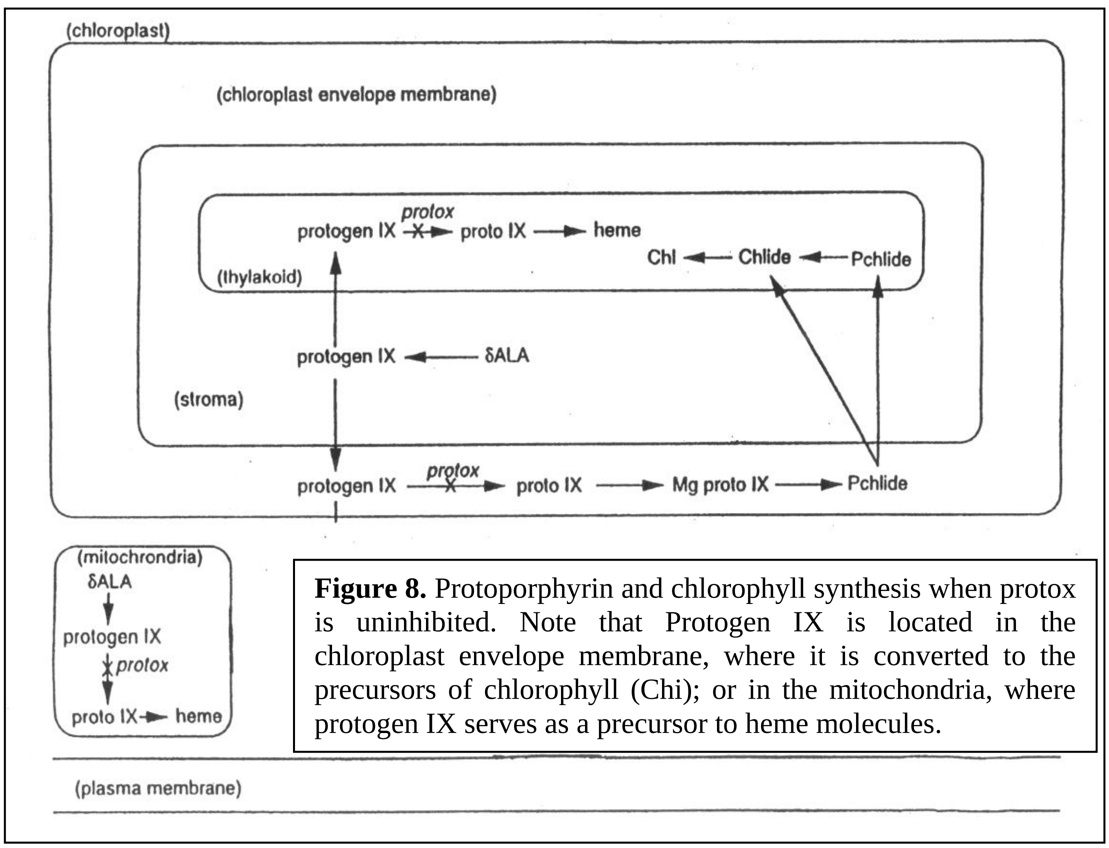
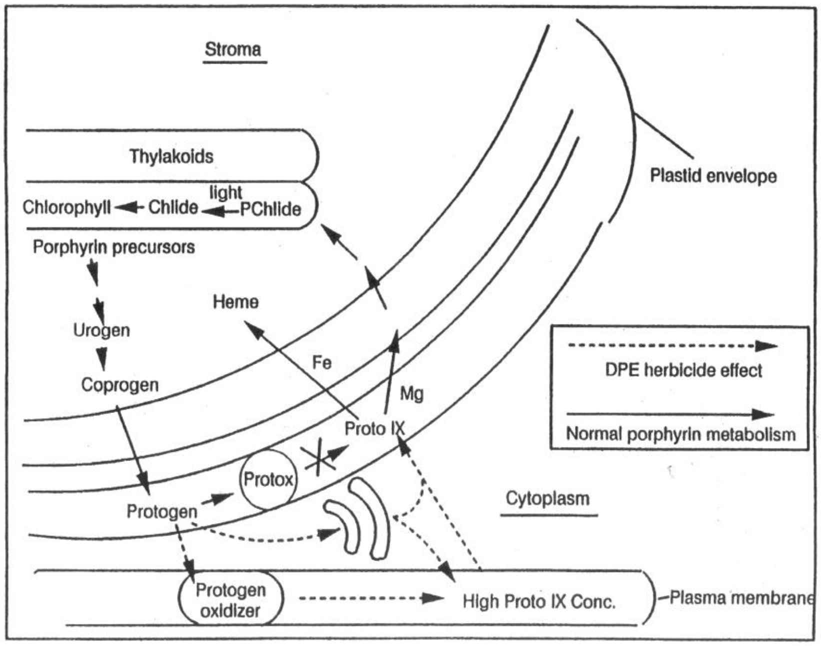


Figure 8. Protoporphyrin and chlorophyll synthesis when protox is uninhibited. Note that Protogen IX is located in the chloroplast envelope membrane, where it is converted to the precursors of chlorophyll (Chi); or in the mitochondria, where protogen IX serves as a precursor to heme molecules.

Figure 9. Diagram of cellular organelles illustrating the locations of precursors and enzymes of chlorophyll synthesis. The solid lines illustrate a normally functioning porphyrin pathway. The dotted line shows how the pathway changes when diphenyl ether herbicides block the activity of the Protox enzyme.



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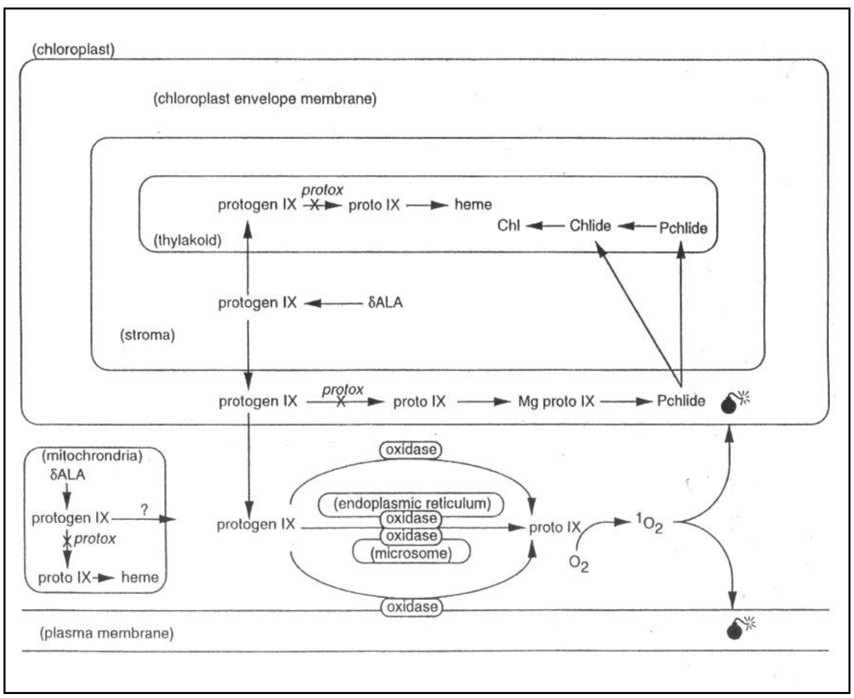


Figure 10. The activity of Protox has been blocked by an herbicide. Protogen IX accumulates and leaks out of the chloroplast envelope membrane, interacting with oxidase and forming singlet oxygen, which ultimately leads to lipid peroxidation and destruction of cellular membranes.

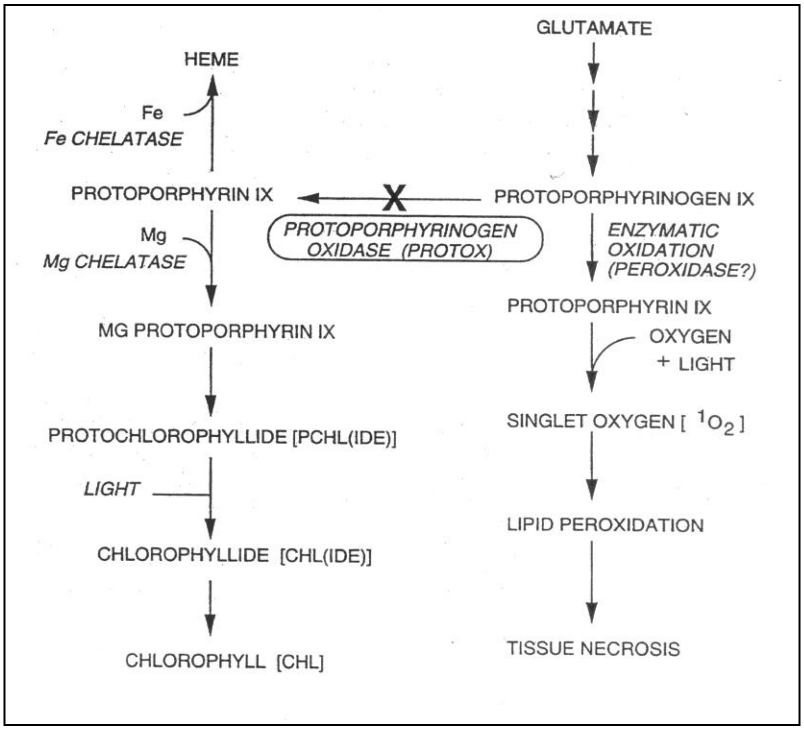


Figure 11. Flow chart of chlorophyll biosynthesis. The left side of the diagram illustrates the pathway when the enzyme protoporphyrinogen oxidase (Protox) functions normally. The right side shows what happens when is inhibited by diphenyl ethers and N-phenyl heterocyclic herbicides.

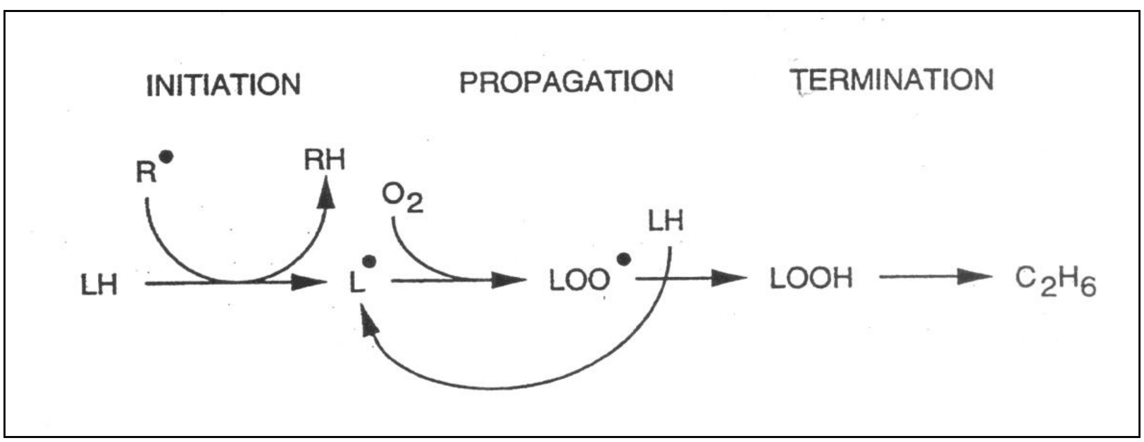


Figure 12. Lipid peroxidation of polyunsaturated fatty acids in plant membranes. An initiating factor (R') such as triplet chlorophyll, singlet oxygen, or a hydroxyl radical removes a hydrogen from a polyunsaturated fatty acid (LH) in the membrane. This hydrogen abstraction process generates a lipid radical (L'). Oxygen reacts with the lipid radical to form a peroxidized lipid radical (LOO'). This peroxidized lipid radical reacts with another polyunsaturated lipid that propagates the reaction within a localized region of the membrane. The lipid peroxides (LOON) formed during propagation are unstable and degrade to short chain hydrocarbon gases such as ethane (CZH6).

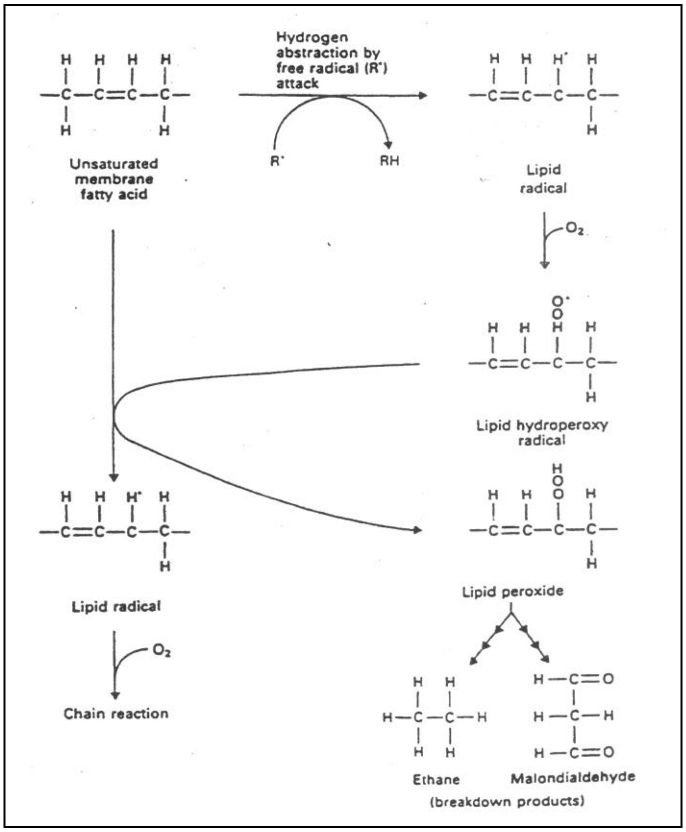


Figure 13. Chemical structure diagrams that illustrate the steps in lipid breakdown that results from free radical generation following herbicide interactions with plant cellular components.

Photosynthesis & Pigment Synthesis Inhibitors

Josie Hugie, Research and Development Scientist, Syngenta Crop Protection
Email: josie.hugie@syngenta.com

1. Photosynthesis II (PSII) Inhibitors

Uptake & Translocation

Chemistry: Lipophilic – penetrates cuticle

Basic molecules - Xylem mobile only --> Transpiration stream

Mode & Mechanism of action

PSII inhibitors compete with plastoquinone (PQ) at QB binding site of D1 protein

- Blocks electron flow through photosynthesis
- Creation of reactive oxygen species (ROS)
- ROS damage membranes

Resistance http://www.hracglobal.com/

HRAC **Group 5**

Triazines (atrazine, simazine), Triazinones, Triazolinones, Uracils, Pyridazinones, Phenyl-carbamates

HRAC **Group 6**

Nitriles (bromoxynil), benzothiadiazinones, phenyl-pyridazines

HRAC **Group 7**

Ureas (diuron), Amides

Resistance: Known mechanisms

Target site resistance: Mutation does not favor binding

Metabolism: Less common - Crop tolerance & selectivity

Symptomology

- Soil Applied Symptoms: Initial injury = first photosynthetic leaves
  Chlorosis leaf margins & older leaves
- Foliar Applied Symptoms: Chlorosis & necrosis at leaf tips, older leaves first
- Injury and carryover: greater with late application, dry season, & soil pH >7.2

2. Pigment synthesis Inhibitors

Mode of action

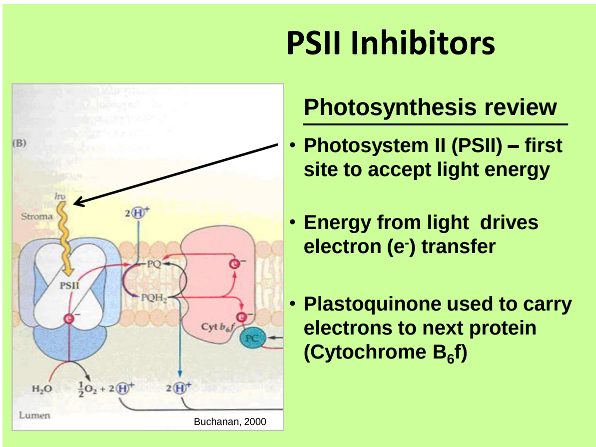
- Depletion of antioxidants (plant protective pigments)
- Increases damage from reactive oxygen (ROS)
- Damages membranes & cellular compartments

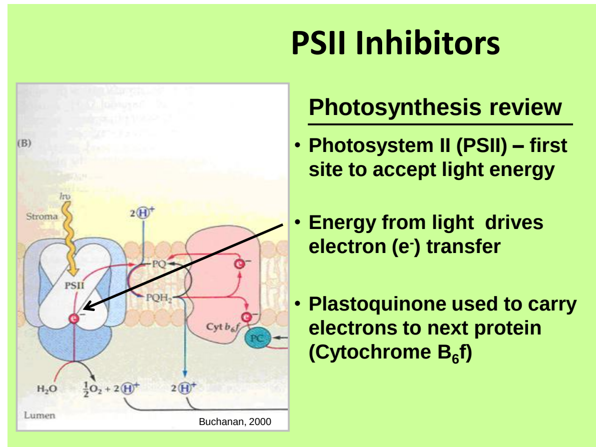
Uptake & translocation

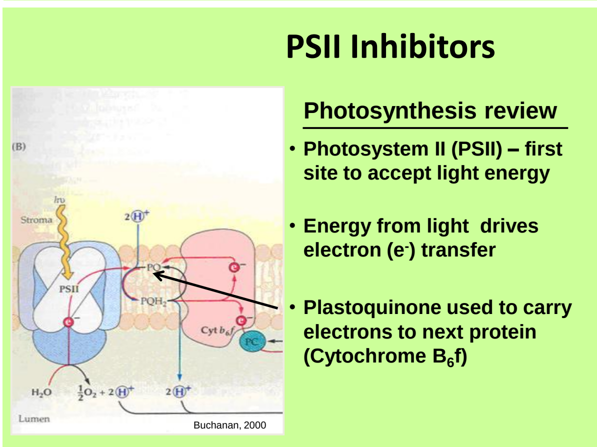
- Weak acids: Penetrate cuticle - Phloem-trapped
- Translocated through phloem to <u>new tissues</u>

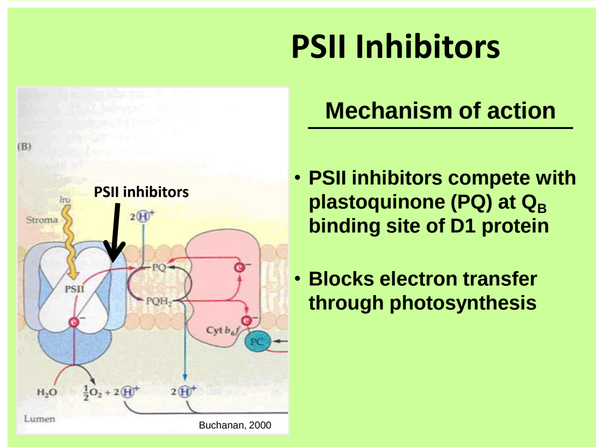
Mechanism of action

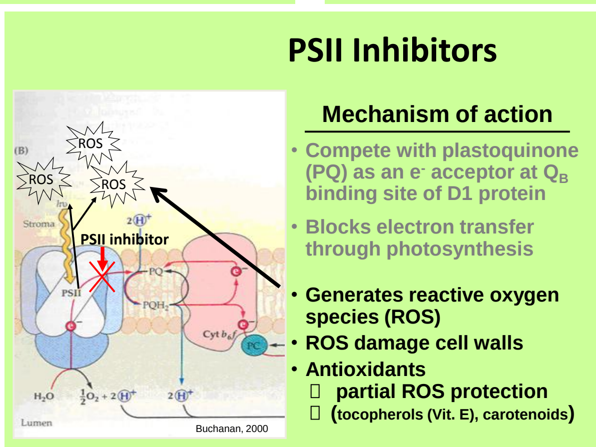
- HPPD inhibitors: Depletes tocopherols, carotenoids, & plastoquinone
- 1-deoxyxylulose-5-phosphate synthase (DOXPS) inhibitors:
  Deplete carotenoids & plastoquinone
- Phytoene desaturase (PDS) inhibitor: Depletes carotenoids
- Lycopene cyclase inhibitor: Depletes carotenoids





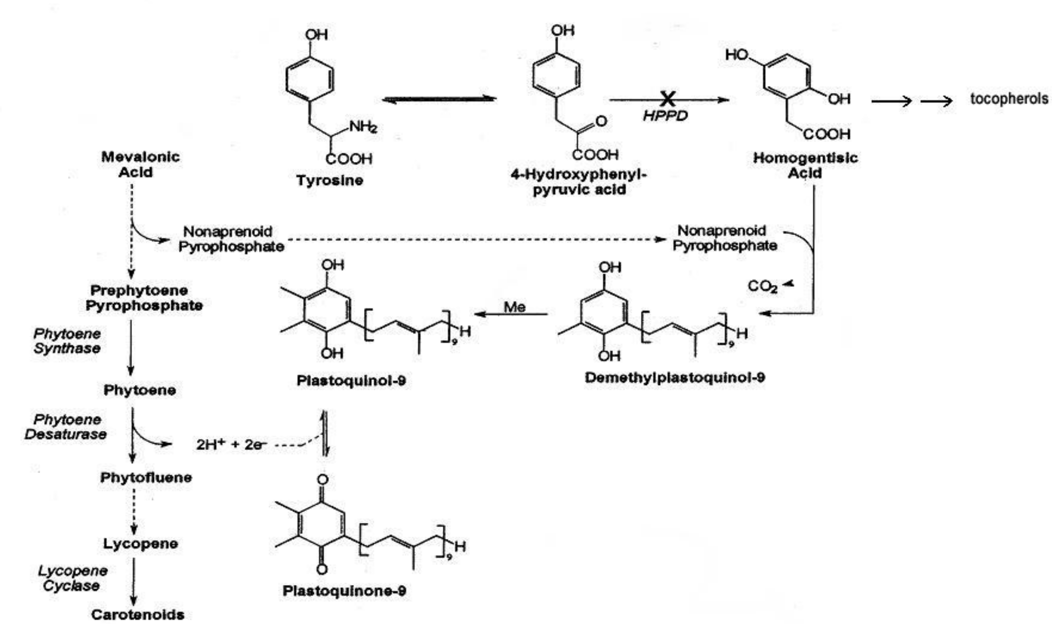


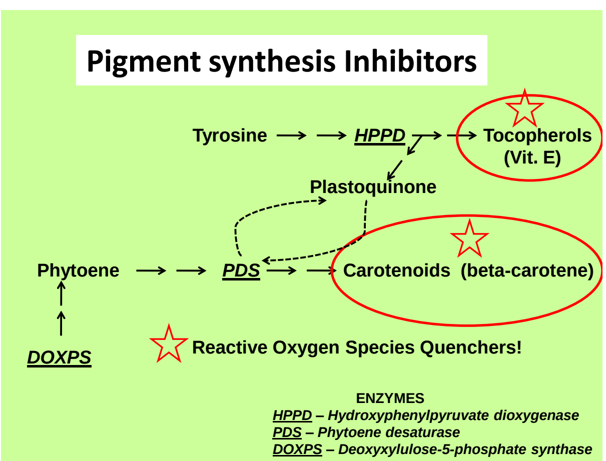


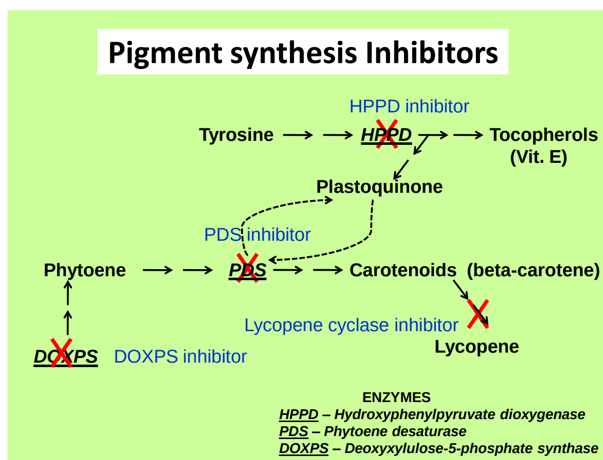


Pigment synthesis Inhibitors

A QUICK BIOCHEMISTRY LESSON







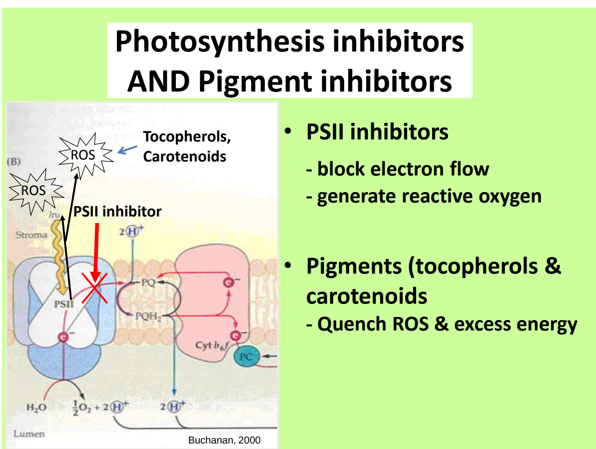
Resistance

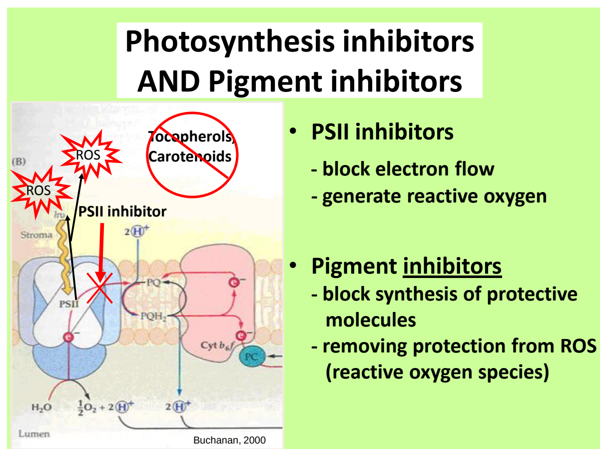
- HRAC **Group 11 (*lycopene cyclase*)**
  Triazoles (amitrole)
- HRAC **Group 12 (*phytoene desaturase*)**
  Pyridazinones (norflurazon), pyridinecarboxamides, 'other' - fluridone
- HRAC **Group 13 (*unknown*)**
  Isoxizolidinones (DOXP synthase inhibitor), Ureas, Diphenyl ethers
- HRAC **Group 27 (*HPPD*)**
  Triketones (mesotrione), isoxazoles, pyrazoles

Symptomology

- New tissue chlorotic or white
- Bleached tissue - necrotic

3. <u>Interaction of PSII & Pigment inhibitors</u>





4. <u>Summary</u>

- **Photosystem II (PSII) inhibitors**
  - Xylem mobile
  - Block electron transfer
  - Reactive species generation
  - Necrosis on leaf margins, older leaves
- **Pigment synthesis inhibitors**
  - Phloem mobile
  - Block antioxidant synthesis
  - Increased Reactive Oxygen Species damage
  - Chlorotic or bleached young tissue

Evaluation of alternative herbicides and the double knock down technique for control of multiple herbicide-resistant hairy fleabane (*Conyza bonariensis*)

Marcelo L. Moretti[1], Bradley D. Hanson[2], Kurt J. Hembree[3], and Anil Shrestha[1].
[1]California State University, Fresno, CA 93740; [2]University of California, Davis, CA 95616 ;
[3]University of California Cooperative Extension, Fresno, CA.

Weed management in perennial cropping systems of the San Joaquin Valley (SJV) relies on a few array of herbicides for postemergence treatments resulting in a continuous use of the same herbicides. Glyphosate and paraquat are among such herbicides, and due to their repeated use a glyphosate-resistant population of hairy fleabane was documented in 2007. Later in 2009, a glyphosate-paraquat multiple-resistant population of hairy fleabane was reported in SJV as well. This multiple-resistant biotype showed an 8- to 16-fold resistance to glyphosate, paraquat, or both herbicides when treated at the 5- to 8-leaf stage. To avoid rapid spread of this biotype, alternative herbicides were tested for control. A greenhouse study was conducted to evaluate the efficacy of glufosinate (69 fl.oz/ac), 2,4-D (2 pints/ac), carfentrazone (1 fl.oz/ac), saflufenacil (1 oz/ac), and double knock-down with glyphosate (27.6 fl.oz/ac) followed 10 days later by paraquat (4 pints/ac) as postemergence treatments. Rimsulfuron, penoxsulam, and flumioxazin were tested as preemergence applications. It was found that glufosinate, saflufenacil-alone or in any combination with glyphosate, and 2,4-D as postemergence treatments and all three preemergence herbicides provided satisfactory control (greater than 90%) of the multiple-resistant biotype. The double knock-down method did not control the multiple-resistant biotype but controlled the susceptible biotype. Among the preemergence treatments, all tested herbicides provided more than 90% control for over 60 days. Penoxsulam and flumioxazin were significantly better (95% control or more) than rimsulfuron (90% control). Therefore, all pre- and postemergence treatments tested in this study can be used as alternate herbicides to glyphosate and paraquat for control of the multiple-resistant biotype of hairy fleabane in the SJV.

Testing Multiple Herbicides for control of Erodium species

Kristin A. Weathers, Department of Botany and Plant Sciences, 2150 Batchelor Hall, University of CA, Riverside, Riverside, CA 92521. kristin.weathers@email.ucr.edu
Milton E. McGiffen, Department of Botany and Plant Sciences, University of CA, Riverside.
Carl E. Bell, UC Cooperative Extension, County of San Diego
Edith B. Allen, Department of Botany and Plant Sciences, University of CA, Riverside.

Exotic annual filarees (*Erodium* spp.) germinate at high densities and early in the growing season. This is a particular problem in restoration situations, where they germinate a dense carpet that makes it difficult for native species to establish and survive. This study was set up to compare five different herbicides at a variety of rates on two of the most common filaree species. These herbicides included glyphosate (broad-spectrum herbicide), triclopyr and aminopyralid (two herbicides selective for broadleaf weeds), and clethodim and fluazifop (two herbicides selective for grasses). The grass specific herbicides were tested because fluazifop had been documented to control redstem filaree (*Erodium cicutarium*) in the desert where it was applied for grass control. Studies in Australia have also shown *Erodium* species to be sensitive to a grass-specific herbicide not available in the U.S. A grass-specific herbicide that was also selective for Erodium species would be useful in the restoration of filaree-invaded plant communities such as coastal sage scrub, where native species are predominantly forbs and shrubs that would be injured by broadcast application of broad-leaf herbicides. However, field reports of the effectiveness of grass-specific herbicides on filaree in non-desert environments of southern California were highly variable. Therefore, while glyphosate and the broadleaf herbicides were tested at high and low label rates, the grass-specific herbicides were tested at both labeled rates and rates higher than allowed by the label to better determine at what rates and in what situations the grass-specific herbicides might be used to control filaree.

Plots were established at two sites in San Diego County, one dominated by broadleaf filaree (*E. botrys*) and the other dominated by redstem filaree. Herbicides were applied in early winter in both 2009 and 2010. Visual damage ratings were performed at 2-, 4- and 8-week intervals after application, and percent cover readings and density counts were taken at some point after the 8-week rating and as close to peak flower for the plant community as possible.

In the broadleaf filaree trials, triclopyr at both 1 and 2 quarts/acre and glyphosate at both 1 and 2 quarts/acre had the highest damage ratings in 2009, and the differences were significant from the control even 8 weeks after application. In 2010, triclopyr and glyphosate were also the highest at the 4-week damage rating, and by the 8-week reading the ratings for triclopyr and glyphosate while still in the most effective group were slightly less and statistically similar to aminopyralid at 7 oz/acre. In 2009, fluazifop at 12 and 18 oz/acre rates (within the range allowed by the label) showed mid-range damage ratings that were statistically different than the control. However, by 8-weeks, fluazifop at 72 oz/acre (three times the concentration allowed by the label) was the only grass-specific treatment showing damage greater than the control, and it was significantly lower than the damage ratings of triclopyr and glyphosate. The mean percent cover of broadleaf filaree was less than 3% in all the glyphosate and triclopyr plots more than 8 weeks after application in 2009. The mean percent cover of broadleaf filaree was not significantly different in any of the fluazifop or clethodim plots than in the control plots in either 2009 or 2010.

The redstem filaree trials showed similar patterns. Redstem filaree showed more visual damage to damage than broadleaf filaree in the fluazifop treatments. However, the the 12 and 18 oz rates of fluazifop did not provide complete or season long control of redstem filaree. In 2009, 8-week damage ratings at above-label 36 oz and 72 oz rates of fluazifop were statistically similar to the triclopyr and glyphosate as the most effective treatments against redstem filaree. However, in 2010 only the triclopyr treatment had a significantly higher damage rating than the control plots after 8 weeks.

Triclopyr at 2 qts/acre was the most effective herbicide treatment in controlling both species of filaree. Glyphosate at 2 qts/acre and triclopyr at 1 qts/acre was statistically similar results to the triclopyr 2 qts/acre for both species and years. Label rates for fluazifop showed some damage on both species (more on redstem filaree) but did not control either species. Fluazifop at 72 oz per acre controlled redstem filaree, indicating that multiple applications within a growing season might provide control of redstem filaree. Aminopyralid showed activity, but did not control as effectively as the previously discussed herbicides.

CWSS Student Paper and Poster Contest

Title: Comparison of pre-plant weed control treatments in organic broccoli

Authors (names separated by commas): Nathália Mourad, Marcelo Moretti, Sajeemas Pasakdee and Anil Shrestha

Abstract:

Weed control is a major problem in organic vegetable cropping systems. It is essential to start with clean weed-free beds to reduce early season weed competition and potential crop loss. Pre-irrigation followed by postemergence control is an integrated weed management (IWM) strategy. Many methods can be used for postemergence control of the weeds that emerge after pre-irrigation, including mechanical, thermal, and chemical. The objective of this experiment was to compare the efficacy of four postemergence weed control methods prior to transplanting broccoli: hand-hoeing, propane flame, organic herbicide (GreenMatch®), and steam in pre-irrigated organic broccoli plots. A non-treated control plot was also included. Weed densities (prior to planting and prior to hand weeding) was 60 to 80% lower and time for hand weeding was more than 70% shorter in the treated plots compared to the untreated control. Flaming was the most efficacious treatment. The results for steaming, GreenMatch, and hand weeding were similar Therefore, pre-irrigation followed by any of the pre-plant burndown (preferably flaming) treatments may be a good IWM strategy in organic broccoli systems.

Use of Selenium-enriched Mustard and Seed Meals as Potential Bioherbicides and Green Fertilizer in Organic Spinach and Broccoli Productions

Annabel Rodriguez [1,2], Gary Banuelos[2], Sajeemas Pasakdee[1], and Anil Shrestha[1]
[1]California State University, Fresno; [2]USDA-ARS;
Dept. of Plant Sci., 2415 E. San Ramon Ave., M/S AS72, Fresno, CA 93740;
559-278-5784; ashrestha@csufresno.edu

New plant-based products can be produced from seed harvested from Brassica species used for phytomanaging selenium (Se) in the west side of central California. Se-enriched seed meals produced from white mustard (*Sinapis alba*) plants and plants were tested as potential bioherbicides and green fertilizers in spinach (*Spinacea oleracea*) and broccoli (*Brassica oleracea)* production under organic field conditions for one growing season. Treatments consisted of adding either mustard meal (containing 2.2 mg Se/kg dry mass) or control-soybean meal (containing <0.1 mg Se/kg dry mass) (*Glycine max* L. Merr.) to the soil at rates equivalent to 0.5 and 2 t/acre, respectively, 2 ½ weeks before planting. During the growing season we observed that mustard meal treatments (especially high) lowered the emergence of resident winter annual weeds more than soy meal treatments. High rates of mustard meal reduced hand weeding time and weed biomass by almost 50% compared to all treatments. Fresh and dry biomass of both spinach and broccoli plant yields were, however, greatest with high soy treatment followed by high mustard meal treatment. Among the nutrient accumulation, plant Se, calcium (Ca), manganese (Mn), and zinc (Zn) consistently increased in spinach leaves and in broccoli florets with high mustard meal treatments. Amending soils with Brassica seed meals have practical viability for use in organic agriculture as a potential bioherbicide and as a green fertilizer for promoting Se and other nutrient content.

Optimum temperatures for two biotypes of horseweed (*Conyza canadensis*) and hairy fleabane (*C. bonariensis*) germination

Katrina Steinhauer and Anil Shrestha
California State University, Fresno

Horseweed (*Conyza canadensis*) and hairy fleabane (*Conyza bonariensis*) are two common weeds found in orchards, vineyards, and roadsides in the San Joaquin Valley (SJV). In recent years, these two species have become a more widespread problem in the SJV due to the evolution of glyphosate resistance and paraquat resistance (in hairy fleabane only). Therefore, alternate control approaches are required for the herbicide-resistant horseweed and hairy fleabane. An approach would be to develop an integrated weed management (IWM) system for these species. Weed biology is an integral part of IWM and it includes aspects of seed germination and seedling emergence. A major environmental factor driving seed germination and seedling emergence is temperature. In recent years, these species have been noticed to germinate and emerge year-round in the SJV. Hence, the optimal temperature for germination of these species needs to be determined. Studies in the SJV have found differences in the growth and development of glyphosate-resistant (GR) and glyphosate-susceptible (GS) biotypes of these species. However, differences in optimum temperature for germination and emergence of these two biotypes are unknown. Therefore, the objective of this experiment was to determine the optimum temperature for germination and seedling emergence from seeds of known GR and GS horseweed and hairy fleabane collected from the SJV. A growth chamber experiment was conducted at California State University, Fresno in 2010. Pots were filled with media and 30 seeds of each species and biotype were planted on the surface of the media. The experiment was arranged as a split-split plot and replicated four times with temperature as the main effect, species as the sub plot, and biotype as the sub-sub plot. Growth chamber temperatures were set at 5/0, 10/5, 15/10, 20/15, 25/20, and 30/25 C (day/night) temperature, respectively. Seedling emergence counts were recorded every day and an emerged seedling was removed as soon as it was counted. Seedling emergence was monitored for about 6 weeks. Results showed that optimum temperature for germination of both species was 25/20 C. Some germination was observed at temperatures as low as 10/5 C. Germination, in general, was greater for horseweed than for hairy fleabane. This may be because of the differences in maturity of the seeds at the time of collection or other factors. Significant differences were seen in germination of the GR and GS horseweed seeds at the lower and higher temperatures but not at the optimum temperature. The germination of seeds from GS horseweed plants was always greater than those from GR plants at the sub-optimum temperatures. However, the differences were opposite for hairy fleabane because the germination of seeds from GR hairy fleabane plants was greater than those from GS plants at almost all temperature regimes, except at 5/0 and 30/25 C. These findings may be interesting as the study showed that germination of the biotypes at different temperature ranges was different although the seeds were collected from areas within a 50 mile radius. The differences between biotypes could be a result of environmental rather than genetic factors, but this needs to be ascertained. In conclusion, the experiment determined the optimum temperature of both species as 25/20 C and found differences between biotypes in germination and seedling emergence. The experiment is being repeated.

Preliminary screening of suspected glyphosate resistance in Palmer Amaranth (*Amaranthus palmerii*) in the Central Valley finds negative results

Jeff Gallagher, Marcelo Moretti, and Anil Shrestha
California State University, Fresno

Palmer amaranth (*Amaranthus palmeri* S Watson) is a highly competitive annual weed belonging to the Amaranthaceae family. In the last 5 years, glyphosate-resistant (GR) biotypes of Palmer amaranth have been reported from the south-eastern US. In recent years, a few cases of poor control of this species have also been reported in the Central Valley. A suspected case of GR Palmer amaranth in San Joaquin County led to this study.

A study was conducted at California State University, Fresno in the summer of 2010. Seeds were collected from suspected GR Palmer amaranth plants along Hwy 99, Stockton, CA. Seeds from known glyphosate-susceptible (GS) Palmer amaranth were also used for comparison. Sixty 4 x 4" plastic pots were filled with a potting mix and about 12 seeds were planted in each pot. The pots were placed in the sun and regularly monitored for moisture and germination. At 31 days after planting (DAP), the plants were sorted into three categories by height: short (<3"), medium (3-6"), and tall (>6") and sprayed with Glyphosate Weathermax at 27.5 fl oz/ac, 30 psi, 20 gal/ac volume by means of a CO_2 backpack sprayer equipped with a flat fan nozzle. A set of unsprayed plants for each plant size was also included. Each set had 14 pots of short, 5 pots of medium, and 4 pots of tall for a total of 46 pots. About 45 DAP, the plants were cut and placed into brown bags for drying, and then weighed for biomass.

Typical symptoms of glyphosate injury were present at 22 days after treatment on the short and medium plants and they were dead. However, the treated tall plants showed no injury symptoms and appeared similar to their untreated control counterpart. The treated tall plants outweighed the untreated control, which indicated that glyphosate had no affect on them. These results indicate that this Palmer amaranth biotype is still susceptible at the labeled rate of glyphosate. Although this study tested negative for glyphosate resistance, the size of the plant at the time of application made a difference as the taller (> 6") plants survived the glyphosate application. At this point, it is not known if GR populations of Palmer amaranth exist in other locations of the Central Valley. Growers and land managers should be cautious and plan for management strategies to prevent the onset of glyphosate-resistance in this species in California.

State of the State: The Regulator's Perspective

Mary-Ann Warmerdam, Director, California Department of Pesticide Regulation
mwarmerdam@cdpr.ca.gov

The California Department of Pesticide Regulation (DPR), like other state departments and agencies, is in transition under new Gov. Jerry Brown. Gov. Brown has proposed $12.5 billion in cuts statewide. DPR receives no general funds. It is funded by registration and licensing fees and a 2.1-cents-per-dollar "mill assessment" collected at the wholesale level. Our ability to provide services has been affected by furloughs, retirements and a hiring freeze.

The good news is DPR's proposed budget includes $2.5 million to expand the state Department of Food and Agriculture's (CDFA) pesticide analysis capabilities to support DPR's regulatory activities, including monitoring for illegal pesticide residues and investigations. CDFA's laboratory analyzes samples for DPR. This funding would replace equipment, purchase new equipment and hire staff to support the expanded capabilities.

The following are updates on several issues:

- The U.S. Environmental Protection Agency (U.S. EPA) has implemented safety measures for four soil fumigants to increase protections for agricultural workers and bystanders. The fumigants are chloropicrin, dazomet, metham sodium/potassium and methyl bromide.
    - Examples of safety measures include buffer zones, posting requirements, applicator training programs, application method, rate restrictions, emergency preparedness and response requirements.
    - The first phase – primarily buffer zones – is being implemented this year. Don't expect amendments for labels until late spring/summer. The second phase is 2012.
    - Registrants must end sale and distribution of fumigant products bearing old labels no later than Nov. 30, 2010. After that date, registrants can only sell and distribute products bearing new labels.
- Methyl iodide was registered Dec. 20, 2010, when emergency regulations designating it a restricted material took effect. Methyl iodide was registered by U.S. EPA in 2007 as a replacement for methyl bromide, which damages the earth's ozone layer. Our decision to register followed U.S. EPA's approval of CA-specific labels for four methyl iodide products.
    - Methyl iodide is the most evaluated pesticide in DPR's history. We have adopted the toughest health-protective restrictions in the nation.
    - Methyl iodide is a restricted material that requires a use permit from the county agricultural commissioner, who can deny a permit only if it's likely the use would result in a substantial adverse environmental impact that cannot be reduced with additional restrictions.

- A lawsuit challenging DPR's registration and emergency regulations was filed Jan. 4, 2011, in Alameda County Superior Court by the Pesticide Action Network North America, United Farm Workers, Californians for Pesticide Reform, Pesticide Watch Education Fund, Community and Children's Advocates Against Pesticide Poisoning, Worksafe Inc., and two farmworkers by Earth Justice and CA Rural Legal Assistance.

- Methyl bromide regulations took effect on Nov. 26, 2010, after years of litigation. A 2004 lawsuit by California Rural Legal Assistance challenged DPR's level of methyl bromide in ambient air. To comply with the San Francisco Superior Court order, we submitted new regulations "jointly and mutually" developed with the Office of Environmental Health Hazard Assessment to the Office of Administrative Law.
- Permit conditions for MITC (generate methyl isothiocyanate) were finalized. Implementation of permit conditions will be phased in through March.
- As of Jan. 8, 2011, chloropicrin is a toxic air contaminant. This action does not immediately put further restrictions on its use. However, it requires DPR to determine appropriate statewide health-protective measures for residents and bystanders. A full risk assessment that addresses occupational exposures is still under way. Target date for completion is early 2012.
- Regarding surface water protection, DPR has a long history of addressing detrimental effects from pesticides dating back to the early 1980s when large fish kills in Sacramento Valley agricultural drains were linked to the rice herbicide Ordram. In 2007 regulations were adopted to protect surface water from agricultural insecticides applied during the dormant season.
    - Pesticides continue to be detected in surface water despite efforts to control discharges. DPR held three workshops in 2010 to accept comments on development of additional regulations to address drift, irrigation and stormwater runoff. We are working with state and regional water quality control boards to clarify overlapping regulatory roles.
    - We are proposing new regulations to protect surface water quality, initially for non-agricultural uses. We will be looking at pyrethroids and possibly other pesticides. Our target date for submitting a regulatory package to the Office of Administrative Law is late spring. We plan to follow up with proposed regulations for agricultural uses in late 2011 or early 2012.
- DPR encourages integrated pest management (IPM) through its Pest Management Alliance Grants and IPM Innovator Awards.
    - Alliance Grants are awarded to partnerships that develop IPM practices to reduce or eliminate pollution and pesticide exposure in agricultural and urban environments. We have awarded approximately $10 million in grant funding since 1996. A total of $400,000 will be available beginning July 1, 2011. Project concept summaries are due Feb 7, proposals are due April 7 and grants awarded June 30.
    - IPM Innovator Awards recognize efforts to reduce risks associated with pesticide use and share research and methods with others. More than 100 California organizations have been honored since 1994. Applications are accepted year-round.

More information about DPR is posted on our Web site at **www.cdpr.ca.gov**.

The Right of Way Perspective
Balancing Biology, Reality, and Sustainability

William D. Nantt, Landscape Specialist, 4th District CalTrans

The views expressed by the author do not necessarily reflect the views of the CA Department of Transportation. Accuracy, completeness, veracity, honesty, exactitude, factuality and politeness of comments are not guaranteed.

In light of current economic conditions that exist in most places, but especially here in California I think the theme for this year's CWSS is most fitting. I'm going to focus on the "reality" portion of the title. A fellow named James Baldwin once said,

"*Not everything faced can be changed, but nothing can be changed until it is faced.*"

I meet people from many walks of life in my job. Some work for various agencies such as federal, state, county and city governments. Others work for districts of various types. I work with weed management organizations, business interests and interested members of the public. One thing they all have in common is a fundamental misunderstanding of what Caltrans is, what it is allowed to do, and when it comes to managing weeds, how few resources are dedicated to it. Caltrans is a state agency consisting of roughly 21,000 employees. For comparison purposes the department of corrections has triple that number of employees. The maintenance division of Caltrans, where ninety nine percent of all weed management takes place, has only 25% of all Caltrans employees. In the maintenance division well under 1000 employees are fully dedicated to vegetation management and only a fraction of them are full time weed management personnel.

Caltrans is an organization run by Engineers. Unless you are an engineer (or in a few cases, an architect) you can only promote to low level management. Engineers exhibit certain traits that give Caltrans a distinctive feel. Engineers like to design concrete, steel and asphalt solutions and tend to lose interest in mundane maintenance issues. In fact maintenance personnel feel as if engineers look down on them.

Caltrans maintenance has changed fairly dramatically over the past few years in the face of the ongoing state budget crisis. As with many governments, maintenance is often the first thing cut. Caltrans maintenance crews have been reduced over the last five years by 50% and over the last ten years by up to 70%. Currently there is a hiring freeze and in District 4, the nine Bay Area counties, there are 100 openings in field maintenance and another 20 in various office positions. As if this isn't enough of a challenge the average age of a Caltrans employee is fifty years of age.

Maintenance headquarters in Sacramento has its own set of challenges. The Office of Roadsides has multiple openings and the Statewide Landscape Program Administrator position has not been filled in well over 2 years. Issues once addressed at state level are now often addressed at district level, so the overall vegetation program doesn't have the uniform feel it once had. This isn't necessarily bad because we have some good vegetation managers and PCA's at the district level.

Maintenance workers with Caltrans are literally where the rubber meets the road. These men and women are the people who implement the Caltrans vegetation management program. They are much maligned and very much misunderstood. It takes a certain personality type to handle what these folks do on a day to day basis. Because the job is so dangerous and the fact that these are relatively low paying jobs, maintenance employees tend to have no more than a high school education. Maintenance workers tend to be very deliberate, cynical and tend not to trust anyone wearing a tie or holding a Blackberry in their hand. To get things done with these people you must understand them. They need to be shown that a new method or technique works….not told. Once you have their trust these people make excellent friends and allies.

Work on or near the highway is inherently dangerous. Every year there are thousands of deaths and injuries on California highways. On average more than one Caltrans maintenance employee is killed each year and many are injured.

Due to California's unique geographical layout and large population, much of the freight moved is done so by semi truck. Trucks are massive, carry tons of weight and travel at relatively high speeds. Trucks and passenger vehicles often don't coexist very well and when you have to slow them down or move them over in a Caltrans work zone, problems result. In the latest information I can site, there were 70 fatalities in Caltrans work zones in 2008.

Because Caltrans work zones are dangerous to both the public and Caltrans employees, maintenance employs strategies to save lives and reduce injuries. Caltrans uses massive vehicles with articulated crash cushions to absorb the energy of an impact. We also use early warning vehicles to notify motorists of an upcoming work zone and shadow trucks in the immediate vicinity of any work being performed on the roadway or a narrow shoulder. It takes three trucks and three employees to spray a four foot fire control strip. Safety will always trump the expense of using multiple people and equipment to perform any operation. Worked performed in the roadside environment such as mowing, is considered safer and requires fewer safety precautions. Caltrans utilizes many specialty vehicles which have been adapted to perform routine maintenance duties for safety and efficiency reasons. Once requested it can take several years to finally take possession of one of these vehicles. Obviously you can't purchase one of these vehicles off the shelf. The base vehicle is purchased at the headquarters level and sent to a location in Sacramento where it is outfitted to Caltrans specifications. Due to resource reductions and furloughs this process takes years and often the supervisor who requested the vehicle has moved on and another supervisor with different needs has taken their place. Often the recipient of the new equipment has to request a modification at the local level further adding to the time an old or obsolete piece of equipment must be used.

The Shop owns all vehicles and maintenance personnel are not allowed to modify the equipment. This is problematic as the Shop is understaffed and furloughed. It can take weeks just to have basic maintenance performed on a vehicle. Anything more serious can take months. Obviously this is a problem for a spray crew attempting to put down a preemergence herbicide during a narrow weather window when they have equipment problems. Backup vehicles are not an option due to equipment reductions over the past five years. Contracting out repair work is performed on rare occasions with emergency justification only due to Union restrictions.

Politics play a big role in any public service job at any level of government and with Caltrans maybe even more so. Governors can issue executive orders which can supersede any plans you may have at the local level. The Caltrans Director is an appointed position and serves at the pleasure of the governor. With the current governor's appointee this will be the fourth Caltrans director in the last four years. Caltrans Directors can issue orders which supersede your planned duties. This lack of experience and continuity at the top can cause indecisiveness at lower levels, but also gives competent managers at lower levels a little more freedom.

The California legislature can have an effect on what we do as well. In 2010, 750 new bills were passed and signed into law. The total number of laws in California exceeds 57,000. This creates scenarios where after some time we find out that a law has changed and we were late adopting it. With personnel shortages at all levels the information flow isn't what it was.

Another department that influences what we do is Caltrans legal. As you might expect, Caltrans is a big legal target. We get sued not only by outside interests but by our own employees as well. Depending on risk management factors, legal can dictate policy to stem the loss of money paid out in legal rulings. This can work in our favor. In the case of wildfires, we were given the ability to use more herbicides contrary to what our EIR allows. Previous legal decisions have had a big influence on Caltrans policies.

There are a variety of outside interests who have had an influence on Caltrans policy. Anti chemical groups have impacted the vegetation management policy of Caltrans: In the early 1990's Caltrans was sued by a group concerned with Caltrans' over-reliance on herbicides for vegetation control. Caltrans hired a consultant to study the situation and craft an environmental impact report. In 1992 Caltrans adopted the consultant's recommendations. The highlights of the 1992 EIR included adoption of an IVM approach, the reduction of herbicide use by 50% by the year 2000 (which was met) and by 80% by 2012. In addition Caltrans agreed to a reduction of total acres treated.

The 80% reduction by 2012 may have already been achieved depending upon one's interpretation of the original report. The original draft did not include herbicides used for landscape weed control, but have been included in the reductions ever since. Surfactant usage was included as well.

Almost 20 years later and two things are clear. Caltrans ability to address the issues of wildfire management and the spread of noxious weeds in our right of way has been limited. The EIR stated that the ability of Caltrans to adopt certain IVM tactics was resource dependent. Resources have been greatly reduced since 1992 and hopefully decisions made in 2012 will recognize this fact and allow us more flexibility. The EIR resulted in some positive results. Oversight is necessary, so is the ability to adapt.

I've just pointed out some of the challenges we at Caltrans face in getting our job done. Now I'd like to focus on what we can do and what you can do to reach our common weed management goals.

Due to resource limitations which I'm certain are permanent, future weed related accomplishments will have to be done in a spirit of cooperation. Communication will be the key to getting anything done. On the Caltrans side we must do a better job of intra department communication. We are not currently very efficient at working together as an agency. Design, Construction, and Maintenance need to get on the same page, if we are to be successful at structural weed control. For example, weed control mats have been specified for all new guardrail installation statewide. My guess is not even 1% of new guardrail installations receive these mats. Construction is not being held to the standard, but Maintenance doesn't have any recourse other than to complain. This needs to change.

Caltrans needs to do a better job of keeping up with the latest methods and techniques. Due to resource reductions, personnel in some locations are not allowed to travel for training or meetings. In my opinion this is the time we need to maximize efficiency by keeping abreast of the most current methods of getting the job done. Not all landscape specialists were able to attend this meeting due to travel restrictions in their districts. Due to lack of advocates for our position in Sacramento, this sort of situation is difficult to remedy.

Better communication between Caltrans and county agriculture commissioner's offices would greatly improve weed control statewide. Weed Management Area (WMA) meetings are excellent vehicles for accomplishing this. Caltrans responds to organized letters of concern, especially when many parties are involved. For example, if the Ag Commissioner's office is concerned about Yellow star thistle on Caltrans right of way and another letter was produced from a fire management district with fuel load concerns, Caltrans headquarters may allow the district PCA to use more herbicide than they have been allotted. If herbicides were an issue perhaps additional mowing would be authorized.

In addition to various counties, WMA, and landowner concerns, working together helps to deal with political groups with axes to grind. A united front makes for a less inviting target for those who just like to complain. Not all complaints are baseless. Efforts need to be made to mitigate legitimate concerns. One tool we have is the Adopt-A-Highway program. We have used this program to allow groups concerned about pesticide use to maintain a defined area in a manner they can live with. This program is underutilized.

Property owners adjacent to Caltrans right of way have an underused option at their fingertips. The Property Owners Roadside Vegetation Act of 1991 allows property owners to work on our right of way to control vegetation. Due to limits on how many acres we can treat with herbicides or mow, landowners are often dissatisfied with levels of weed control we obtain between the roadway and the fence separating their property from ours. Landowners may have legitimate concerns about the potential spread of noxious weed seed and wildfire onto their land. Encroachment permits can be issued to owners after consultation with a Landscape Specialist.

Working with the private sector is an underutilized avenue for getting things done. If it were not for some chemical representatives, we would not have met our training obligations in 2010. The prolonged budget impasse made it impossible for us to pay for our DPR approved training classes. Dow AgroSciences recognized our plight and paid the DPR fee so we could proceed with our goal of providing continuing education for our certified personnel. Other industry assistance was received from DuPont, Wilbur-Ellis, Helena Chemical, and Target Specialty Products for other matters.

I've mentioned many challenges Caltrans faces in general and specific to weed management as well as some solutions to keep us moving forward. In conclusion I'd like to say that it is challenges that make us increasingly more efficient, as long as the challenges don't overwhelm our capacity to change. My fellow PCAs and I are a stubborn bunch and I liken us to the Black Knight in Monty Python's Search for the Holy Grail. We won't easily admit defeat and if we can't win, we'll call it a draw!

The State of the State on Weeds: The AG Industry Perspective
It's Time to Fight Back Against Environmentalists' Untruths

Renee Pinel, President/CEO Western Plant Health Association

If you believe that it is important for your business to remain profitable and viable in the wake of a continuous barrage of bad publicity - often whipped up by overzealous environmental groups promoting their own agendas and quoting "bad science" to support their claims - then the answer can be found here.

For too many years now environmentalists have been dominating the media with their anti-business messaging that has resulted in a series of what many call frivolous lawsuits in attempts to delay, block or outright ban the use of products that make homes and business safe from disease and pests.

One need only point to the fairly recent citizen uproar involving the aerial pheromone spraying of the light brown apple moth over Santa Cruz and Monterey counties in California to understand how the ill-informed public, local politicians and environmental groups can short-circuit efforts to protect our food source from insect invaders. Even though the U.S. Environmental Protection Agency and California agricultural officials assured anxious residents that pheromone aerial applications posed no safety concerns and was the most effective way of eliminating the invasive pest, the frenzy whipped up by the media and community action groups killed the aerial spraying campaign.

The light brown apple moth known to feed on hundreds of different plants, was first detected in 2007 and has since been found in 18 California counties which have been under quarantine - which requires counties to have crops including nursery stock, regularly inspected and follow strict procedures before their crops can be moved into or out of the quarantined zones.

Let’s consider a world without pesticides, a reality that many green groups have as their end objective. Simply put, that would mean allowing crop-damaging diseases, insect infestations and noxious weeds to decimate the human food supply chain and drive grocery prices through the roof; it would allow vector-borne illnesses caused by rats and mosquitoes, such as encephalitis and West Nile virus, and Lyme disease caused by ticks, to run rampant; and cockroaches and mold/mildew would penetrate uncontrollably into such areas as our homes, restrooms, school cafeterias and elsewhere, spreading known allergens that cause asthma and other diseases.

Let's take it a step further: other insects and plant pests, such as poison ivy, fire ants, spiders, lice, bedbugs and termites, now effectively controlled by pesticides, would be free to wreak havoc on humans and their dwellings. And let's don't forget that poor Fido would be left on his own to scratch away platoons of invading fleas.

Yet, it seems like almost daily there are media reports highlighting the dangers of pesticides, which fruits and vegetables are more safe to consume, new demands for wider and wider buffer zones from residential and business neighborhoods, and this survey and that study pointing out yet new risks and dangers from working or living in and around these products. More often than not, much of this information is "misinformation," passed along and circulated by environmental groups who have their own agendas and fund-raising demands to fulfill.

For instance, between 2000 and 2009, three tax-exempt, nonprofit environmental groups - Western Watersheds Project, Forest Guardians and the Center for Biological Diversity - filed more than 700 cases against the federal government. Between 2003 and 2007 the federal government paid more than $4.7 billion in taxpayer money to environmental firms; and that's a conservative estimate. In one 15-month-long case the Earthjustice Legal Foundation and the Western Environmental Law Center filed for $479,242 in attorney fees. Insult to injury, consider this: the president of the Environmental Defense Fund rakes in an annual $446,072 in salary; in second place for salary is the $439,327 paid to the president of the World Wildlife Fund.

What can you do about it? Well, since public opinion frequently makes its way into the halls of your local elected officials, you can counter the claims of these environmental groups by making your viewpoints heard by attending sessions with your government representatives. The more industry participation we have during these sessions the greater our strength in showing that industry is serious and devoted to enlightening elected representatives about the many benefits available when using sound pest prevention and eradication practices. These benefits obviously enhance and improve environmental safety and public health, and practicing these methods can help dispel the many myths that place our industry in a negative light.

You can help make a difference. Your voice does matter. If we don't do something now, we will continue to be frustrated by the faulty and distorted stories being circulated by those wishing our industry ill. Make up your mind today to take a stand and get involved for the good of our businesses, our industry and for the world's growing population.

What You Can Do To Get Involved

- Write a Letter to the Editor and set the record straight whenever a news item places your business and industry in a bad light.

- Belong to an industry association and make sure it has an active legislative program that fights bad bills and regulations, and provides members with information on these issues.

- Participate in your association's legislative events, whether they are Capitol legislative days or district events.

- Ask your association to arrange group in-district visits with your legislator where you and your peers can make your presence felt.

- Monitor legislative bills that can damage your business interests and let your representatives know of the many flaws, and vote accordingly.

- Contact environmental groups directly and let them know the flaws in a press release or Web site posting if the science is distorted or untruthful.

The Scientist's Perspective: Weed Science Engaging

John Jachetta, Ph.D., President, Weed Science Society of America
Email: jjjachetta@dow.com

As a scientific society, WSSA is uniquely positioned to provide real value through our growing impact and leadership on subjects important to the membership and the Nation. WSSA members have been called on frequently to provide science-based information and National leadership in areas critical to the country's success.

This year, we created a special WSSA Herbicide Resistance Education Committee to address emerging issues on the topic. Lead by David Shaw (Mississippi State University), this committee is developing a comprehensive education strategy on herbicide resistance. One critical deliverable resulting from this committee's activities will be the development of an "Herbicide-Resistant Weeds Management Report", funded by USDA-APHIS. In part, the justification for this report notes that "there exists a need for a systematic understanding of the most contemporary publicly available information on the extent to which weed resistance management programs are being utilized in various managed ecosystems and an understanding of how successful they are at achieving their goals." This report is scheduled to be completed in mid-2011; sooner if possible.

Through our WSSA-EPA Subject Matter Expert, Jill Schroeder (New Mexico State University), we have been steadily moving forward to coordinate our resistance management education efforts with the Agency. As Weed Scientists, we understand that a program of resistance management education will help only if it is based on a comprehensive understanding of resistance, both as an economic as well as a biological phenomenon, and only if it includes active participation by all parties that contribute significantly to herbicide use decisions.

A wide range of new materials are planned for the WSSA website including new training modules targeting the Certified Crop Advisor program, grower organization and Extension Specialist. Additionally, WSSA has formed a sub-committee to begin developing the training modules and materials are planned in a wide range of formats and at a number of levels, including: foundational information, region-specific, commodity-specific, and weed-specific resources.

The regulation of spray drift remains problematical; the risk assessment tools that EPA employs are based on aging data and the application technology in current use has improved significantly. WSSA supports science-based risk assessment that considers the benefits of pest control and the clear validation of the advancements in application technology.

In the further service of our public mission, WSSA has been very involved with the developing National Pollutant Discharge Elimination System (NPDES) permitting program for pesticide use in the riparian corridor. Congress enacted the Clean Water Act (CWA) more than

30 years ago, adding and later updating the NPDES permitting program several times since then. In the decades that EPA has administered the CWA, the Agency has never issued an NPDES permit for the application of a pesticide to target a pest that is present near or in water. Instead, EPA has been regulating these types of applications through the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Overall, this new decision marks a partial pre-emption of FIFRA by the CWA, layering numerous new requirements on applicators of legally-registered products that have wide value in society. This new rule also exposes applicators to extensive legal jeopardy through citizen lawsuits and Agency actions. Without careful design and execution, the implementation of this pesticide NPDES General Permit could have significant unintended consequences. To help EPA understand the impact of this program, WSSA, working with the US Army Corps of Engineers and the Aquatic Plant Management Society, has worked with EPA Office of Water to help them appreciate the need for weed management in the riparian corridor; part of this effort has been the organization of several educational tours for the Agency to more deeply understand aquatic and riparian vegetation management in Florida and New Mexico so that the Agency can communicate directly with those affected.

We know that as Weed Scientists, we have a special responsibility to contribute to both the national and international effort through our basic and applied research into weed physiology, stewardship and the management of natural and managed ecosystems. Because our community of committed scientists provides a unique strength, WSSA has clearly become a visible and recognized force in the public and national discussion.

The Effects of Small Grain Herbicides on Wheat and Barley Growth

Steve Orloff, Steve Wright, Lalo Banuelos, and Rob Wilson*
**UC Cooperative Extension, Siskiyou County, 1655 South Main St. Yreka, CA 96097*
Email: sborloff@ucdavis

Wheat is an important crop throughout most of the agricultural areas of California. Weed control is a significant problem for small grain producers and nearly all fields are treated for weeds each year. Several new small grain herbicides have been developed, some of which are commonly used in other areas of the country. Some of these herbicides may have a fit California but have not been used commercially because producers and pest control advisors are not familiar with them or they are concerned about the possibility of crop injury. Research is needed to evaluate many of the newer herbicides that are used successfully in other production areas.

Most grain fields contain both broadleaf and grassy weeds. This usually necessitates the use of two different herbicides. Ordinarily the application timing for grass and broadleaf herbicides is different. This presents a problem for producers, who for cost reasons, would like to control all weeds in a single herbicide application. Usually the grass herbicide application timing is earlier because small grasses are easier to control. The broadleaf herbicide is often applied later due to crop safety concerns. So, if a grower wishes to combine grass and broadleaf herbicides and treat early, he or she runs the risk of injuring the crop. Conversely, if the grower chooses to combine herbicides and treat at the later application timing, the grower runs the risk of poor weed control (the grass weeds may have become too large to be effectively controlled) or reducing crop yield from prolonged weed competition. In addition some of the grass herbicides require separate applications at least 7 to 14 days apart to avoid antagonism. More information is needed regarding crop safety of different herbicides. This is especially the case when herbicide tank mixes are used. Therefore, research is needed to evaluate new herbicides and herbicide tank mixes to determine their crop safety and effect on yield when applied at different growth stages.

Field experiments were conducted in both the San Joaquin Valley and Northern California. Herbicides that were evaluated included 2, 4-D, Clarity, MCPA, Shark, Osprey, ET, Axial, Puma, Atlantis, and p ryoxsulam (Simplicity). Many of these were applied alone and in tank-mix combinations. Two application timings were evaluated (an early application at the 2-4 leaf stage and a later application at the early tillering stage before canopy closure). In the trial conducted at the Intermountain Research and Extension Center (IREC) in Tulelake we evaluated the crop injury to two spring wheat varieties (Yecora rojo and Alpowa) and a spring barley variety (Metcalfe). Trials were also established at the West Side Research and Extension Center (WSREC) and with cooperating growers in the Tulare County to evaluate crop injury and weed control with the herbicides listed above.

There were hard frosts after both herbicide application dates that may have compounded the herbicide injury in the Tulelake trial. This is a common occurrence in this cold environment and herbicides need to be evaluated under these conditions. Yecora rojo and barley showed far more injury symptoms than did the wheat variety Alpowa. Injury was greatest with Osprey, Atlantis and pryoxsulam (Simplicity) on barley (Figures 1 and 2). This is understandable, as none of these herbicides are registered for this use. Puma also caused significant injury to the barley. The injury was greater with the early application at the intermountain location but not in the Central Valley. At the Central Valley locations, combinations of ET or Shark with Axial tended to cause more injury than when these herbicides were used alone. However, the injury rarely exceeded a rating of 20 percent, and was nearly gone after a few weeks. Early season injury did not translate into a significant yield decrease at either location (see Figure 3 for Central Valley yield results). Barley yield in the intermountain area was significantly decreased with the application of the compounds that are not registered for use on barley. The early application of 2,4-D caused twisted wheat spikes and tended to reduce yield slightly.

Early applications were more effective for wildoat control in the Central Valley study where weeds were present and control evaluated. An early application is not always superior and growers should monitor the wild oat growth stage relative to the wheat growth stage to properly time herbicide applications. Wildoat was controlled with Axial and Puma alone and in tank mixes. Simplicity and Osprey controlled wildoat at the early but not the late application timing. Wild oat control with Simplicity at the later application timing was improved with the use of a crop oil concentrate or adding ammonium sulfate over just using a non-ionic surfactant.

With new herbicides and application timings we are getting closer to achieving complete weed control (grasses and broadleaves) without severe injury in a single application. However, we are not quite there yet with currently available herbicides and with existing label restrictions on tank mixes. More research and perhaps more herbicide products are needed to ultimately achieve this goal.

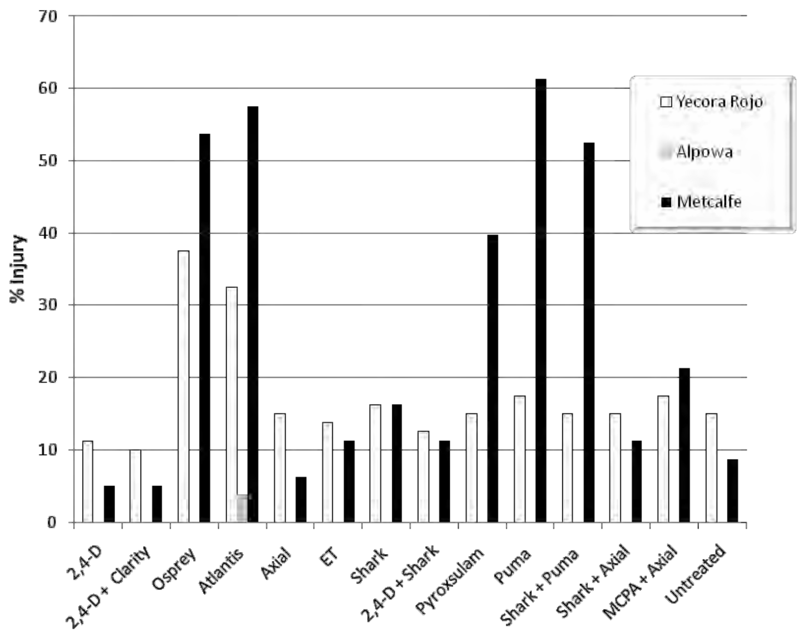


Figure 1. Effect of herbicide treatment on crop injury to Yecora rojo wheat, Alpowa wheat and Metcalfe barley in the Intermountain Region when applied at the early application timing (3 leaf stage).

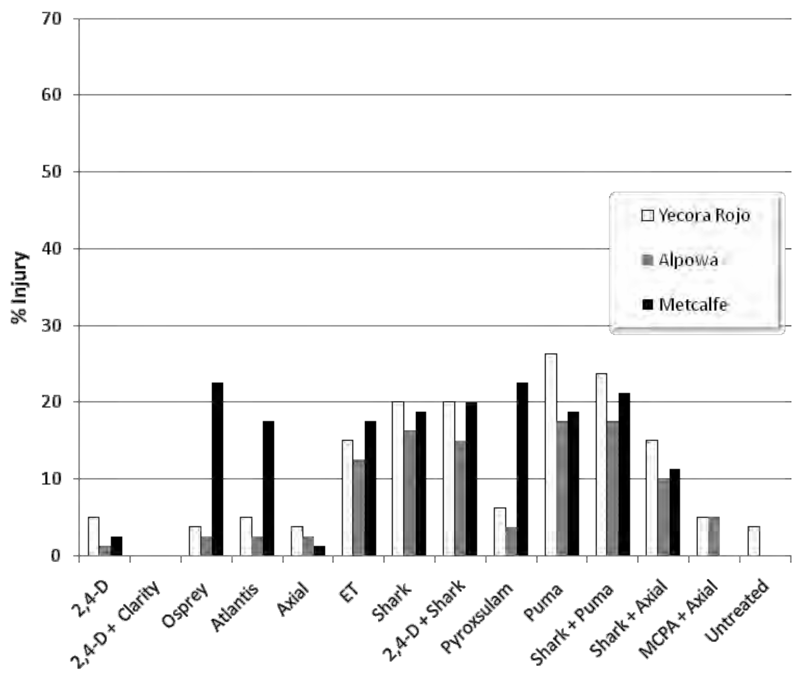


Figure 2. Effect of herbicide treatment on crop injury to Yecora rojo wheat, Alpowa wheat and Metcalfe barley in the Intermountain Region when applied at the late application timing (6-8 leaf stage).

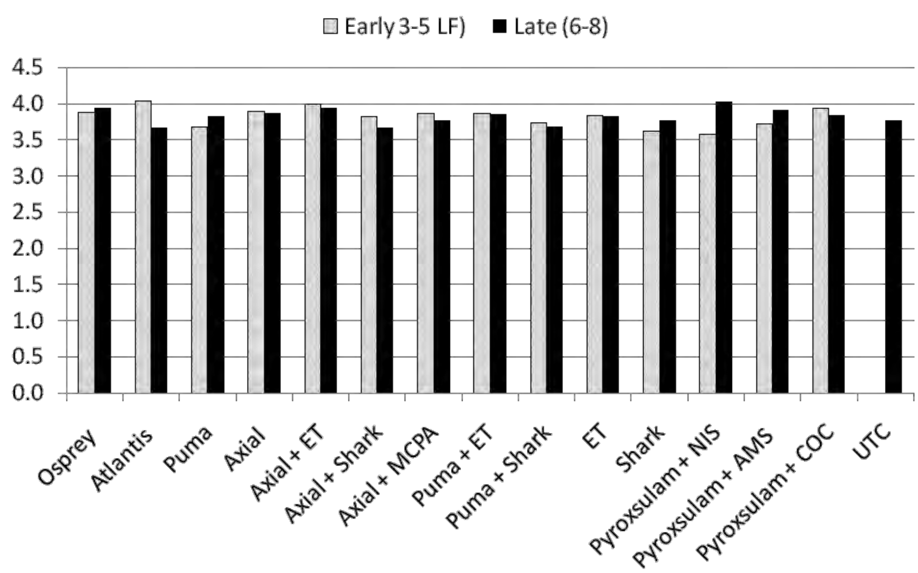


Figure 3. Effect of herbicide treatment and timing on wheat yield (UC West Side Research and Extension Center, Fresno County. 2011).

Impacts of Long-term Cultural Practices on Weed Flora in Cereals

Robert F. Norris
Weed Science Program, Plant Science Department, University of California, Davis, CA 95616.
rfnorris@ucdavis.edu

The Long Term Research in Agricultural Systems project was initiated in the fall of 1993 at the University of California, Davis, research farm. The project compares three nitrogen supply systems: no additional nitrogen, adequate nitrogen fertilizer, and use of a vetch and pea winter legume cover-crop. The systems were either rain-fed or with supplemental irrigation as required in the spring. A two-year wheat/fallow rotation was employed. The wheat versus fallow entry points into the two-year rotations were maintained separately. Weeds in clean fallow systems were controlled with glyphosate. Broadleaf weeds in the wheat were controlled with a mixture of MCPA and bromoxynil. All treatments were replicated three times, and each individual plot was one acre (220 ft by 220 ft). Winter annual weeds were evaluated by annual counts in five quadrats per plot; quadrat size was adjusted according to weed density so that at least 100 weeds were assessed at each location.

Long Term Research in Agricultural Systems

A 100-year experiment located at the Russell Ranch, west of Davis: 1994-2008 **Photo by Ford Denison**

The total number of weeds showed no consistent change over the first 14 years. Species composition of the weed flora did change, however, in relation to nitrogen supply, irrigation, and weed management.

- Shepherd's purse (*Capsella bursa-pastoris* (L.) Medic.) was the dominant weed at the initiation of the experiment in 1994, but had been reduced to a minor species in all systems by 2008. All other weed species constituted less than 1% of the population at initiation in 1994.
- Systems using a winter legume cover-crop to provide nitrogen had higher, but variable, overall weed populations, which were dominated by common chickweed (*Stellaria media* (L.) Vill.) and miner's lettuce (*Claytonia perfoliata* Willd.) by 2008. Miner's lettuce did not increase in cover-crop systems with the fallow entry point until after 2003.
- After an initial lag period of about 8 years, yellow sweetclover (*Melilotus officinalis* (L.) Lam.) became a significant component of the weed population in systems that did not receive additional nitrogen.

- Henbit (*Lamium amplexicaule* L.), unexpectedly, became a significant component of the weed flora in the fallow entry point systems that did not utilize winter legume cover-crops; no increase occurred in systems that started as the wheat rotation at initiation.
- Species such as little mallow (*Malva parviflora* L.), coast fiddleneck (*Amsinkia intermedia* Fisch. & Mey.), wild mustard (*Sinapis arvensis* L.), common sowthistle (*Sonchus oleraceus* L.), and tooth-pick ammi (*Ammi visnaga* (L.) Lam.) were present in several systems, but populations were variable and remained at low levels.
- During the first eight years of the project littleseed canarygrass (*Phalaris minor* Retz.) populations increased in all systems with wheat as the crop at entry. Annual applications of the grass-killing herbicide fenoxaprop-p-ethyl since 2002 resulted in a subsequent decline in the grass population. However, for reasons that are not clear, the littleseed canarygrass increased between 2004 and 2008 in systems that were fallowed at initiation.
- Annual bluegrass (*Poa annua* L.) has increased in all systems with supplemental irrigation in contrast with rain-fed systems, and has become more abundant in systems employing the winter legume cover crop.

The following conclusions can be made after 14 years of different management strategies. Changes in weed populations required multiple years to be manifested; short term predictions (less than 5 years) were usually wrong.

- The two entry points into the rotations resulted in different changes in weed populations; no explanation can be provided for these differences.
- Utilizing a winter legume cover crop to provide nitrogen resulted in a small overall increase in total weed density; major population shifts towards increased common chickweed, miner's lettuce and annual bluegrass occurred. The winter legume cover crop suppressed the invasion of henbit into that treatment, but caused increases in miner's lettuce populations.
- Using only a broadleaf herbicide in the wheat crops resulted in steadily increasing littleseed canarygrass populations in all systems during the first eight years.
- Lack of nitrogen fertilizer allowed invasion by the nitrogen fixing weed yellow sweetclover.
- Several weeds developed larger populations in response to supplemental irrigation used in the spring to improve wheat yield.

The results clearly demonstrate that different management practices can result in alteration of species composition of the weed flora in wheat agricultural ecosystems, and that some changes could be expected based on understanding the ecology of weeds.

ROUNDUP-READY ALFALFA: The Long and Winding Road

Daniel H. Putnam, Department of Plant Sciences, One Shields Ave., University of California, Davis, CA 95616 dhputnam@ucdavis.edu

INTRODUCTION

Alfalfa is the fourth largest crop in both acreage and economic importance in the United States, with over 20 million acres of alfalfa hay grown nationwide (USDA-NASS data). It is principally grown for consumption by dairy animals, but a portion is used by horses, beef cows, sheep and goats. Western states, from Colorado west, account for about 42%, Midwest states 50%, and Eastern states 8% of US alfalfa hay production. Alfalfa is California's largest acreage crop, and alfalfa hay production is greater in CA than in any other state.

Genetic engineering (GE) has had a major impact on the major US-grown field crops, particularly corn, soybean, and cotton, which have had very high rates of adoption of both Glyphosate-Tolerant (GT), and *Bacillus thuringiensis* (BT) traits. GT-Tolerant alfalfa, also known as Roundup-Ready Alfalfa (RRA) has had a major effect on herbicide options for alfalfa growers during the past 6 years, but has also had a checkered legal and regulatory history. This paper reviews the history and the issues surrounding the introduction of Glyphosate-Tolerant (also known as Roundup-Ready) Alfalfa (RRA) through early 2011.

INTEREST BY THE INDUSTRY

There have been some claims that a small minority (7%) of US alfalfa fields receive herbicides (USDA-NASS data, Center for Food Safety statements on website), and thus there is little need for this technology. However, this is certainly not true of California alfalfa fields. California alfalfa fields had 1.4 million acres with herbicides applied in 2009 (CA-DPR, Pesticide Use Reporting) – this alone is 7% of the US alfalfa acreage, indicating that the 7% figure on a national basis is highly suspect. I estimate that a minimum of 90% of California alfalfa fields have herbicides at some point during their lifetime, importantly for stand establishment. Current herbicide strategies have been effective in many environments, but have limitations in terms of crop injury, restrictions due to rainfall, temperature and growth stage, and groups of weeds that are controlled, as well as environmental impacts on water quality. Thus there has been considerable interest among alfalfa growers in this technology. Interest in RRA has been keenest by growers who have had difficulty in controlling weeds such as nutsedge, dodder, common groundsel and dandelion which are not easily controlled by other methods.

ROUNDUP-READY ALFALFA SAGA-Regulation, Lawsuits, and Science

The introduction of GT alfalfa began with the transformation of the first GT lines in 1997 (Table 1). The first RRA varieties were released by Forage Genetics International in 2005 after USDA-APHIS deregulation, but production was halted in 2007 due to a lawsuit that stopped further plantings (APHIS, 2007). The risks of unwanted pollen-mediated gene flow as well as the possibility of Roundup resistant weeds were the key legal and regulatory issues raised in the lawsuit and addressed by APHIS during their subsequent regulatory reviews. These controversies have remained even after USDA-APHIS re-deregulated the trait in 2011, with the issuance of its final Environmental Impact Statement (EIS) in January of 2011 (see USDA-APHIS documents), and will very likely be subject of further lawsuits.

THE TECHNOLOGY

The GT-Tolerant alfalfa technology, or Roundup-Ready Alfalfa (RRA), which enables the use of glyphosate safely on RRA varieties, has been more extensively reviewed in other publications. In brief, Van Dynze et al. (2004) and others (Canevari et al., 2007) reviewed the pros and cons of this technology, and found a range of positive traits for RRA, including its broad spectrum efficacy, high flexibility in application timing, lack of plant-back restrictions, lack of crop injury, economic benefits, benefits for animal feed safety, water quality, and the prevention of spread of noxious weeds. Potential problems of this technology were recognized to be the potential for herbicide resistance, weed shifts to weeds not controlled by Roundup, market acceptance of the hay by GE-sensitive growers and buyers, notably export and organic, and gene flow which might infect neighboring growers during seed production. As it turned out, the possibility of excessive gene flow contamination of neighbors, and the possibility of rampant herbicide resistance were the key subjects of the lawsuit and subsequent APHIS EIS.

THE GENE FLOW ISSUE

Figure 1. Steps necessary for gene flow to occur between alfalfa forage production fields sufficient to cause adventitious presence (AP) in hay.

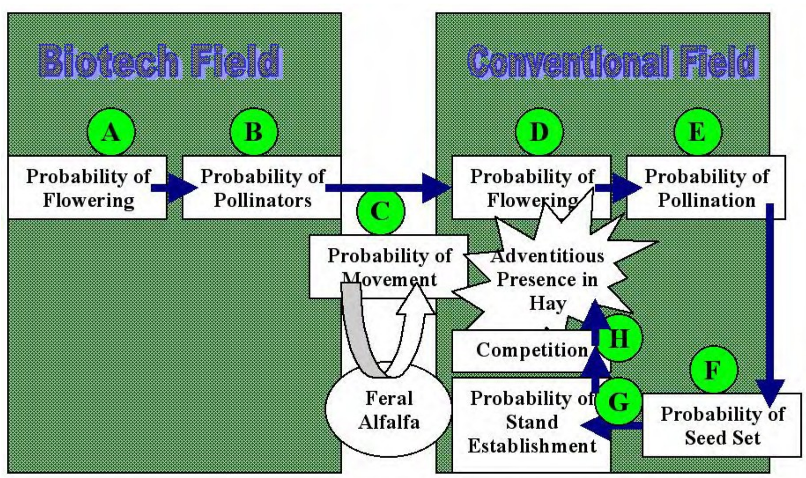


Figure 1. Steps necessary for gene flow to occur between alfalfa forage production fields sufficient to cause adventitious presence (AP) in hay.

Alfalfa is a cross-pollinated crop. Therefore, in seed production, gene flow is a necessary phenomenon and promoted by seed growers since pollinators are required for maximum seed production. However, in production systems, unwanted gene flow from field to field can create contamination (also known as Adventitious Presence or Low Level Presence) of an unwanted gene in a neighboring field. For hay production, a range of barriers to gene flow can prevent inadvertent gene flow (Figure 1). A series of probabilities for separate events are required, and these probabilities are much lower than with seed. The question of market tolerance threshold is a key aspect of this issue- that is whether markets will tolerate small amounts (e.g. less than 0.1%) AP, or whether markets will demand zero levels. It is anticipated that export hay is likely to tolerate somewhat higher AP whereas organic may be lower, levels that will be largely determined by markets.

THE ROUNDUP RESISTANT WEED ISSUE

The excessive development of roundup-resistant weeds as a consequence of the one more GT crops (in addition to corn, soy, cotton) were listed during the lawsuit and de-regulation process as a risk to be considered. A more complete analysis of this issue, and methods to prevent weed resistance, can be found in Orloff et al., 2009.

While it is yet undetermined whether RRA presents a higher risk of resistance than with annual crops (it is my view that the risk is lower), there is no dispute that greater repeated applications of the same herbicide over large acreage increase the risk of both weed shifts and weed resistance. A few key points about this issue: 1) Weed shifts (to weeds not normally controlled by Roundup) are clearly a more important than weed resistance, which requires selection pressure over years. 2) Genetic resistance to an herbicide results from the application of any herbicide, not just glyphosate, and is not necessarily linked to GE crops. 3) Diverse strategies of cultural practices, diverse herbicides are required to prevent resistance or shifts in any system, not just GT cropping systems. 4) There are readily available and well –understood methods to prevent either weed shifts or weed resistance in alfalfa (Orloff et al., 2009). 5) The development of resistance to glyphosate is primarily a technological issue – negating the usefulness of the herbicide. It is a practical problem for farmers, not necessarily an environmental problem. 6) It is important for growers to adapt resistance strategies from the outset, not just wait for weed resistance to occur and then try to address it later.

THE CONCEPT OF CO-EXISTENCE and NEED TO PREVENT RESISTANCE

The de-regulation of Roundup-Ready alfalfa in January of 2011 has determined that GE (genetically-engineered) crops are very likely going to be a part of the future of alfalfa production. RRA is really only the first of several proposed GE traits in alfalfa, with low lignin, higher quality, salt tolerant and other traits proposed. Thus it is abundantly clear that the alfalfa industry must discover methods that GE-adapting and GE-rejecting growers can continue to farm in the method of their choice. This requires coexistence strategies involving better knowledge of gene flow and crop contamination risks, human factors such as communication and willingness to work with neighbors, and awareness of the need to respect and protect differing production systems. Additionally, strategies to prevent the excessive development of Roundup-resistant weeds are required.

Table 1. Important landmarks in the history of Glyphosate-Tolerant (Roundup-Ready) alfalfa.	
1997	First GT-Tolerant Events (Montana State University)
1998-2011	Variety Development (ongoing)-Forage Genetics
2003	Petition for deregulation submitted (contained Environmental Assessment)
2005	USDA-APHIS comes to a FONSI (Finding of No Significant impact), OK's release of RRA.
2005-2007	>300,000 acres planted in US
2006	Lawsuit filed by Center for Food Safety alleging important environmental effects of 'gene flow' and resistant weeds not addressed by APHIS.
2007, January	Legal Decision by 9th Circuit Judge stopping further plantings, requiring APHIS to do a more involved Environmental Impact Statement (EIS)
2007, March	No Further Plantings allowed; Current plantings were allowed to be harvested, with restrictions.
2007-2009	EIS under development by USDA-APHIS
2009, Dec.	Draft EIS issued by APHIS for public comment. Tens of thousands received.
2010, June	Alfalfa Case reaches Supreme Court. Court decides in Favor of Monsanto, that 9th Circuit should not have forced the ban, and that the decision should have been under the control of APHIS.
2010, December	Final EIS issued by APHIS. Additional public comment allowed. Proposed 3 solutions. Two potential de-regulations were presented, one with restrictions, one without.
December-January	More than 16,000 comments received by APHIS. Majority of public comments were against GT alfalfa, as a symbol of GMOs in the food system, comments solicited by activist groups. Majority from farming community were in favor.
2011 January	Aphis makes final determination of non-regulated status for GT-alfalfa, rejecting partial de-regulation (restrictions on planting in seed growing areas)
February, 2011	First opportunities for planting GT-alfalfa after 4 year ban.

REFERENCES - please see: http://alfalfa.ucdavis.edu biotechnology link.

Integrating Transgenic and Conventional Herbicides in Cotton

Steve Wright, Lalo Banuelos, Jamie Changala, Nancy Loza,
Sara Avila, Katie Wilson, Matt Mills, Tony Garcia
Univ. of Calif. Coop. Extension, Kings/Tulare Co., Tulare, CA (sdwright@ucdavis.edu)

Herbicide tolerant cotton acreage has increased dramatically in the United States and amounts to approximately 90 percent in other cotton growing states whereas in California Roundup Ready cotton is grown on 50 percent of the upland and 65 percent of California Pima cotton. The herbicide tolerant acreage of cotton should continue to increase as higher yielding varieties receive these traits. Last season approximately 400,000 acres of cotton was produced and acreage should be over ½ million in 2011 due to extremely high prices.

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 horseweed in California. Cotton growers have also reported poor control of barnyardgrass, pigweed and lambsquarter in some cases.

Roundup Ready technology has provided growers with an excellent tool for managing many annual and perennial grasses, including difficult to control weeds such as nightshades, annual morningglory, and nutsedge. Some of the advantages to this system include the following: Glyphosate can be applied post emergence so growers can wait and see the weeds present. There are no plant back restrictions. This technology has allowed growers to reduce tillage operations and also experiment with ultra narrow row systems. 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.

Even with the herbicide tolerant technology weeds like annual morningglory, lambsquarter, and barnyardgrass are increasing especially when growers are only relying on glyphosate. In other cotton growing states where Roundup Ready cotton is grown on greater than 90 percent of the acreage weed shifts have developed after many years of a reduced tillage systems coupled with extensive use of glyphosate. These weeds include palmer amaranth, horseweed, giant ragweed, and tropical spiderwort.

With the adoption of herbicide tolerant systems there are concerns that certain weeds would develop resistance or cause weed shifts due to the repeated use of a single herbicide. Concerns have already surfaced in California regarding reduced control in some cases of barnyardgrass, sprangletop, pigweed, and lambsquarter with continual use of Roundup Ready systems. In several of the southern states, several weeds have developed resistance to glyphosate where cotton has been grown for a number of years in conservation tillage fields. Amaranth species (pigweed) is becoming more difficult to control. Roundup Ready corn in Roundup Ready cotton is now a problem. Sprangletop, horseweed, and fleabane have now infested most canals, roadsides, and field edges throughout the San Joaquin Valley. In some cases these weeds are just beginning to encroach into the cotton fields.

In many regions, reduced tillage, spot treatments, early postemergence-directed applications, and hand hoeing has decreased because of this technology. Now with more resistant weeds such as palmer amaranth, growers have to bring some of the older technologies back into the system such as the use of some tillage, hand weeding, and the use of residual herbicides. If glyphosate usage continues to increase, the industry incentive to support existing and older active ingredients may decrease. If glyphosate resistant weeds continue to develop and major shifts in weed populations occur, fewer herbicide options may be available due to the number of older herbicides lost to re-registration and the decline in the number of herbicides brought to market.

Dr. Stanley Culpepper reported that a recent survey of weed scientists focused on weed shifts in GR cotton systems. Six scientists in six states (AL, GA, FL, MO, NC, and TX) responded to the survey. All scientists noted weed shifts have occurred, and *Amaranthus* species, annual grasses, dayflower species (*Commelina* sp.), morningglory species *(Ipomoea* sp.), and winter annuals were becoming more problematic in response to currently utilized GR management systems. Four of six states noted these shifts are of economic concern and all specialists are addressing weed shift issues by recommending 1) the use of residual herbicides in current GR programs, 2) the addition of other herbicides in mixture with glyphosate, 3) rotation to other herbicide chemistry, and 4) rotation away from GR crops when feasible.

A major concern for an increase in glyphosate resistant weeds is that cotton is often rotated with Roundup Ready corn. There has been considerable interest in reduced tillage corn. A crucial aspect of no-till corn management should revolve around weed control. Keeping noxious weeds and grasses out of dairy silage is essential if the highest quality silage is to be harvested. Corn growers have access to a variety of different herbicide programs, but the Roundup Ready® corn system is the easiest in terms of managing weeds when the tillage is eliminated or used less frequently. By the 2010 season, Roundup Ready Corn comprised 50 percent or more acreage. Most no-till corn growers who use the Roundup Ready system do not use a pre-emergence herbicide, preferring instead to rely on over-the-top applications of Roundup UltraMAX® herbicide, often alone but sometimes in either tank mixes with 2,4-D, dicamba, halsulfuron (Sempra) or in conjunction with separate treatments of these herbicides. Corn growers who use dairy manure as fertilizer need to work extra hard to stay on top of weed control. Some tillage once in awhile, and combined with use of different herbicides, may be necessary where dairy manure is applied to fields.

The results of several cotton studies demonstrate the value of Glytol + Liberty Link Cotton, which will provide an alternative to glyphosate but broadleaves must be small. Research with

“Widestike" Technology gave a 1X safety rate using glufosinate on cotton. Our research demonstrated no advantage to increasing spray pressure or water volume for annual morningglory control when using glyphosate or glufosinate. One study demonstrated a need to use a 4X rate of glyphosate to obtain control of lambsquarter in a field that was in no-till Roundup Ready corn for several years.

Summary

The potential for herbicide resistance should receive serious and thoughtful attention. As weed management systems change with new herbicides and herbicide resistant crops are introduced, resistant management must be an integral part of the production system. If selection pressure is maintained through the continuous use of the same herbicide, herbicide resistance will soon render it ineffective.

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. Keep in mind many of the weeds were not being easily controlled before herbicide tolerant technology was available. Therefore it will continue to be necessary to use every available tool in the future to economically control weeds in this year’s crop and effectively control weeds from building up in the seed bank for future crops.

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Dry Bean Weed Control in California: Past…Present…Future.

Kurt Hembree
Farm Advisor, UC Cooperative Extension, Fresno County
1720 S. Maple Ave. Fresno, CA 93702, email: kjhembree@ucdavis.edu

The first dry beans commercially produced in California were limas, in the early 1900's. Today, the four major classes of dry beans grown in the state are blackeye, lima, red kidney, and garbanzo. Other types grown include black turtle, cranberry, pinto, small red and white kidney. In 2009, California produced 68,100 acres of dry beans with a value of over $78.7 million (table 1). Dry beans are legumes so add nitrogen to the soil, making them a good rotational crop. Production costs range from $300 to $500/acre, depending on variety, location, and cultural practices used. Weed control costs also vary for similar reasons. Growers spend about $35/acre for preplant herbicide treatments and another $20 to $30/acre for postemergent treatments. Cultivation and in-season hand weeding is needed in weedy fields, adding additional costs to production.

Table 1. Harvested acres of dry beans in CA

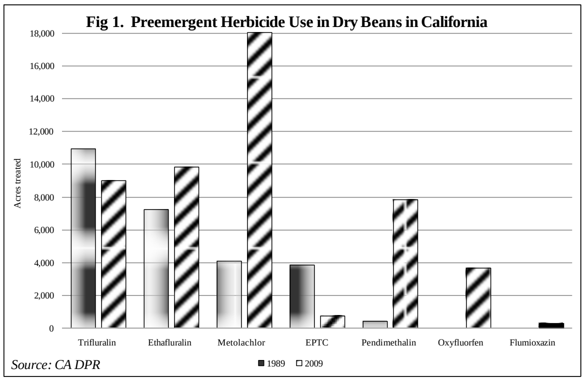
Bean Type	2007	2008	2009
Baby lima	15,600	11,700	14,600
Large lima	15,600	11,700	14,300
Blackeye	12,500	7,100	12,400
Garbanzo	6,000	6,300	14,000
Kidney	2,000	2,600	2,800
Other	6,300	12,500	10,000
Total	58,000	51,900	68,100

Source: USDA NASS

Problematic weeds commonly found in dry bean fields include black nightshade, prickly lettuce, barnyardgrass, volunteer cereals, annual morningglory, and nutsedge. Weeds impact bean growth and production directly by hindering stand development, delaying crop maturity, and lowering yields. Bean quality can also be impacted by the presence of weeds. For example, the juice from black nightshade berries can stain mature beans, reducing seed quality and price.

The number of herbicides labeled in dry beans in California has not changed significantly over the last 20 years (figures 1 and 2). This is, in-part, because the different bean types often exhibit different sensitivities to the same herbicides. Consequently, it has been challenging to identify herbicides that provide effective weed control without harming the different bean types. So growers continue to face similar weed problems as in past years. The herbicides currently registered for use in dry beans in California are listed in table 2. Most of the products used at the time of planting have similar modes of action, so control similar weeds. Also, post-plant preemergent herbicides are limited to garbanzo beans only. Furthermore, products used after crop establishment only provide postemergent control of grassy weeds. Unfortunately, there are no preemergent products labeled for use at lay-by before row closure. So, one to two early-season cultivations plus a mid- to late-season hand weeding is often required for complete weed control, increasing the cost of production. Late-season hand removal of weeds in dry beans is not encouraged because bean pods can be shattered. A pre-harvest desiccant is sometimes used to help control annual morningglory if it is present before harvest.

Since herbicides options are limited, growers should plant into fields with an historically low weed population. Equally important is consideration for the specific weeds that are known to be present and whether or not the labeled herbicides are effective on those particular weeds. Efforts should be made to control weeds during the fallow period and before planting to help reduce the impact of weed competition on early crop stand development. Applying pre-irrigation water, followed by a shallow tillage operation or a postemergent herbicide treatment (usually glyphosate), can be used to kill emerged weeds and reduce the weed population before planting. Until new and effective herbicides become available, particularly for mid- to late-season applications, weed control in dry bean production will continue to be a challenge for growers.



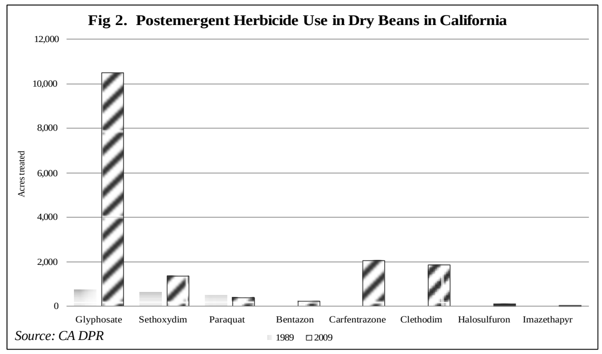


Table 2. Herbicides registered for use in dry beans in California

Herbicide	Treatment information
	Fallow ground or preformed beds
carfentrazone	up to 1 day after planting
glyphosate	up to before crop emergence
oxyfluorfen	up to 60 days before planting
paraquat	anytime before planting
pyraflufen	up to 30 days before planting
	Preplant mechanically incorporated
EPTC	not for blackeye, garbanzo, or limas
ethafluralin	crop injury if deep seed, overlaps, and stress
metribuzin, pendimethalin	garbanzos only
s-metolachlor, trifluralin	all bean types
	Post-plant before crop and weed emergence
flumioxazin, metribuzin, oxyfluorfen, pendimethalin	garbanzos only
imazethapyr	garbanzos only (up to 3 days after planting)
	Post-plant after crop and weed emergence
carfentrazone	hooded sprayer for row middles
clethodim, sethoxydim	controls only grasses; 30-day PHI
	Pre-harvest desiccant
carfentrazone	All bean types; 0-day PHI

Sources: UC IPM Guidelines and CDMS.net

The Challenge of Weed Management in One - Two Acre Ponds

John A. Roncoroni UCCE Weed Science Farm Advisor, Napa
Email: jaroncoroni@ucdavis.edu

In recent years there has been an increase in the number of one and two acre ponds. These ponds are important sources of irrigation water and frost protection. In the high value vineyards of California's North Coast these ponds provide water for drip irrigation from June through October. Many vineyards use these same ponds to provide frost protection (through overhead irrigation) from March through April.

These ponds are often used as part of the overall 'winery experience' provided to visitors and must be clean and attractive. Many ponds also provide recreation through boating, swimming and fishing. In mansy of these ponds aquatic weeds have become a major problem. The major weed and algae problems come from floating mats of filamentous algae, Pacific mosquitofern (*Azolla filiculoides*), Eurasian watermilfoil*(Myriophyllum spicatum),* American Pondweed *(Potamogeton nodosus),* Creeping waterprimrose *(Ludwigia species), and* Common cattail *(Typha latifolia).*

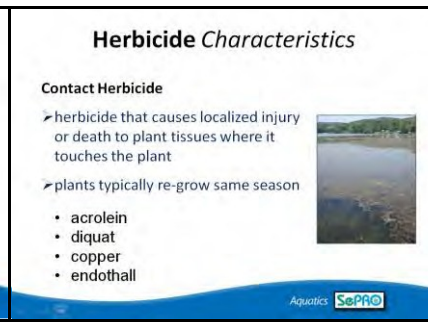
There is a lack of trained personnel to assist the grape growers manage their 1 and 2 acre ponds and many small problems become big problems very quickly. Weed control options in vineyard ponds are often expensive. These options include mechanical harvesting of weeds, dredging the ponds to increase depth and manual removal of weeds above and below the waterline. Herbicide treatments can be effective but are also costly; some examples of approximate costs for one acre herbicide treatment: Glyphosate: $300, Fluridone: $900 to $1,000, Endothall: $650, 2,4-D: $300-600, Diquat: $300 to $400. Grapes are very sensitive to growth regulator type herbicides such as 2,4-D and Triclopyr and because of this many growers are reluctant to use them. Safe and effective herbicides such as Fluridone-have a long waiting period which makes there use difficult at best.

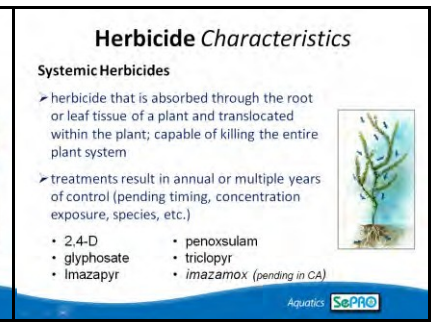
Field days that provide information to the growers on available services and management options were very popular. Even in very wet years water available for crop production is always and issue and the management of small ponds for irrigation and frost protection will become an even more important issue in the future.

Characteristics and Modes of Action of Aquatic Herbicides

David C. Blodget, SePRO Corporation, daveb@sepro.com

Herbicides are an effective part of integrated plant management programs. The United States Department of Environmental Protection, Office of Pesticide Programs has approved registration of approximately 300 herbicides for use sites such as agriculture, rights of way and aquatics. Today, there are 10 herbicide active ingredients currently approved for aquatic use in California. Utilization of herbicides for the control of nuisance and invasive plants in and around water can be challenging. Baseline knowledge of herbicide characteristics and mode of action is essential when evaluating the use of herbicides as part of any plant management program. This presentation will highlight and discuss common herbicide classification categories, best management practices, and how they influence aquatic herbicide selection. In addition, how characteristics of water dynamics, concentration exposure requirements and application technique should be integrated in operational aquatic plant treatment program design and implementation.





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Aquatic Algae: Characteristics and Methods of Control

Paul Westcott, Southwest Regional Manager, Applied Biochemists / Arch Chemicals, Inc
e-mail: paulwestcott@appliedbiochemists.com

Algae are one of the most diverse and widespread organisms, inhabiting almost every habitat on Earth and generating more oxygen via photosynthesis than all other plants combined. Their many forms, structures and other adaptations for survival can make control of problematic algal species difficult. In many situations, algaecides are the preferred management option due to rapid activity and their ability to at least temporarily alleviate the problems associated with high densities and secondary compounds (i.e. toxins, taste, and odor) that restrict critical water resource usages and require immediate intervention. For these situations, selection of an efficacious algaecide is crucial, since application of an ineffective algaecide or excessive amounts can be costly in terms of time, resources, as well as ecological risks.

Applied Biochemists in conjunction with Clemson University and other researchers have cooperated with public and private stakeholders over the past 10 years in advancing the science of algae control and aquatic management. A key focus and objective has been to optimize the use of U.S. EPA Registered Algaecides to manage algal problems within acceptable margins of safety to both man and environment. This Targeted Algal Management has involved development of effective algaecide screening protocols; corresponding algal toxin measurements; determination of impacts on non-target organisms; post-treatment residue levels; field trials to verify laboratory results and establishment of successful operational treatment programs. Applied Biochemists continues to develop and produce specific algaecide formulations to optimize the control of problematic algae and cyanobacteria species.

The Ever Changing California NPDES Aquatic Pesticide Permit: What Now?

Michael S. Blankinship,
Blankinship & Associates, Inc. Agricultural & Environmental Consultants
322 C St., Davis, CA 95616   Email: mike@h2osci.com

Aquatic weed specialists working for drinking water, flood control, and irrigation interests manage algae and a variety of aquatic weeds including submersed, floating, emergent and riparian species. These weeds can create flow restrictions in irrigation canals and flood control structures and pose taste, odor and aesthetic problems in drinking water storage and conveyance facilities. Use of chemicals to control these weeds in surfacewater in California is limited to the following:

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

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

Year	Action	Permit Required?
1996	Talent Irrigation District Acrolein/Copper 90,000 juvenile steelhead dead	No
1998	Headwaters Suit; Alleged CWA Violation	No
2001	9th Circuit Court Decision Overturns Lower Court; CWA violation cited; NPDES Permit Required. Permit Required	Yes
2002	CA issues Emergency General Permit for Discharge of Aquatic Pesticides	Yes
2002	Forsgren Case: Permit Required	Yes
2004	New 5 year Permit Issued by CA	Yes
2005	Fairhurst Case: Permit NOT Required	No
2007	EPA states that Permit NOT Required	No
Jan 2009	6th Circuit Court: Permit Required	Yes
June 2009	6th Circuit Court: 2 Year “Stay” Granted = Permit NOT Required	No
Mar 2010	Supreme Court will not hear the case	Yes
Aug 2010	Congress introduces bill to overturn 6th Circuit Court	Maybe
Apr 2011	EPA issues final aquatic pesticide permit	Yes

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

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

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

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

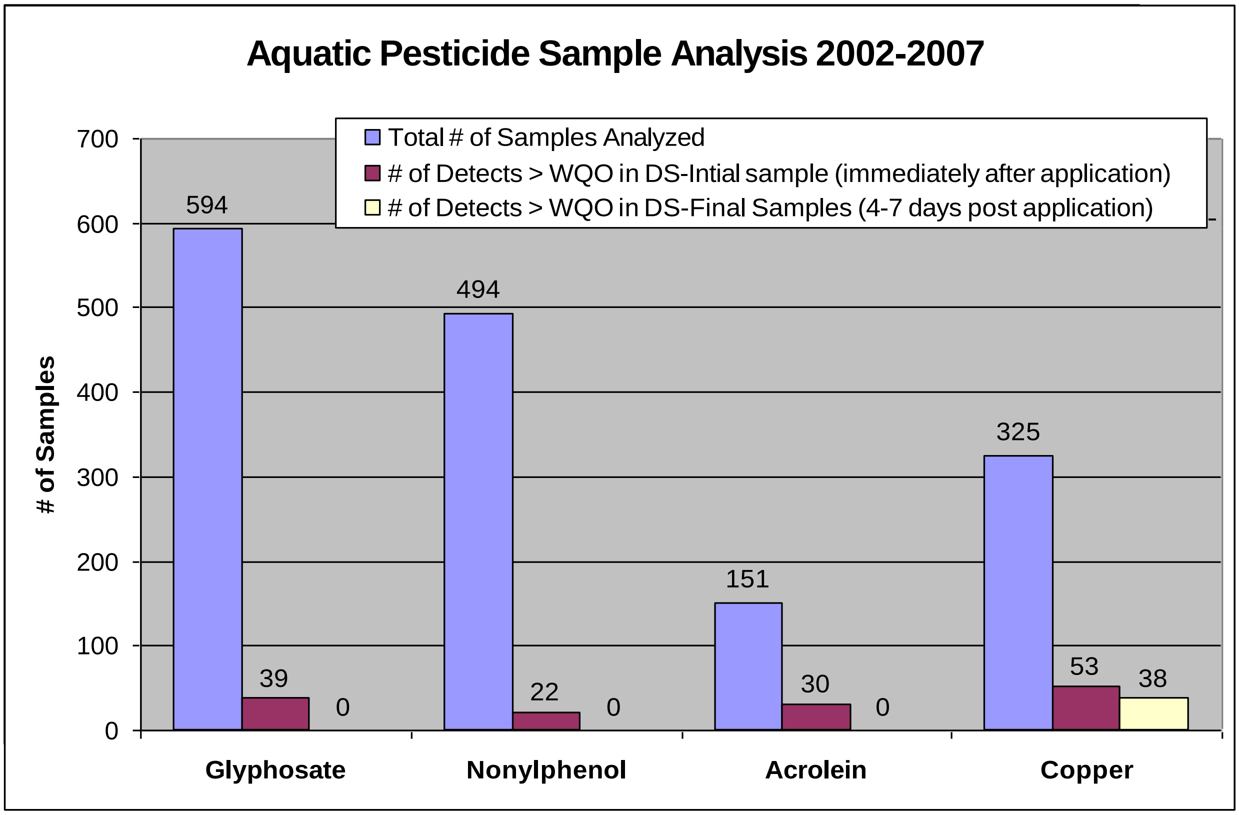
USEPA

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

California

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

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



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

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

- California Aquatic Pesticide Permit ("Weed Permit")
  http://www.waterboards.ca.gov/water_issues/programs/npdes/aquatic.shtml
- Goby 11 Injunction
  http://www.epa.gov/oppfead1/endanger/litstatus/factsheet.html
  http://www.epa.gov/oppfead1/endanger/litstatus/use-limitation.html
- Red-Legged Frog Injunction
  http://www.cdpr.ca.gov/docs/endspec/rl_frog/index.htm
  http://www.epa.gov/espp/litstatus/redleg-frog/rlf.htm
- Salmonid Injunction
  http://www.epa.gov/espp/litstatus/wtc/maps.htm
- USEPA NPDES Aquatic Pesticide Permit
  http://cfpub.epa.gov/npdes/home.cfm?program_id=410

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

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

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

Biological and Cultural Control of Aquatic Weeds in Ponds

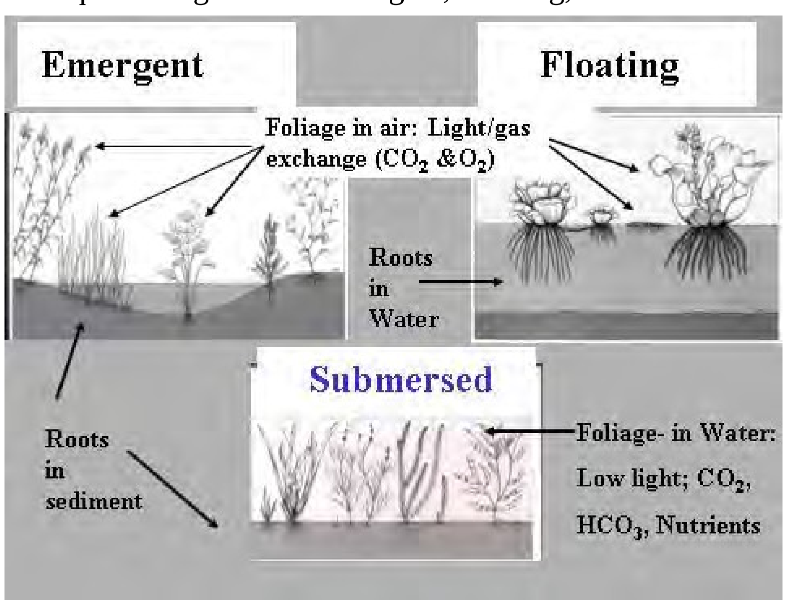
Lars Anderson
USDA-ARS Exotic and Invasive Weed Research, Davis, CA

Topics: Actions to Control Aquatic Weeds

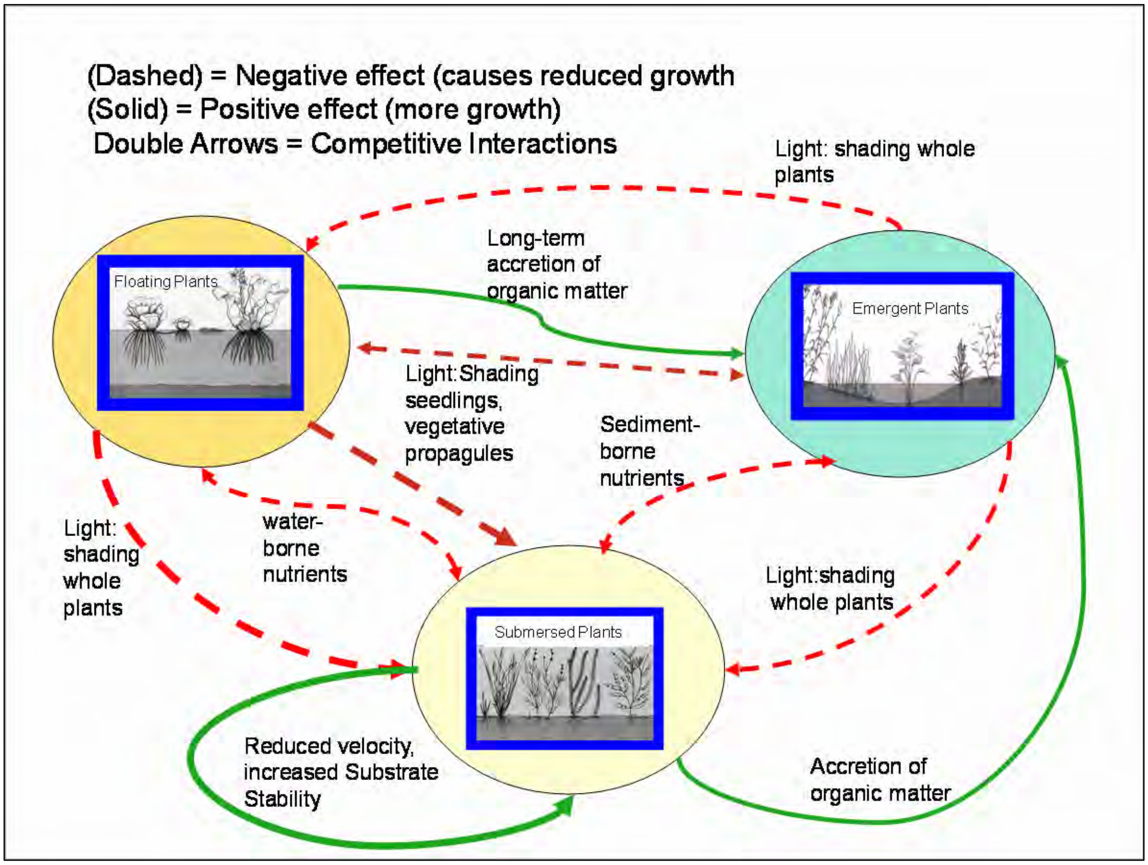
- **Define the Goal(s) –** What is the use of the pond?
- **Prevention**
- **Remediation** - Already infested? Now what?
- **Maintenance** - Protecting management investment

Pond Uses	**Constraints/Regulations/Liabilities**
Irrigation	Water demands, Crops, Herbicide residues, Drift, Timing
Frost Control	Herbicide residues, Sprinkler functions, Timing
Swimming	Exposure/toxicity, "Re-entry", Perceptions (phobias)
Fishing/Aquaculture	Fish toxicity, Residues, Harvest, Water quality (e.g. DO)
Aesthetics	Perceptions (phobias), Waterfowl
Fire fighting	Access, Clogged pumps
Flood detention	Holding capacity, Drainage
Inlet/outlets	Riparian rights (neighbors)

Types of Aquatic Vegetation: Emergent, Floating, and Submersed Plants



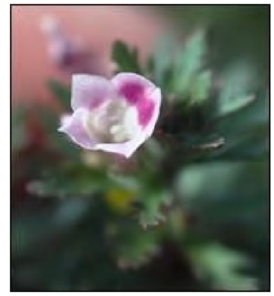
Interactions between Submersed, Floating, and Emergent Aquatic Vegetation Affecting Their Establishment and Growth



<u>Preventative Actions to Minimize Aquatic Vegetation in Ponds</u>

1. Design ponds with steep slopes
2. Design ponds with margin-berms
3. Design so stormwater drains AWAY from pond, not into it
4. Design with circulation (solar?)
5. Design with water-level management
6. Choose **native plants**- <u>in pots preferably</u>
7. Provide mixed plant canopy
8. Monitor for *introduced* Aquatic Invasive Species!!

"Residential Ponds" Require Constant Management



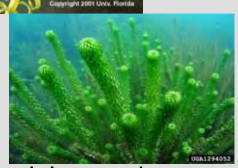
Movement of Aquatic Plants in the Horticultural Trade

- In S. New England 76% of non-native aquatic plants are escapes from cultivation. (Les and Mehrhoff, 1999)
- In New Zealand 75% of aquatic invasive plants are of horticultural origin. (Champion and Clayton, 2000)
- The 1st monoecious hydrilla in CA was traced to a contaminated lily shipment.

Recently published Water Garden "Guides" and "How-To" Books often recommend Aquatic Plants that are prone to becoming invasive.

Do Not Use These Plants!

Trapa natans



Lagarosiphon major

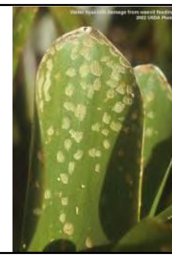
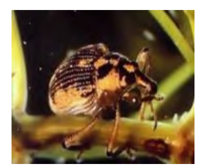
Trapa natans
"Water Chestnut"
An INVASIVE Aquatic Species

Lagarosiphon major
"African Curly Leaved Water Weed"
An INVASIVE Aquatic Species

__Remedial Actions for Weedy Ponds__

1. Identify unwanted plants
2. Options for biological control?
3. Stop or minimize nutrient loading
4. Feasibility to rake/harvest/use bottom barriers?
5. Feasibility for suction removal?
6. Feasibility to install circulatory system?
7. Drain and restart!!

Biological control Agents for Pond Management

Type	Target Weeds	Biological Control Agent	
Fish	Eat anything green	Sterile (triploid 3n) Grass carp	
		Tilapia	
Insects	Waterhyacinth	*Neochetina bruchi (weevil)* Weevil feeding causes leaf damage 	
	Hydrilla	*Hydrellia pakistanae (fly)*	
	Eurasian watermilfoil	*Bagous affinis (tuber weevil)*	
		 *Eurhychiopsis lecontei (weevil)*	
	Giant waterfern (Salvinia) 	*Acentria ephmemerella (moth)*	
		Cyrtobagous salviniae (weevil)	
	Water lettuce	*Neohydronomous affinis (weevil)*	
Pathogens	Eurasian Watermilfoil & Hydrilla	*Mycoleptodiscus terrestris ("MT")*	
Bacterial "Products"	?	Beware of Labels	
Natural products		Barley straw	

<u>Triploid Grass Carp</u>

- Must have permit from CA Dept of Fish and Game (cannot use carp in areas that are considered flood zones)
- Must certify that the fish are indeed triploid (3n)
- *Generalist herbivore – they eat anything green*

<u>Average Plant Density /(# fish per acre)</u>

Low Plant Density / 5 fish per acre

Medium Plant Density / 10 fish per acre

High Plant Density / 15 fish per acre

<u>Sustained Maintenance Actions</u>

1. Monitor fish populations: types, and abundance.
2. Discourage excessive waterfowl use.
3. Establish a routine maintenance schedule.
4. Have a plan to contain/remove new Aquatic Invasive Species.
5. Develop a contingency water source.
6. Maintain pump/drain/fill options.

Evaluation of Herbicides for Postemergent Control of Mature, Highly Stoloniferous Kikuyugrass *(Peranisetum clandestinum)* Maintained Under Rough Conditions

Mark Mahady, President
Mark M. Mahady & Associates, Inc.
P. O. Box 1290
Carmel Valley, CA 93924
(831) 236-2929
markmmahady@aol.com

Introduction

Kikuyugrass *(Pennisetum clandestinum)* is a warm season grass native to East Africa. Kikuyugrass was introduced into Southern California during the I920's by the Soil Conservation Service to control erosion along water ways. This highly aggressive and invasive perennial exhibits medium leaf texture and a yellow green color that spreads by rhizomes, stolons and seeds.

Kikuyugrass exhibits better cool temperature tolerance than other warm season grasses. Germination temperatures range from 66° F to 93° F, with 78° F representing the optimum germination temperature. In many respects kikuyugrass represents a warm season grass that enjoys growth conditions generally best suited for cool season grasses. Kikuyugrass is able to maintain relatively high rates of photosynthesis, even greater than that of cool season grasses, at low temperatures, and, exhibits a higher temperature optimum (86° F) for photosynthesis than tall fescue (57° F). In the moderate Mediterranean climate of the Monterey Peninsula, the peak growth period for kikuyugrass occurs from May to October. Kikuyugrass exhibits slow growth and in some cases under cold conditions, a semi-dormant growth phase during Northern California winters.

In field research trials conducted in the Monterey Peninsula during 2006, SpeedZone Southern (PBI Gordon) applied at standard label rates of 5 pints per acre (pt/A) showed dynamic knockdown on young, non-stoloniferous stands of kikuyugrass 7 days after application (DAA). The addition of QuickSilver (FMC) at 2.7 oz/A enhanced kikuyugrass desiccation, collapse and dissipation. Three sequential treatments of SpeedZone Southern applied at 5 pt/A showed 85% control of young, non-stoloniferous kikuyugrass.

The primary objective of this replicated field research trial was to determine if multiple applications of designated herbicide products would result in acceptable levels of control of mature, highly stoloniferous stands of kikuyugrass maintained under rough conditions.

Materials & Methods

This replicated field research trial was conducted in a rough area located on the 14th hole at the Pebble Beach Golf Links located in Pebble Beach, California. The site was heavily inundated with mature kikuyugrass. The first replication had a mixture of kikuyugrass, perennial ryegrass and *Poa annua*. Replications II, III and IV consisted of virtually 100% mature, highly stoloniferous kikuyugrass.

This coastal area is characterized as a Mediterranean climate with frequent early morning summer fog. During the summer, daytime high temperatures generally range from 62° F to 72° F. with nighttime low temperatures of 44° F to 56° F. Average yearly rainfall is 18.8 inches with a very high percentage of precipitation occurring during the winter months from November to March.

Treatments as presented in Table 1 were first deployed on September 23, 2010 and then followed the specific application schedule presented. The site was mowed one to two times per week at a mowing height of 2.0" and irrigated to avoid moisture stress. The kikuyugrass turf was lush and actively growing on the day of treatment deployment.

Table 1. Treatment and application protocol. Pebble Beach Golf Links. Mark M. Mahady & Associates, Inc., 2010.

	Treatments	**Rate**	**Application** Frequency
1)	Untreated Check		*
2)	Turflon Ultra*	32 oz/A	3x: 21-Day Interval
3)	Turflon Ultra + Drive XLR8**	32 oz/A + 43.5 oz/A	3x: 21-Day Interval
4)	Drive XLR8**	43.5 oz/A	3x: 14-Day Interval
5)	Drive XLR8**	43.5 oz/A	2x: 14-Day Interval
6)	OneTime**	43.5 *oz/A*	2x: 30-Day Interval
7)	SZS' + Drive XLR8** + QS2	6 pt/A + 43.5 oz/A + 2.7 oz/A	3x at 21-Day Interval
8)	Drive XLR8** + QS2	43.5 oz/A + 2.7 oz/A	3x at 21-Day Interval
9)	Drive XLR8** + QS2	65.3 oz/A + 2.7 oz/A	3x at 21-Day Interval
*	Treatments included a non-ionic stufactant (NIS) at 0.125% v/v		
**	MSO (methylated seed oil) was added to Drive XLR8 tank mixtures at 21,8 oz/A		
	SpeedZone Southern		
	QuickSilver		

Herbicides Reviewed

SpeedZone Southern - PBI Gordon

- Carfentrazone 0.54%: 0.04 lb. ai/gallon
- 2,4-D, 2-ethylhexyl ester 10.49%: 0.52 lb. ai/gallon
- Mecoprop-p acid 2.66%: 0.20 lb. ai/gallon
- Dicamba acid 0.67%: 0.05 lb. ai/gallon
- Other ingredients 85.64%

QuickSilver - FMC

- Carfentrazone-ethyl 21.3%: 1.9 lb. ai/gallon
- Other ingredients 78.7%

Drive XLR8 - BASF Corporation

- Quinclorac 15.93%: 1.50 lb. ai/gallon
- Other ingredients 84.07

Turflon Ultra - Dow AgroSciences

- Triclopyr 60.45%: 4.0 lb, ai/gallon
- Other ingredients 39.55%

OneTime - BASF Corporation

- Quinclorac 15.95%: 1.50 lb. ai/gallon
- Mecoprop-p acid 7.98%: 0.75 lb. ai/gallon
- Dicamba acid 2.13%: 0.20 lb. ai/gallon

Individual treatment plots measured 10' x 10' and consisted of a 5' x 10' application plot directly adjacent to a 5' x 10' in-plot check. Side-by-side in-plot checks are very valuable when attempting to observe and measure subtle treatment effects. Treatments were replicated four times. Prior to treatment deployment all plots were rated for percent kikuyugrass cover. A randomization was established that balanced kikuyugrass cover across all treatments in order to ensure equal weed pressure for all treatments.

A calibrated CO_2 propelled spray system pressurized to 26 psi and equipped with four 11004LP Tee-Jet nozzles applied treatments at a spray volume of 1.5 gallons per thousand square feet (1000 ft^2). A pacing watch was used for spray applications to ensure uniform and accurate delivery. Field plots were not irrigated for 24 hours after application nor mowed for 72-96 hours after application.

Field plots were evaluated for percent cover day of application and 56 days after the third application. Percent kikuyugrass control was statistically calculated by comparing percent cover in treatment plots versus percent kikuyugrass cover in untreated check plots. Data were summarized and statistically analyzed. Differences between means were determined via LSD.

Results and Discussion

On the final rating date, 56 DAA3, the four treatments that exhibited the greatest reduction in percent kikuyugrass cover and the highest level of percent kikuyugrass control included the following.

1. Trt #3: Turflon Ultra + Drive XLR8 — 99.9% kikuyugrass control
2. Trt #2: Turflon Ultra — 99.2% kikuyugrass control
3. Trt #7: SZS + Drive XLR8 + QS — 94.7% kikuyugrass control
4. Trt #8: Drive XLR8 + QS — 93.9% kikuyugrass control

Table 2. Percent kikuyugrass control by treatment. Pebble Beach Golf Links. Mark M. Mahady & Assoc, Inc. 2010.

	Treatments	**Rate**	Application Frequency	% **Control**
1)	Untreated Check	*	*	*
2)	Turflon Ultra*	32 oz/A	3x: 21-Day Interval	99.2%
3)	Turflon Ultra + Drive XLR8**	32 oz/A + 43.5 oz/A	3x: 21-Day Interval	99.9%
4)	Drive XLR8**	43.5 oz/A	3x: 14-Day Interval	53.9%
5)	Drive XLR8**	43.5 oz/A	2x: 14-Day Interval	6.8%
6)	OneTime**	43.5 oz/A	2x: 30-Day Interval	45.5%
7)	SZS1 + Drive XLR8** + QS2	6 pt1A + 43.5 oz/A + 2.7 oz/A	3x at 21-Day Interval	94.7%
8)	Drive XLR8** + QS2	43.5 oz/A + 2.7 oz/A	3x at 21-Day Interval	93.9%
9)	Drive XLR8** + QS2	65.3 oz/A + 2.7 oz/A	3x at 21-Day Interval	87.0%

Treatments included a non-ionic surfactant (NIS) at 0.125% v/v
* MSO (methylated seed oil) was added to Drive XLR8 tank mixtures at 21.8 oz/A
SpeedZone Southern
QuickSilver

Summary and Practical Perspectives

Under these soil and turf conditions and under these timing and rate formats, the following conclusions are presented for control of mature, highly stoloniferous kikuyugrass maintained under rough conditions following three sequential applications of the described treatments:

- **Rank #1: 99.9% Kikuyugrass Control, Treatment #3, Turflon Ultra (32 oz/A)** + **Drive XLR8** (43.5 oz1A) + **MSO (21.8 oz/A):** Excellent performance. This top performing tank mix showed dynamic burn down and necrosis with very high levels of control and virtually no observable kikuyugrass regrowth. This tank mix is safe to use on solid stand perennial ryegrass and mixed perennial ryegrass/*Poa annua* turf stands. The high rate of Turflon may show yellowing on *Poa annua.* This tank mix would be highly injurious to fine fescue and creeping bentgrass.

- **Rank #2: 99.2% Kikuyugrass Control, Treatment** #2, **Turflon Ultra (32 oz1A) + NIS (0.125%** vlv): Excellent performance. Turflon Ultra showed consistent, uniform burn down and necrosis with very high levels of control and virtually no observable kikuyugrass regrowth. Turflon Ultra is safe to use on solid stand perennial ryegrass and mixed perennial ryegrass/*Poa annua* turf stands. The high rate of Turflon may show yellowing on *Poa annua.* Turflon Ultra would be highly injurious to fine fescue and creeping bentgrass.

- **Rank #3: 94.7% Control, Treatment** #7, **SpeedZone Southern (6 pt/A)** + **Drive XLR8 (43.5 oz/A)** + **QuickSilver** (2.7 **oz/A)** + **MSO (21.8 oz1A):** Good performance. The addition of Drive to this SpeedZone Southern and QuickSilver tank mix greatly improved activity and kikuyugrass control. This tank mix showed *very* rapid browning and necrosis of kikuyugrass. Minimal kikuyugrass regrowth.

Life After MSMA

Cheryl A. Wilen, University of California Cooperative Extension and UC Statewide IPM Program. 5555 Overland Ave. Suite 4101, San Diego, CA 92123
Email: cawilen@ucdavis.edu

MSMA (Mono Sodium Methane Arsonate) is an older postemergent herbicide used primarily for weed control in turf for control or suppression of dallisgrass crabgrass, sedges, kikyugrass, oxalis, other hard to control weeds. It is safe on bermudagrass, bluegrass, zoysia but on tall fescue may yellow. Currently, there are only 4 turf/landscape products registered in California that are not mixtures with other herbicides:

–DREXEL DREXAR 530 (35.8%)
–DREXEL MSMA 6 PLUS (47.6%)
–TARGET 6 PLUS (48.3%)
–TARGET 6.6 (51%)

Because arsonate is a component of this herbicide, it was re-reviewed by EPA because of potential exposure to arsonate through drinking water. Subsequent to that review, new restrictions were implemented to prevent exposure to inorganic arsenic in drinking water. The restrictions include limiting use in areas of particularly vulnerable ground water, using buffer zones around surface water bodies, limiting the number of applications, and restricting golf course use to spot treatment only.

The current EPA ruling as it applies to turf and landscape uses is that MSMA is allowed on golf courses, sod farms and highway rights of way with sales until December 31, 2012 and material can be used only until December 31, 2013. During 2012 EPA will evaluate the scientific information available on any risk posed by inorganic arsenic and if the evaluation finds no health concern at the doses of exposure of normal use, the use of MSMA will continue beyond 2013.

Pest control advisers and applicators should be aware of the changes on the current label:

- **Golf courses:**
  –One broadcast application allowed on newly constructed courses.
  –Application on existing courses limited to spot treatment (100 sq ft per spot), not to exceed 25% of the total course in one year.
- **Sod farms**:
  –Two broadcast applications allowed per crop.
  –25 foot buffer strip required for fields bordering permanent water bodies.
- **Other MSMA Uses Not Allowed** (sales stopped in 2009, usage stopped Dec.31, 2010).
  –Residential turf
  –Drainage ditch banks, railroad, pipeline, and utility rights of way, fence rows, storage yards and similar non-crop areas
  –Others

With the loss of MSMA, other herbicide options may be used but the site, the turf species, and weed spectrum needs to be considered. Possible alternatives[1] to MSMA include:

- Acclaim - fenoxaprop-p-ethyl (ACCase inhibitor)
- Certainty – sulfosulfuron (sulfonylurea)
- Dismiss – sulfentrazone (aryl triazolinone)
- Drive XLR8 – quinclorac (quinolinecarboxylic acid)
- Monument – trifloxysulfuron-sodium (sulfonylurea)
- Revolver - formasulfuron (sulfonylurea)
- Sedgehammer - halosulfuron (sulfonylurea)

The tables below list the turf species where the herbicides may be safely used and some weeds that are listed on the label as being controlled. This list was developed because the herbicides are safe on the same turf species as MSMA or have an expanded list of turf species where they are safe. They also control or suppress some of the weeds that MSMA was historically used for in turf such as crabgrass, dallisgrass, and sedge species. Note that there are no exact matches for MSMA but knowing the turf species and weed spectrum will help find a suitable replacement. In some cases, these herbicides will control a broader weed spectrum.

A drawback is that these herbicides should not be used without considering a rotational plan. Four of the herbicides on the list are sulfonylureas and resistance may develop if these herbicides are used exclusively.

Turf Species Safety[2]

Herbicide	**Active Ingredient**	**Bermuda-grass (common)**	**Bermuda-grass (hybrid)**	**Buffalo-grass**	**Creeping Bentgrass**	**Fine Fescue**	**Kikuyu-grass**
Acclaim Extra	fenoxaprop-p-ethyl				T	T	
Certainty	sulfosulfuron	T	T	T	T		T
Dismiss CA	sulfentrazone	T	T	T	T	T	T
Drive XLR8	quinclorac	T	M		M	M	N
Monument	trifloxysulfuron-sodium	T	T				
Revolver	formasulfuron	T	T	T			
Sedgehammer	halosulfuron-methyl	T	T		T	T	T
MSMA	**Mono Sodium Methane Arsonate**	**T**	**T**				**N**

[1] Products discussed are for informational use only. Their mention anywhere in this document does not constitute a recommendation or endorsement.

[2] This is not an exclusive list of turfgrass species for herbicide safety for each product. Consult label for more information and sites where they may be used.

Turf Species Safety

Herbicide	Ky Bluegrass	Per. Rye	Rough Bluegrass	Seashore Paspalum	St. Augustine	Tall Fescue	Zoysia-grass
Acclaim Extra	T	T				T	T
Certainty	T		N	T	T	N	T
Dismiss CA		T	T	T	T	T	T
Drive XLR8	T	T	M	M	N	T	T
Monument						N	T
Revolver							T
Sedgehammer	T	T		T	T		T
MSMA	**T**				**N**	**M/N**	**T**

T=Tolerant
M=Moderately tolerant
N=Not tolerant

Weeds Controlled or Suppressed[3]

Herbicide	Barnyard-grass	Common bermuda-grass	Dallis-grass	Foxtails	Goose-grass	Johnson-grass (rhizome)	Johnson-grass (seedling)	Kikuyu-grass
Acclaim Extra	C	S		C	C	S	C	
Certainty			S					
Dismiss CA					C			
Drive XLR8	C			C				C
Monument			S					
Revolver			S		C	C		
Sedgehammer								
MSMA	**C**		**C**		**C**		**C**	

Weeds Controlled or Suppressed

Herbicide	Kyllinga spp.	Large crabgrass	Panicum spp.	Purple nutsedge	Smooth crabgrass	Tall fescue	Yellow nutsedge
Acclaim Extra		C	C		C		
Certainty	C/S			C/S		C	C/S
Dismiss CA	C/S			C/S			C/S
Drive XLR8		C			C		
Monument		S		S	S	C	C
Revolver		S				C	
Sedgehammer	S			C			C
MSMA		**C**			**C**		**C**

C=Control
S=Suppression

[3] This is not an exclusive list of weed species controlled or suppressed for each product. Consult label for additional information and rates.

Emerging Trends in Landscape Weed Management

John T. Law Jr. Ph.D. ValleyCrest Companies
jlaw@valleycrest.com

The theme of this year's conference is Biology, Reality and Sustainability. This is also a good description of concepts to consider for weed management plans in commercial landscapes. Biology is certainly a good place to start. Weed management plans should have a biological science foundation. Scientific knowledge is built up over time by testing what is assumed to be true. Repeated hypothesis testing by many people, in many places, with many different methods can be very powerful. Scientists who study weeds can tell us a lot about weed management. They have tested different weed management plans, production systems and herbicides. The science may be incomplete since the scientific method of conducting controlled studies is expensive and time consuming. However, a weed management plan that includes practices that are not supported by the work that has been done by weed scientists will probably fail. An important part of science based problem solving is defining the problem.

What is the biological definition of weeds? A weed is often a plant that is adapted to disturbed habitats, and consequently weeds are often the best adapted plant on the landscape. Definitions like "a plant out of place" are not very useful. People have been disturbing plants and the soil for a long time. This disturbance became extensive when people domesticated grazing animals. Domesticated grazing animals were selected because they are manageable. Almost all species of domesticated large animals had ancestors that share three social characteristics: they live in herds; they maintain a well-developed dominance hierarchy among herd member; and the herds occupy overlapping home ranges, rather than mutually exclusive territories. These characteristics mean that different groups of animals can be bunched up around our ancestral villages, and they will hang around because they imprint on humans as the leader. The plants around the village were more intensely grazed and more intensely "fertilized" than in naturally occurring habitats. One of the adaptations of many weeds is the production of new leaves to replace those grazed off. Another adaptation is response to fertilizer. Grazing results in high amounts of fertilizer to be dumped in small discrete locations (e.g. cow pies). Plants that survived these conditions were presumably those that could use the fertility and turn it into new growth and/or lots of seeds and/or other ways to rapidly propagate in soil dug up by people or their animals.

When developing a commercial landscape there is a lot of soil disturbance. The existing vegetation is removed and the soil is reshaped, compacted and consolidated to remain stable, and for California, to remain stable during an earthquake. This disturbance usually continues as the site development goes through all the phases required to go from the initial state, through temporary roads, utility installation, constructing buildings and to the final landscape. Weeds are not only adapted to disturbance, they usually can maintain their abundance in repeatedly disturbed landscapes. This often creates the situation where a large seed bank is created over the course of site development. These seeds can be viable for many years and will germinate for many years, especially when soil is re-disturbed in the landscape by digging up weeds, tweaking and repairing irrigation etc. An important part of landscape weed control is not disturbing the soil once the landscape is installed.

Weeds probably initially evolved their invasive characteristics in natural disturbances such erosive water flows, big trees falling over, earthquakes and landslides. As discussed above, people and their domesticated animals have been disturbing climax vegetation for many thousands of years. Many weeds adapted to grazing and Mediterranean climates are hard to control. The roots and other underground parts usually need to be controlled. Short of extensive digging, soil pasteurization or soil fumigation, the only way to do this is with systemic herbicides. Many hard to control weeds in the West are:

- Adapted to fire - weeds are tolerant of loosing their tops either by burning off using flaming or herbicidal soaps, or mechanically with hoes.
- Adapted to drought - many broadleaf weeds immediately grow a large root system which makes them tolerant of loosing their tops from flaming, contact herbicides, or hoeing.
- Adapted to intense grazing by sheep and goats - which makes them tolerant of loosing their tops from flaming, contact herbicides, or hoeing.
- Many weeds from Europe have gone through intense selection from the ice ages squeezing all life into small areas between the ice and the Mediterranean Sea. This also is where people and their grazing animals have been for many thousands of years.

That is some biology of weeds. What about the second part of the Weed Conference theme, Reality. What is the reality of managing weeds for the landscape maintenance business? Probably the most important part of landscape maintenance business is that landscapes need to look good and be maintained at a competitive price. The standard for commercial landscapes like business offices, shopping centers and condominium or apartment complexes is a neat and clean appearance. Most landscape maintenance clients expect at least “Green grass, no weeds, no trash, pretty flowers”. They might not know much about plants, but they “know” weeds do not belong in the landscape. A landscape maintenance term for this attention to neat and clean is “detailed”. From a weed management perspective the “detailing” should not include soil exposed to sun and should not disturb the soil. A common example of a detail that can encourage weeds is edging that leaves a gap between a curb, wall or walkway. This kind of detailing conflicts with sustainability.

Sustainability is the third part of this year’s Conference theme. Business sustainability goals started with recycling, carpooling, lights that shut off automatically and other energy saving encouragements and building enhancements. However, these sustainability goals have now moved to the landscape with IPM programs, irrigation mandates and other policies that impact use of herbicides and other aspects of weed management. Landscape maintenance clients are now addressing weed concerns in ways other than “I shouldn’t see any”.

There are now sustainability terms and concepts commonly used by clients, the media and product marketing. These terms include Green, LEED, native, carbon footprint, natural organic, food web, healthy soil etc. Everyone thinks they know what these terms mean. They are widely used by the media to tell stories and marketing departments to sell products. However, they are not really operational terms. Discussions with clients all too often end with the landscape maintenance account manager asking, “What exactly do you want us to do differently?” Most of the “real” part of sustainability is already incorporated into landscape maintenance. Part of sustainability is don’t waste energy and water. A term for this part of sustainability is efficiency; efficiency is almost always part of business. After all, most savings on utility bills or water bills drop straight to the bottom line. It is no different with herbicides. Herbicides are expensive, as is the training and equipment to apply the herbicides. Much of the time weeds can be efficiently and effectively controlled by not disturbing the soil, never letting soil be exposed to the sun and allowing the surface layer of the soil to dry out as much as possible. These practices do not require extra labor and can be part of regular landscape maintenance. They are part of “working smarter” which good management always promotes. When weeds are encouraged, such as by not using mulch or keeping the soil surface wet, the weeds have to be controlled with labor and herbicides. Just like an electric bill that includes waste, avoidable use of herbicides and/or extra labor reduces profits.

The problem of not being able to define sustainability concepts well enough to develop a sustainable landscape maintenance plan has given rise to various rating systems. The largest national one is LEED (Leadership in Energy and Environmental Design). This is a scoring system devised by the non-profit organization dedicated to sustainable building design and construction called the US Green Building Council. It provides an “agreed upon” system to achieve a sustainability rating. It is important to recognize that it is a consensus based rating system, not a science or evidence based system. Benefits of achieving a LEED rating can include tax breaks, or favorable attention by planning departments. The part of LEED that has the most impact on weed control plans is called Sustainable Sites (SS). The two that include weed control are:

- SS Credit 3: Integrated Pest Management, Erosion Control and Landscape Management Plan.1 point

- SS Credit 5: Site Development — Protect or Restore Open Habitat. 1 point

A common requirement of LEED and other sustainability plans is to keep organic “debris” on site. The organic material is supposed to be composted or used as mulch. The process of achieving stable, weed and disease free compost is difficult on a commercial landscape site. Composting requires equipment and a site where the organic landscape debris can be chopped and mixed and then composted with temperature and moisture control. Using “raw” landscape debris on landscapes has aesthetic problems, and can easily spread weed seeds and stolons.

The water conservation part of sustainability plans, often include drip irrigation. Robust and reliable drip irrigation systems can be designed, installed and managed. However economics and ignorance often results in landscape drip systems that are not that robust and they often develop leaks and clogs. Also, with drip irrigation systems you cannot water in preemergent herbicides and cannot do “grow and kill” to reduce weeds. Any irrigation system and landscape should be designed for irrigation cycles that allow the soil surface few inches to get dry between cycles. The irrigation has to be designed for the very slow infiltration rate on soils that have been engineered for stability.

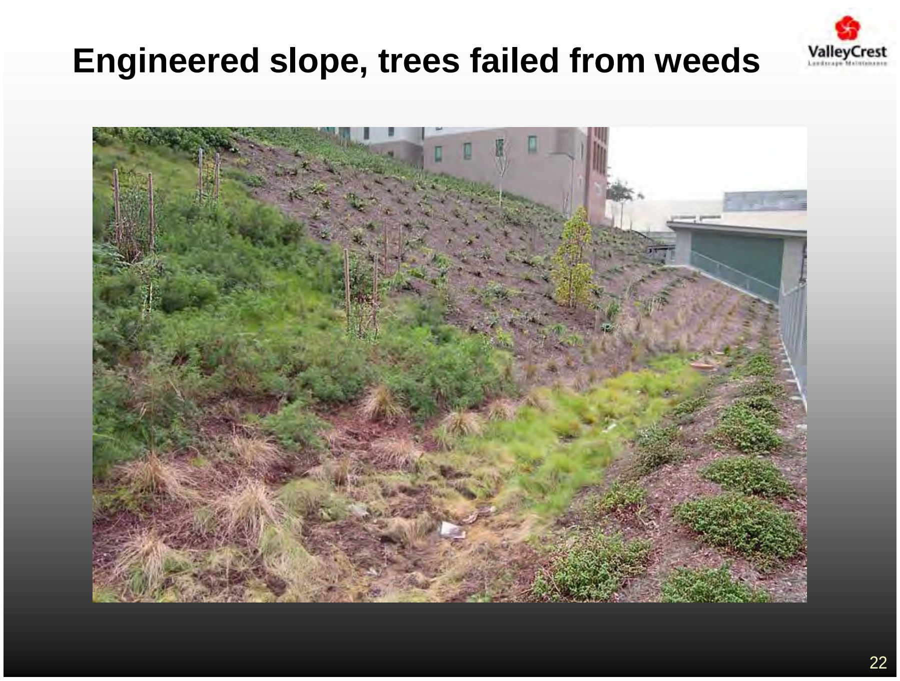
Even though many landscape designs include specifications to loosen construction compacted soil in the areas to be planted, these are not evidence based specifications. In other words, no one has done before and after measurements to prove they are effective. They are just “accepted practices”. Remember that civil engineers specified soil modification by heavy machinery to last the life of the buildings, associated infrastructure and hardscape. By design, this soil compaction is very hard to undo. In my experience, most post construction ripping, tilling and amending of areas to be planted does not result in much lasting improvement of the soil water infiltration rate. Physics tells me that if you change the soil from 95% compaction to 70% compaction, the soil volume will expand and soil will have to be moved to maintain the design contours or not overfill planting beds. Microbiology tells me that incorporated organic amendment is food for microorganisms and they will quickly consume the carbohydrates. This causes the soil to subside, often resulting in depressions that accumulate water, which supports weed seedlings and can cause aeration deficits and poor plant health. When the microorganisms consume the carbohydrates they release a lot of nutrients like phosphate that the landscape plants do not need and cannot use. If these excess nutrients leave the site, they can degrade aquatic systems downstream. Soil science tells me that Western clays are geologically young, very reactive and will stick much tighter to itself than organic amendment. One result of dense soil and shallow rooting is that frequent irrigation cycles are required. This is very favorable for weeds. In spite of the widespread practice and requirement, amending soils for trees and shrubs with organic matter has no scientific support.

IPM plans usually require details on how dependence on traditional herbicides can be reduced. Often non-traditional herbicides are encouraged. These are typically “burn down” type materials. These are usually hazardous, and in the case of acetic acid very hazardous materials for employees to use. Their mode of action is direct plant tissue damage. This mode of action is generally biocidal and the materials are just as damaging to human eyeballs and mucous membranes as they are to weed leaves. These burn down materials require high volume applications and are very expensive. However, as discussed above, weeds can be managed without herbicides, traditional or non-traditional much of the time. To use no herbicides at all, even for establishment greatly increases the amount of landscape labor. Unfortunately, no herbicides is part of many IPM programs promoted by agencies and sustainability consultants. What should be in an IPM program?

The IPM plan should include using shrubs in the landscape design. As discussed before, weeds are the usually the best adapted plants on the landscape. Shrubs are usually next best adapted, and increasing the use of shrubs can reduce weeds. Use shrubs that tolerate hard pruning. Examples of shrubs for California could include Xylosma, Rhaphiolepsis, Ligustrum, non-invasive Cotoneaster species, Pyracantha, Rhamnus, Cotinus, Dodonea, Grevillea, Mahonia, and Pittosporum. There are others. These shrubs can be kept relatively short while maintaining a continuous cover to shade the soil. Also, many planting beds are too small for trees. Other parts of a weed control plan are 4 inches of coarse mulch or 3 inches of finer mulch. If aesthetically acceptable, chipped branches from pruning can be used. They are also good food for the soil food web. Irrigation that wets the entire soil surface will benefit the plants and allow fertilizer and preemergent herbicides to be watered in. Herbicides are very important for establishment or re-establishment after repairs or landscape enhancements. Weeds in the root ball of establishing plants exacerbate water deficit problems new container plants often have.

Fertility is an important part of weed control. Soil testing labs have no calibration data for woody ornamentals in California or the West in general. This means they cannot really interpret the results of their soil tests. They typically do not want to have no interpretation and they typically do not want to recommend nothing, so they often recommend fertilizer when it is not needed. In particular, P is rarely needed by woody ornamentals, and surface applied P is unfortunately a "starter" fertilizer for weeds. Unless the soil P level is less than 5 ppm do not apply it, or at least do not make a surface application.

Herbicides become less important when adapted landscape plants are used. The plants should be adapted to compacted, engineered soil. Shrubs usually are best. The plants should grow well with shallow roots and tolerate both dry soil and saturated soil. Again this is usually certain shrubs. Native and "xeriscape" plants are often poorly adapted. They are not usually adapted to soils engineered for earthquakes.



Optimizing Organic Herbicide Activity

W. Thomas Lanini, University of California, Davis Email: wtlanini@ucdavis.edu

In recent years, several organic herbicide products have appeared on the market. These include Weed Pharm (20% acetic acid), C-Cide (5% citric acid), GreenMatch (55% d-limonene), Matratec (50% clove oil), WeedZap (45% clove oil + 45% cinnamon oil) and GreenMatch EX (50% lemongrass oil). All are contact-type herbicides and will damage any green vegetation they contact. However, they are safe as directed sprays against woody stems and trunks.

These herbicides kill weeds that have emerged, but have no residual activity on those emerging subsequently. While these herbicides can burn back the tops of perennial weeds, perennial weeds recover quickly.

These organic products are effective in controlling weeds when the weeds are small and the environmental conditions are optimum. In a recent study, we found that weeds in the cotyledon or first true leaf stage were much easier to control than older weeds (**Tables 1** and **2**). We also found that broadleaf weeds were easier to control than grassy weeds, possibly due to the location of the growing point (at or below the soil surface for grasses) or the orientation of the leaves (horizontal for most broadleaf weeds).

Organic herbicides could be applied when preparing the seedbed for turfgrass sod production and then again with the first flush of weeds. Grass seed could be planted a bit deeper (1/4 to ½ inch deeper) to delay turfgrass emergence, so that the organic herbicide could control the broadleaf flush without adversely affecting the turfgrass.

Organic herbicides kill only contacted tissue so good spray coverage is essential. A large, flat nozzle (ie. 8006) would be preferable in turfgrass production. In tests comparing various spray volumes and product concentrations, high concentrations at low spray volumes (20% concentration in 35 gallons per acre) were less effective than lower concentrations at high spray volumes (10% concentration in 70 gallons per acre). We also found that adding an organically acceptable adjuvant resulted in improved control. Among the organic adjuvants tested thus far, Natural wet, Nu Film P, Nu Film 17 and Silwet ECO spreader have performed well.

Although the recommended rate of these adjuvants is 0.25 % volume per volume (v/v), increasing the adjuvant concentration up to 1% v/v often leads to improved weed control, possibly due to better coverage. Work continues in this area, as manufacturers continue to develop more organic adjuvants. Because organic herbicides lack residual activity, repeat applications will be needed to control new flushes of weeds.

Temperature and sunlight have both been suggested as factors affecting organic herbicide efficacy. In several field studies, we observed that organic herbicides work better when temperatures are above 75° F. Sunlight has also been suggested as an important factor for effective weed control. Anecdotal reports indicate that control is better in full sunlight.

However, in a greenhouse test using shade cloth to block 70% of the light, we found that weed control with WeedZap improved in shaded conditions (**Table 3**). The greenhouse temperature was around 80° F. It may be that under warm temperatures, sunlight is less of a factor.

Recent experiments have assessed winter weed control during cool conditions (Table 4). In spite of cold temperatures, plantain control was very good with Weed Pharm, or the high rates of Weed Zap or Biolink. Annual bluegrass control was also good with these same materials.

Organic herbicides are expensive and may not be affordable for commercial crop production at this time. Moreover, because these materials lack residual activity, repeat applications will be needed to control perennial weeds or new flushes of weed seedlings. Finally, approval by one's organic certifier should also be checked in advance as use of such alternative herbicides is not cleared by all agencies.

Table 1. Broadleaf (pigweed and black nightshade) weed control (% control at 15 days after treatment) when treated 12, 19 or 26 days after emergence.

	-----------------Weed age	---------------------	
	12 Days old	19 days old	26 days old
GreenMatch Ex 15%	89	11	0
GreenMatch 15%	83	96	17
Matran 15%	88	28	0
Acetic acid 20%	61	11	17
WeedZap 10%	100	33	38
Untreated	0	0	0

Table 2. Grass (Barnyardgrass and crabgrass) weed control (% control at 15 days after treatment) when treated 12, 19 or 26 days after emergence.

	-----------------Weed age	---------------------	
	12 Days old	19 days old	26 days old
GreenMatch Ex 15%	25	19	8
GreenMatch 15%	42	42	0
Matran 15%	25	17	0
Acetic acid 20%	25	0	0
WeedZap 10%	0	11	0
Untreated	0	0	0

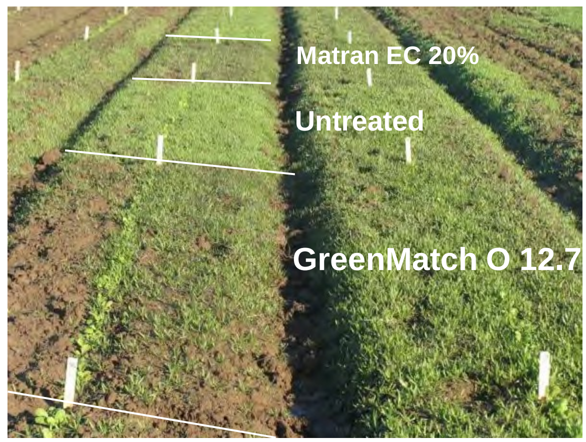
Table 3. Weed control with WeedZap (10% v/v) in relation to adjuvant, spray volume and light levels. Plants grown in the greenhouse in either open conditions or under shade cloth, which reduced light by 70%.

	Pigweed control (%)		Mustard control (%)	
	Sun	Shade	Sun	Shade
WeedZap + 0.1%v/v Eco Silwet (10 gpa)	31.7	93.3	26.7	35.0
WeedZap + 0.5%v/v Eco Silwet (10 gpa)	31.7	48.3	43.3	71.7
WeedZap + 0.5%v/v Natural Wet (70 gpa)	26.7	94.7	26.7	30.0
Untreated	0.0	0.0	0.0	0.0
LSD.05*	5.7		11.5	

* Values for comparing any two means. Pigweed and mustard were each analyzed separately.

Table 4. Plantain and annual bluegrass control (%) at 4 and 9 days after treatment (DAT). Applications made on Jan. 6, 2011 - 40ºF. All treatments included Eco Silwet 0.5% v/v.

Treatment	Plantain control		Annual bluegrass control	
	4 DAT	9DAT	4DAT	9DAT
Biolink 3% v/v	52	48	15	35
Biolink 6% v/v	63	80	40	63
MOI-005 5% v/v	2	13	0	2
MOI-005 10% v/v	10	20	0	3
GreenMatch 7.5% v/v	12	13	3	5
GreenMatch 15% v/v	23	38	10	52
Matran 7.5% v/v	5	8	2	3
Matran 15% v/v	20	17	5	30
Weed Zap 7.5% v/v	18	28	10	42
Weed Zap 15% v/v	52	78	23	78
Weed Pharm 100%	82	90	53	87
Untreated	2	0	0	0
LSD .05	23	19	13	29



Managing Herbicide Resistance in Turf and Landscape Sites

Todd Burkdoll, Market Development Specialist,
BASF Corporation, Turf and Ornamentals   Email: James.burkdoll@basf.com

What does managing herbicide resistance have in common with fighter aircraft?

- Something better may come along and make you obsolete
- What you think is a superior defense program may have some inherent weaknesses that can cost you Big $$$ or worse…..

The goal of any production system is efficiency resulting in sustainable profit

- The performance of any tool is determined by how it is used
- Crop protection products can be your best friend or your worst enemy, depending upon how you use them.
- Operator resources (tools) are finite
  - Too much input $$$ will reduce profit $
  - New tools are expensive to produce

First steps in managing weeds

- Know your enemy (weeds) and what they need to thrive
  - Annual vs. Perrenial,
  - cool season vs. warm season,
  - propagation strengths-weaknesses
- Understand what tools/weapons are available to manage
  - Cultural
  - Chemical
    - Pre-emergent vs post

Know your tools and how to use them.

- Efficiency is the result of effective planning.
- Think ahead before you plant,
  - What are problematic weeds indigenous to the area.
    - Check with local extension or pest control advisors
  - Read an understand the labels of any crop protection tools before using them.
    - Know your tools and how to use them.
  - Make sure the necessary tools are available—communicate with your supplier

Know your tools and what their strengths and limitations are.

- Contact activity vs. Systemic
- Residual-how long doe it really last?
- Weed activity spectrum
- Rainfast or not?

- Worker safety, REI, PHI
- Read the labels and do your homework first.

Know your tools and when to use them.

- What should you start with and what should you use next?
    - Product selection and plan of attack.
    - Alternation is necessary for resistance mgt. and weed shifts
    - Alternation is required depending on the target weeds

Does the product fit?

- Site
- Growth stage
- Weed

Understanding resistance

- Resistance does not arise from pesticide exposure
- Repeated, uninterrupted use of a pesticide selects a population that is tolerant.
    - similar to backcrossing plants to bring out a phenotypic trait
- Natural tolerance or physical barriers (waxy cuticles, hairy leaves/stems) can impede herbicide efficacy---weed shifts.
- Repeated use of the same chemistry year after year will result in weed shifts and can select for a resistant population.

Every Crop/Site use is different and the management of weeds for each crop is different

- There are no silver bullets
- Each chemistry has its strengths and weaknesses
- Use each according to the label and in rotation with other chemistries with differing MOA.

Chemical Control Efficiency

- **COVERAGE**
- High Enough Rate
- **COVERAGE**
- Proper Timing
- **COVERAGE**
- Preventive Program
- **COVERAGE**
- Resistance Management
- **COVERAGE**

References:

Better Plants Pest Management Guide 2010, BASF Corporation.
Freehand product label, BASF Corporation

New Vegetation Management Herbicides from DuPont

Ronnie G. Turner and Stephen F Colbert, DuPont Crop Protection

Registration of four new vegetation management herbicides from DuPont is anticipated to occur in early 2011. The new products combine the proven efficacy of DuPont's sulfonylurea herbicides with the new active ingredient aminocyclopyrachlor. Aminocyclopyrachlor is a new auxin mimic herbicide discovered by DuPont Crop Protection. It combines foliar and residual activity with upward and downward movement to provide excellent annual and perennial broadleaf and brush control.

- DuPont™ Plainview™ herbicide is a broad-spectrum bareground weed control product designed specifically to help utility and industrial site managers improve site safety.

- DuPont™ Viewpoint™ herbicide delivers broad-spectrum brush control for greater safety at utility sites and along roadways.

- DuPont™ Streamline™ herbicide was designed to help land managers maintain desired grasses without sacrificing brush control.

- DuPont™ Perspective™ herbicide controls invasive weeds and helps restore desirable grasses to more natural habitats.

Alternative Roadside Weed Control in Santa Cruz County

Steve Tjosvold and Richard Smith, University of California Cooperative Extension
Email: satjosvold@ucdavis.edu and rifsmith@ucdavis.edu

The County of Santa Cruz maintains approximately 600 miles of public roads. Of those, approximately 340 miles are actively managed for weed control. The diverse and discontinuous vegetation in the country or mountains presents a challenge for the County Public Works Department suffering from budget constraints and personnel shortages. The Department goals are to: (1) maintain sufficient sight distances for drivers, pedestrians, and cyclists, (2) Prevent vegetation encroachment that might infringe on the safe use of the roadway and (3) Reduce fire hazard. Traditionally management has consisted of an initial mowing where necessary to reduce biomass, followed by a carefully timed Roundup® (glyphosate) application to the vegetation regrowth. A correctly timed application of glyphosate often eliminated the need for additional vegetation control measures for the remainder of the year.

Roundup®, however, has received considerable attention by groups and individuals questioning its safety in the environment. On May 17, 2005 the Santa Cruz County Board of Supervisors the Board of Supervisors established a moratorium on roadside spraying of herbicides on county maintained roadways. Mowing was left as the only viable option for roadside vegetation management. In a recent cost analysis by Public Works (October 2010), mowing was more than 275% the cost of a comparable glyphosate application.

French broom (*Genista monspessulana*) is one of the most common and important invasive weeds found growing on these roadways, as well as other areas of the central coastal area and other parts of California. It resprouts readily from the root crown and is a prodigious seed producer. In light of the budgetary constraints that the County faces, it is the intention of this research to evaluate the use of alternatives to Roundup®, especially those herbicides that are organic, biorational, or exhibit characteristics that could be used for vegetation management in a sustainable way.

The trial was established along Empire Grade Road near Bonny Doon, California. Plots were selected that had predominantly French broom, California blackberry (*Rubus ursinus*), perennial pea (*Lathyrus latifolius)*, and various other broadleaf and grass weeds. Each plot was 15 feet long by 5 feet wide (0.00172 acre). Treatments were applied on May 4, 2010. Applications were made with three passes of a wand with one 8005VS air induction nozzle applying the equivalent of 50 gallons of water per acre. Air temperatures peaked at 75º F on the day of application. Weed control evaluations were carried out 7, 14, 28, 56 and 112 days after application by rating the percent of weed control on the following scale: 0 = no weed control to 10 weed completely dead.

Treatments (Table 1) were selected to contain organic, biorational, and other herbicides that had the "caution" safety category and therefore meet the County of Santa Cruz IPM pesticide use policy without specific exemption. The exception was WeedPharm (acetic acid) which is labeled with a “danger” category and Finale (glufosinate) which is labeled with a “warning” category. Roundup® was included as the former herbicide standard used by the County. Some treatments had contact activity and were effective by essentially desiccating weeds, while others had some systemic activity and therefore absorbed by weeds and resulted in weed control by other modes of action.

Table 1 Treatments in trial

Product Trade Name	**Active Ingredient**	**Activity**	**lb a.i. /A**	**Product/A**	**Safety Information**
Greenmatch EX	lemongrass oil	Contact	15% v/v	7.5 gals	organic “caution”
Weed Pharm	acetic acid (20%)	Contact	100% v/v	50 gals	“danger”
Matran	clove oil	Contact	15% v/v	7.5 gals	organic “caution”
Scythe	pelargonic acid	Contact	9%	4.5 gals	“caution”
Milestone VM Plus	aminopyralid triclopyr	Locally systemic	0.22 ae	9.0 qts	“caution”
Finale	glufosinate	Locally systemic	3%	1.5 gals	“warning”
Roundup	glyphosate	Systemic	2%	1.0 gal	“caution”
Untreated			---	---	

Surfactants: Nufilm P, 0.25% v/v added to Greenmatch, WeedPharm, and Matran.
Dynamic added 0.25% v/v to Milestone VM Plus.

Roundup was found to be very effective in controlling French broom and other weeds. Its past use as the standard and effective product by the County was justified in this trial. Products that had locally systemic properties, Milestone and Finale were effective in killing some smaller French broom plants (basal diameters less than 9 mm) and inhibiting growth of larger plants. Organic and other contact herbicides do not kill French broom. French broom recovery occurred quickly and was demonstrated in almost all cases just 2 weeks after herbicide treatment. Of those that were contact herbicides Scythe and Matran desiccated foliage most effectively (Figures 1-4).

Figure 1. Overall vegetation control

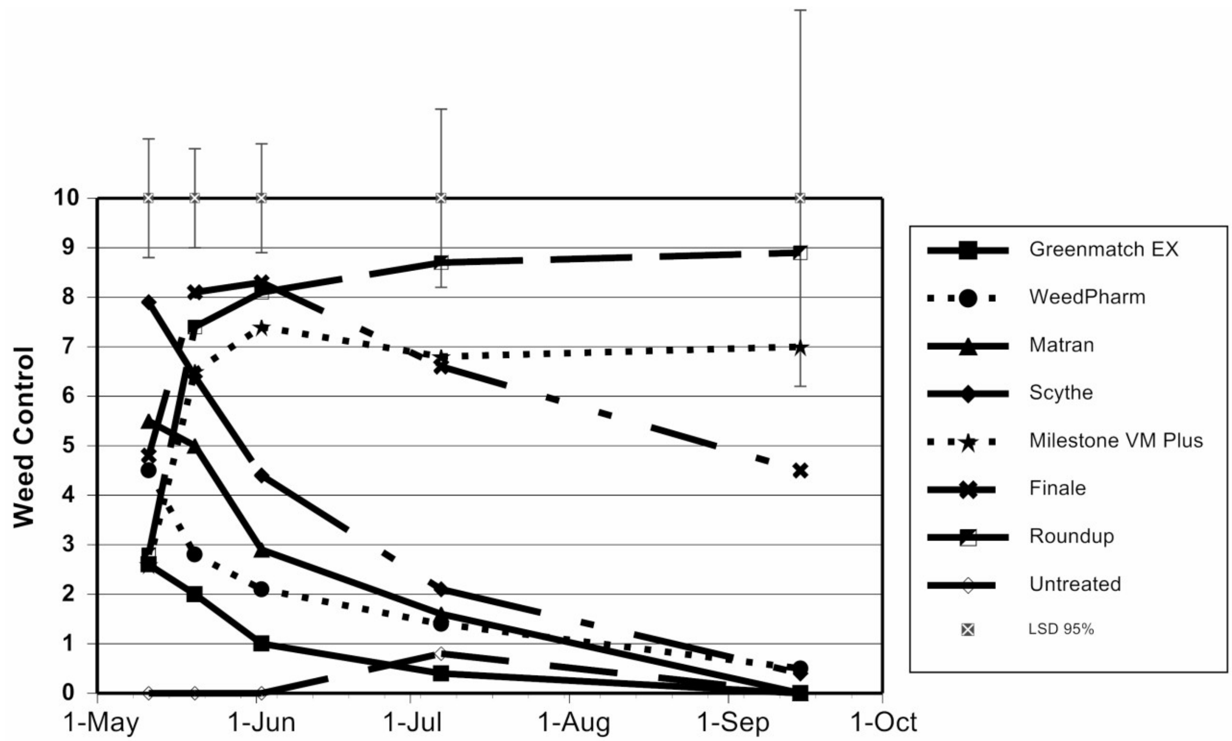


Figure 2. French broom control

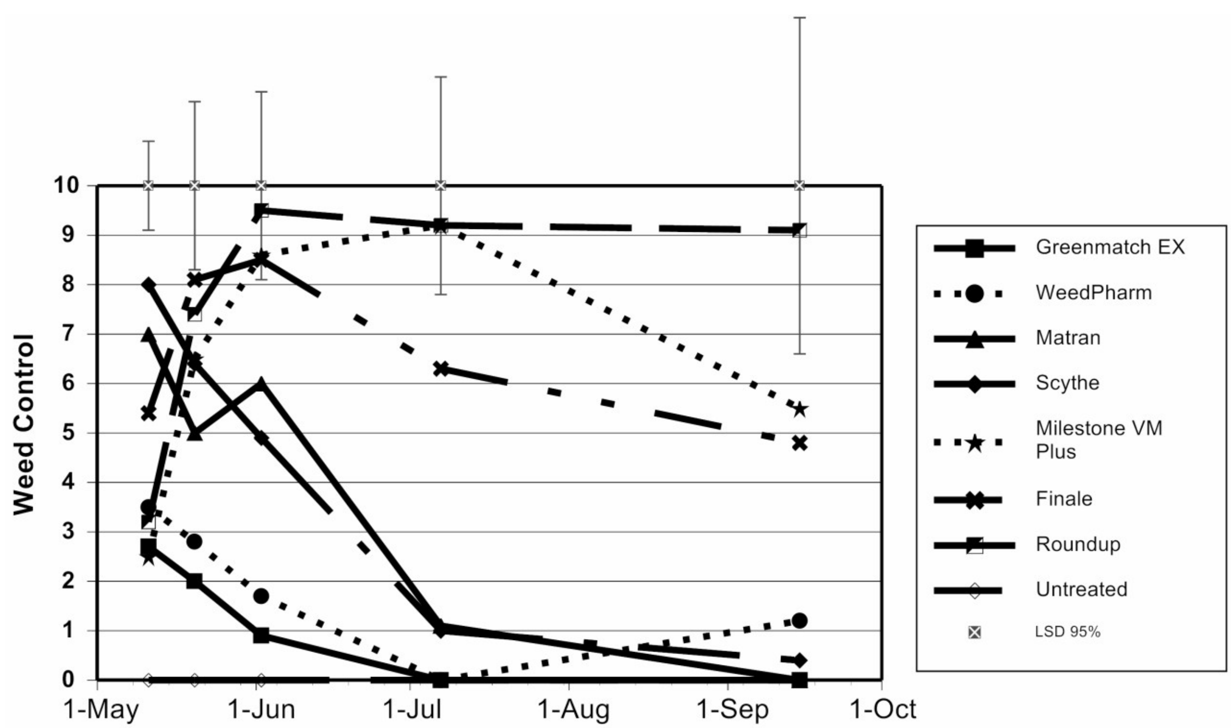


Figure 3. Blackberry control

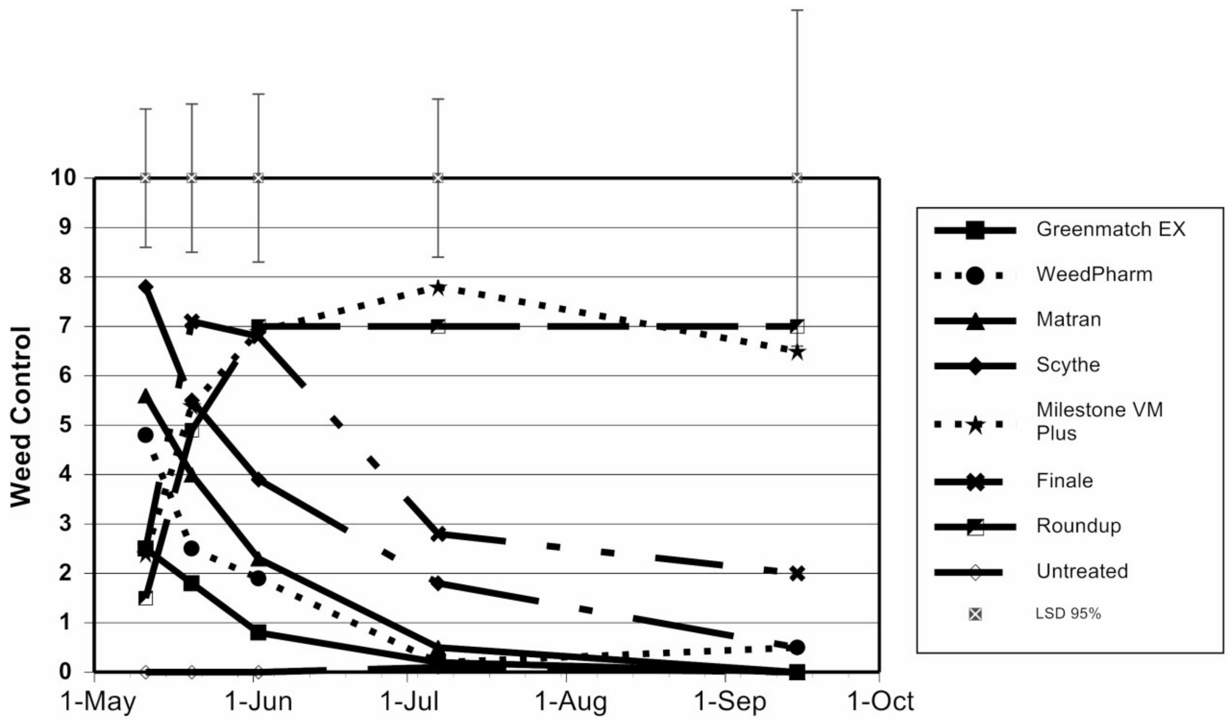


Figure 4. Perennial pea control

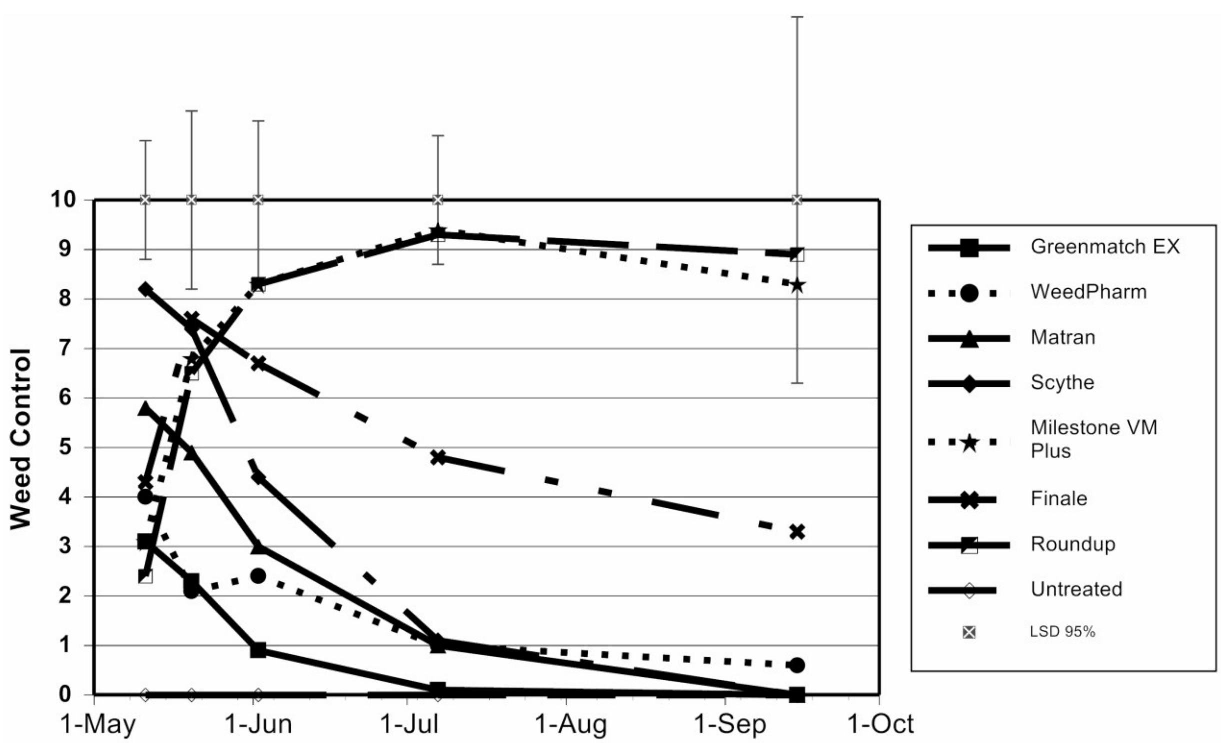
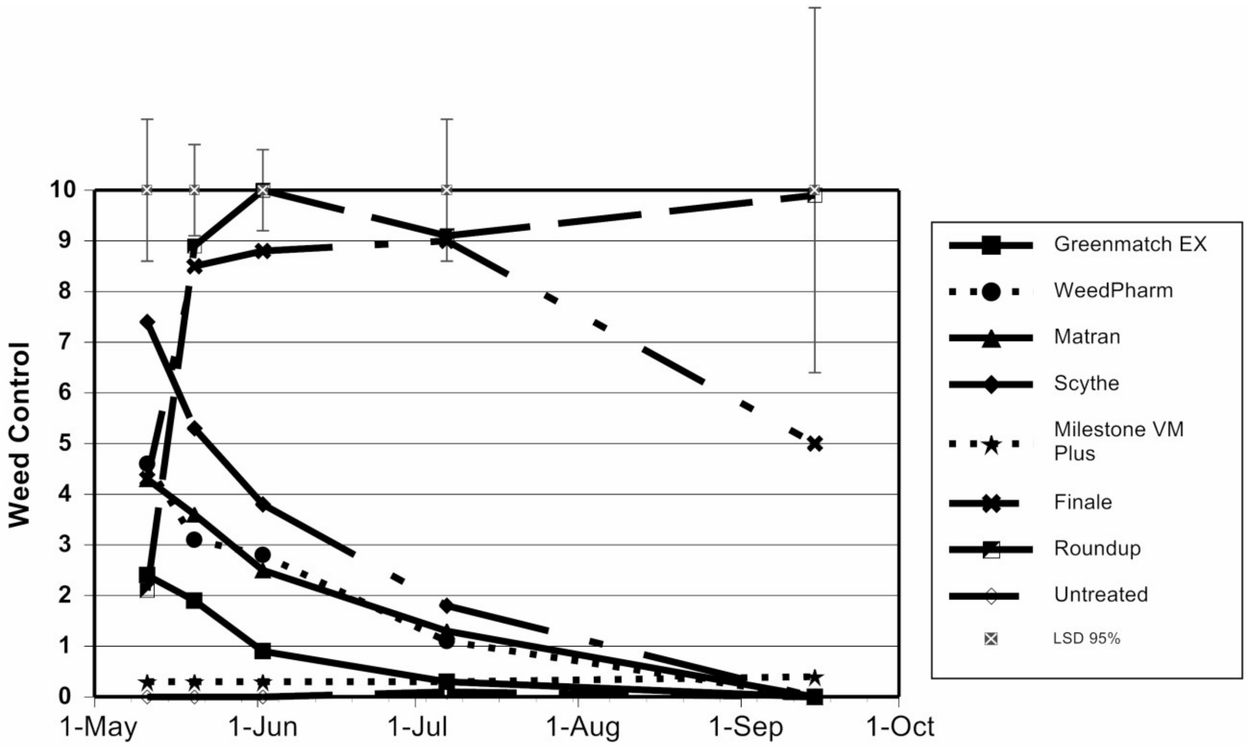


Figure 5. Grass control



Update on Physical Barriers for Weed Control

Jennifer A. Malcolm, Caltrans Headquarters, Division of Maintenance
(Now at California Department of Corrections and Rehabilitation
916-255-3860 email: jennifer.malcolm@cdcr.ca.gov)

Caltrans Integrated Vegetation Management Program consists of seven different methods of vegetation control. When using structural or physical barriers, Caltrans has a variety of materials and products to choose from. Hardscape (or hardscaping) and structural methods are interchangeable terms. Basically, hardscape is the use of hard inert material surfaces such as stamped asphalt, patterned concrete and rock cobble – in comparison to living soft material surfaces such as organic mulches and fully landscaped areas. Caltrans has ten different highway hardscaping treatments. Four products will be discussed further in detail - fiber weed control mats, rubber weed control mats, CRMCrete and cullet.

When choosing an appropriate vegetation management strategy, Caltrans considers safety for our highway maintenance workers, safety for the traveling public, and how structural controls can lead to increased mobility. Generally, structural methods involve higher costs during initial installation (which sometimes get expensive), but they lead towards reduced maintenance needs, resources and costs in the long run. Structural elements are the best way designers can assist maintenance forces in achieving Caltrans' herbicide reduction goals. Hardscaping can unify and tie elements together and be aesthetically pleasing. There are a wide variety of treatments, colors and patterns available. Structural methods can also decrease sight distance concerns, improving safety. Hardscaping works best is in small areas that are difficult to access and maintain, such as under guardrails and bridgerails, around signs and delineators, and in narrow areas that motorists drive into, such as gores and areas between ramps.

It is important to really KNOW your site before deciding upon which type of product might work best for you and your site. Are there defined edges such as concrete borders or curbs? Is the site an unusual shape or area – such as a triangular area being covered with rectangular products? Is the site inconvenient for worker and equipment access? How much time is allowed in your work window? Every site has slightly different characteristics and issues to consider before choosing one product over another.

Fiber Weed Control Mats are synthetic polyester fibers spun together to create a mat that prevents weed growth but allows water and air to percolate. Steel guardrail posts have fabric collars slipping over their top, which are then sealed to the mat below with caulking to prevent openings.

Fiber weed mats have been installed at Caltrans sites since 1999. The first installation was at the Mad River Bridge approach area, between two raised separated two lane highways going each way. The product was installed in the narrow, steeply-sloped center drainageway where vegetative growth was unwanted. The product is still performing well today, 12 years later.

Recent new three-beam and guardrail project installations are bladed evenly down the center divide, then installed with excellent ground preparation work. Wrap the product up and around the guardrail to tie it off above the ground when doing paving overlays directly adjacent to the product. A site near Garberville in Northern California has performed well over the past 12 years. Fiber weed control mats are considered a successful treatment by Caltrans. Current installation costs (at prevailing wage) are approximately $35 - $80 per square yard.

Rubber Weed Control Mats were originally developed for the recreation industry to address playground safety surfacing and the American Disabilities Act. The product consists of recycled tire rubber bonded together with a resin through a cold press process into a mat that lies directly on the ground. Rubber weed control mat tiles prevent sunlight and water from reaching the ground surface, thus retarding seed germination and plant growth. Flammability can be a safety concern due to toxic smoke produced when burning. The first Caltrans installation was underneath median guardrail over 8 years ago in the Santa Cruz area.

Rubber Weed Control Mat Installation includes uses under new and existing guardrail, thrie-beams, and bridgerails, around sign posts and under fences. The tile's weight keeps the mat in place, so normally staking or stapling is not required. Tiles are joined together with an overlap that is usually sealed with asphalt crack filler or resin adhesive. Manufacturers have different methods of joining their products. Staples, overlaps, glue strips, caulkings, and sealants have been used, depending upon the specific manufacturer. However, after time, the rubber product tends to shrink and pull away from wood posts. Follow-up maintenance is necessary.

Installation methods have improved over the years. No more kneeling, gluing and sealing small squares or mats. Break out the big equipment! Use long linear rolls of product and drive the new steel guardrail posts directly through it. Use individual large mats for curving areas and rolled mats for the straight-aways. Costs now run approximately $25 to $45 per square yard (at prevailing wage).

CRMCrete stands for Crumb Rubber Modified Concrete. CRMCrete is a concrete-based product that includes recycled scrap tire crumb rubber material and homopolymer polypropylene high performance reinforcing fibers, all blended into a slurry. CRMCrete utilizes a product that currently adds to California's existing waste stream. It helps to keep tires out of our landfills and gives a 'gold star' to agencies willing to partner with other agencies.

Caltrans has installed CRMCrete around sign posts and guardrails. Placement/installation is similar to that of concrete and stamped concrete. Typical CRMCrete installation includes pouring CRMCrete into place, tamping and leveling as necessary, and finishing. CRMCrete normally doesn't require the same level of formwork as standard concrete. Polypropylene fibers act like rebar or welded wire mesh. 'Leave-out sections' around the posts are necessary to allow the safety rail post to twist and bend upon impact. It also allows simple repairs for maintenance crews, since the leave-out section is the only area typically needing repairing. It breaks first upon impact due to its grout mix (instead of concrete in the leave-out sections), thus saving the rest of the area from breakage.

Caltrans crash tested the product in 2006 to determine if FHWA safety guidelines have been achieved. Caltrans' Standard Plans have been revised to include this product statewide as a standard for use in guardrail, bridgerails and thrie-beam installations.

Current installation techniques also became bigger, faster and included larger paving equipment. A recent application covered 3,000 feet in one day. The cost has been greatly reduced too – the product came in at $3.25 per square foot, or just under $30 per square yard installed on the recent Redding Interstate 5 site (at prevailing wage). CRMCrete is closer in price to that of fiber and rubber mats and has longer durability and lifecycle costs. CRMCrete has become a successful hardscaping product for Caltrans.

Cullet is the professional term used when referring to recycled glass mulch. Results are not yet conclusive, with half the sites passing and the other half failing. Cullet is applied similarly to wood mulch. Lay a barrier between the soil and the recycled glass mulch (just in case it may need removal at a later date). We have tried Visquene and the typical black weed fabric. Dump the glass mulch on top and spread it out to an even thickness. Caltrans typically uses cullet in the ½" to $^{5}/_{8}$" size, in a wide variety of colors, and sometimes up to 1" size. If you want to be creative, pick specific colors of glass for aesthetics.

Once successful cullet location is downtown Los Angeles in the median along Highway 101, behind the guardrail, installed to prevent homeless from setting up their tents and living in this area. It has been very successful at this location in reducing homeless squatting, although currently there are some weeds sprouting through the recycled glass mulch. At a northern California site, Caltrans put cullet under guardrail without an underlayment. Seven years later, cullet is still successful in the compacted areas underneath the guardrail! Unfortunately, cullet has not been successful in landscaped areas with weeds coming through the product in less than 3 years after application. More test sites are needed to determine whether or not cullet will be successful.

Driving Issues in Utility Vegetation Management

Nelsen R. Money, NRM-VMS, INC., Grass Valley, CA
Email: nelsen.money@gmail.com

Today's Utility Vegetation Managers can be successfully in an integrated vegetation management, IVM, program if they also consider an integrated resource management approach, IRM. Many vegetation managers are incorporating all the tools of IVM except herbicides due to a lack of knowledge on how to successfully implement them with an IRM strategy.

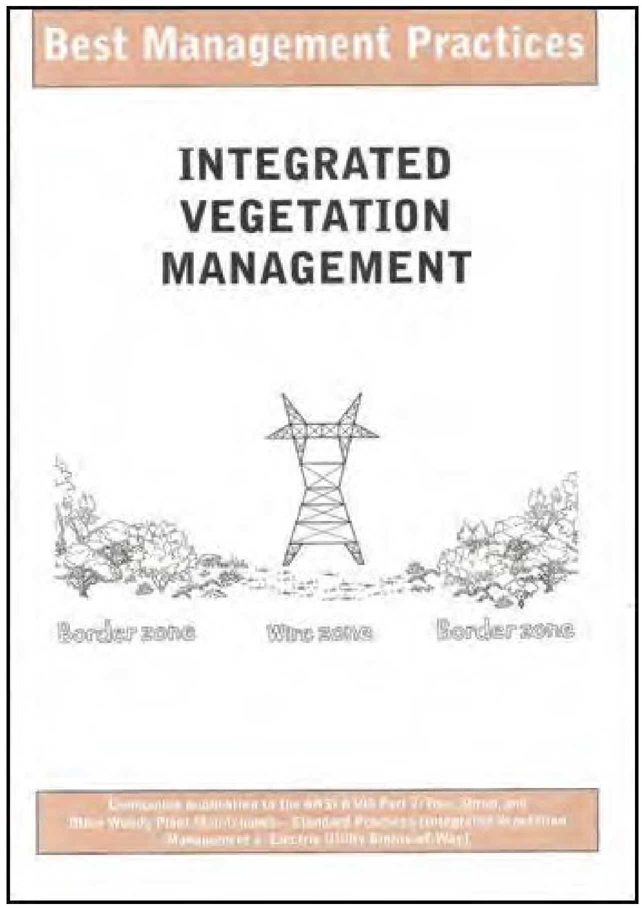
We know that IVM is a system of managing pest vegetation in which action threshold are considered, then all possible control options are evaluated and finally the management tactics are selected and implemented. Control options are based on worker/public safety, environmental impact, effectiveness, and site characteristics and economic. All utilities should be following ANSI A300 Part 7, Integrated Vegetation Management that can be found on the ISA Website. The tools are manual, mechanical, biological, cultural and chemical. Manual is generally chainsaws, chippers, hand saws, etc. Mechanical can be rubber tired or track mounted mowers or saws on booms. Biological can be goats, cattle and some biological pest controls are available. Cultural can be mulches, grass seeding, and agricultural control of right of ways. Chemical is the use of herbicides. There are many herbicides to choose from depending on the vegetation to be controlled and protected. Chemical application methods can vary from broadcast foliar, backpack foliar, basal stem, hack and squirt and spot gun. Chemical tools seems to be the most challenging for many utilities but can create more sustainable vegetation types at the most economical cost.

Many utilities see the IRM as a series of challenges to vegetation management. IRM can actually be the foundation to support the use of herbicides in your utility vegetation program. IRM is an interdisciplinary and comprehensive approach to land and natural resource management decision making that is designed to protect the ecological resources, cultural resources and economic resources. **IRM** is used to build mutual benefits between landowner and the Right of Way Owner. **IVM** Provides the tools to successfully manage for IRM.

Ecological resources are threatened, endangered and sensitive species, noxious and exotic species, wildlife and Fisheries, and watershed. Utilities need to see these challenges as opportunities to build partnerships with landowners and agencies. Threatened, endangered and sensitive plant species can be protected and their habitat enhanced if the vegetation manager is talking with the botanist about how they can protect and enhance the habitat that the plant needs. For example, when controlling fast growing cottonwoods in right of ways with protected elderberry in the understory, we can manually get clearance with climbers and then use hack and squirt to kill the remaining tree in place. You also get the added benefit of a cavity nesting snag for wildlife. These rights of ways can also be very valuable to pollinators and Vegetation Managers can gain support from the Pollinators Partnership.

Utility vegetation managers can also use the presence of noxious or exotic weeds in a right of way to build partnerships with the landowners and agencies. Usually including spot applications to control noxious weed within the right of way and access roads is a minimal increase in cost and builds long term partnerships with landowners.

Wildlife resources can be enhanced in right of ways with the encouragement of stable early succession plant communities. We have seen a decrease in earl succession plant communities with the reduction of ranching and logging and the control of wildfires. Vegetation managers can encourage more species richness by maintaining early succession habitat next to mature forest types. Some of the endangered or threatened wildlife species can benefit from the right of way vegetation. Vegetation managers need to talk with wildlife biologist on what species would benefit from a wire zone-border zone concept. The use of backpack foliar or basal applications to selectively control invading trees and brush species usually have fewer disturbances on wildlife than manual and mechanical mowing.



Cultural resources are usually protected with the elimination of mechanical and some manual treatments. Backpack foliar or basal stem applications can control tree and brush species without any disturbance of the cultural resources. Vegetation managers should promote these IVM tools to help protect the cultural resources.

Economic resources can be the recreational resources that intersect right of ways. Partnerships with park managers, city foresters and arborists can help utility vegetation managers accomplish their goals and meet some of the landowner’s goals. Bike and hiking trails can frequently benefit from selective herbicide use instead of the large manual mowers. The use of backpack foliar, basal or hack and squirt applications can be made in the late fall and winter for low impact on recreational use.

As utility vegetation managers, we need to use all the tools of IVM to create sustainable plant communities and remember that herbicides can be a cost effective and reduce many of the environmental issues of other tools when applied by professional applicators.

Control of Brush and Weeds with Milestone (aminopyralid) and Combinations

Ed Fredrickson, Thunder Road Resources and Vanelle Peterson, Dow AgroSciences

Species Evaluated

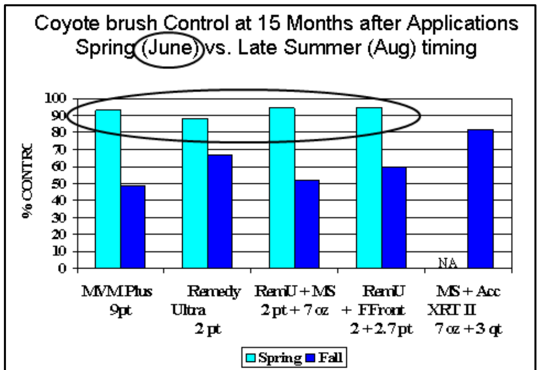
- Coyote Brush (*Baccharis pilaris*)
- Scotch Broom (*Cytisus scoparius*)
- Russian Thistle (*Salsola tragus*) and
- Common Field Mustard (*Sinapis arvensis*)

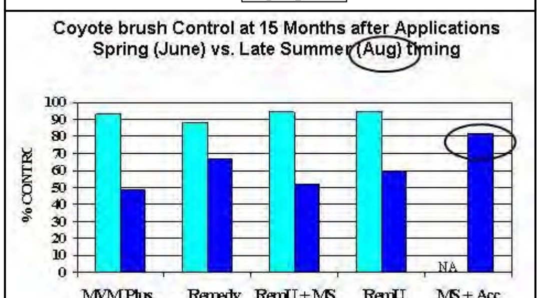
Coyote Brush Trial

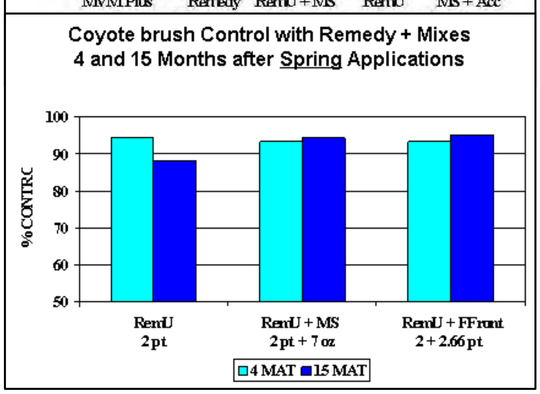
- Fort Bragg, Ca
- 2 Spray Timings
  - June 1, 2009
  - August 21, 2009
- 20 Gpa
- Broadcast Applications
- Milestone®, Milestone Vm Plus, Remedy® Ultra, Forefront® R&P, Accord® XRT II

Conclusions

1. Milestone VM Plus, Milestone + Remedy Ultra, and Remedy Ultra+ Forefront R&P provided excellent control in the Spring.
2. Spring timing better than late summer timing.
3. Addition of Milestone appears to suppress sprouting.
4. Late summer application of Milestone + Accord XRT II gave excellent control and appears to still be dying back.

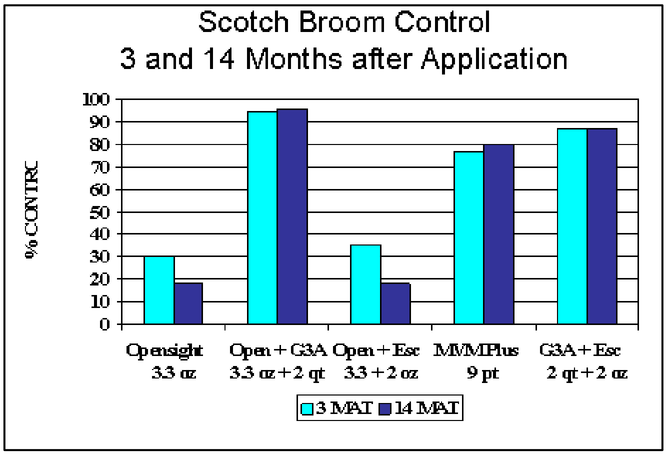


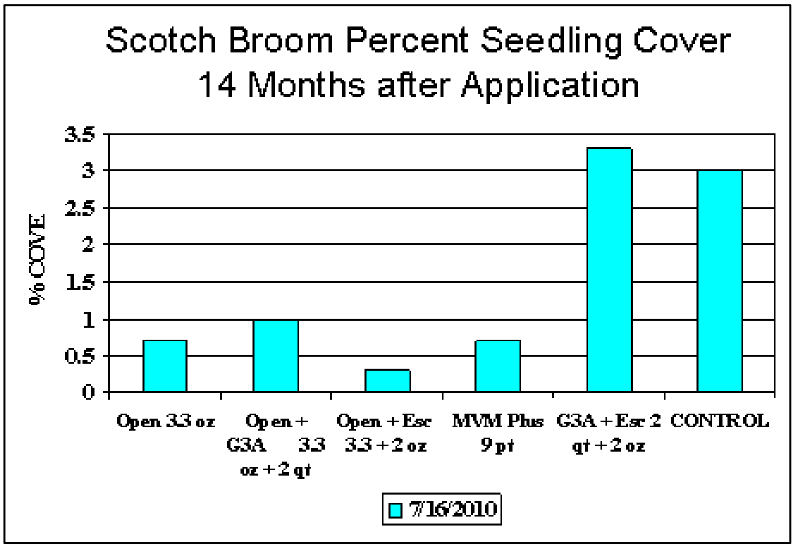




Scotch Broom Trial

- Round Mountain, CA
- 30 GPA
- Broadcast application
- Spray timing May, 15 2009
- Actively flowering when treated
- Opensight®, Milestone® Vm Plus, Escort, Garlon® 3A





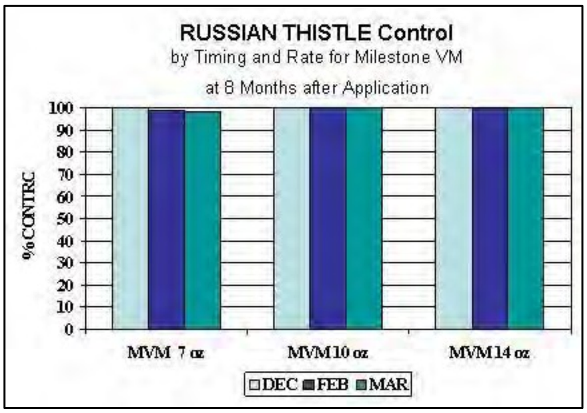
Conclusions

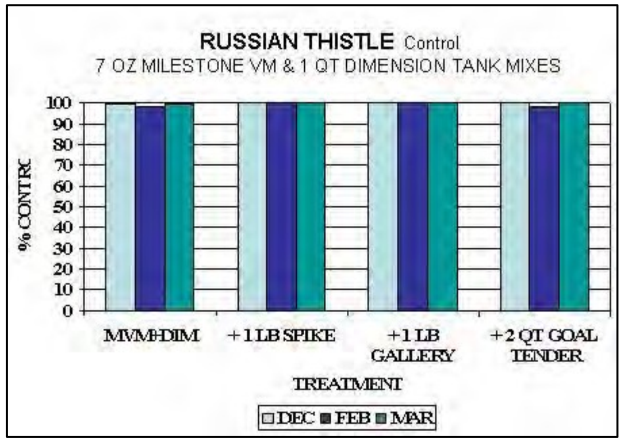
1. Best Treatment = Opensight + Garlon 3A

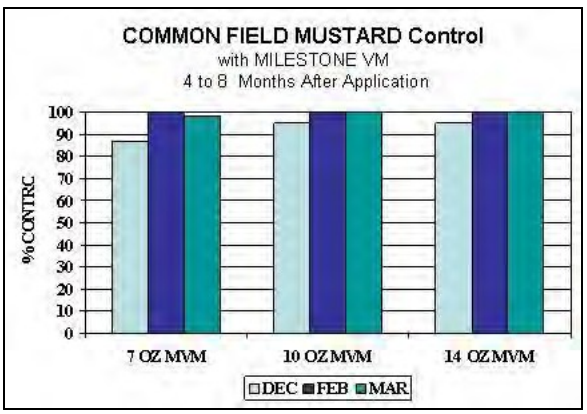
   Rate = 3.3 oz + 2 qts
2. Opensight alone is weak on Broom.
3. Control is significantly enhanced with the addition of Garlon 3A.
4. The addition of Milestone reduced seedling Broom germination.
5. Percent control was still increasing from 3 MAT to 14 MAT for treatments with Garlon 3A and decreasing for those without it.

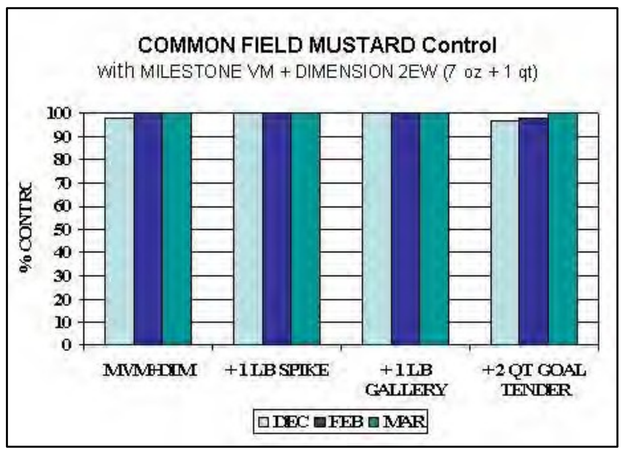
Russian Thistle and Common Field Mustard Trial

- Willows, CA
- Three spray timings: December, February and March
- 40 GPA
- Pre-emergent applications
- Broadcast
- Milestone® VM, Dimension® EW, GoalTender®, Oust, Telar, Spike® 80DF, Accord® XRT II, Gallery® 75DF, Payload
- All treatments include Accord XRT II at 2 qt/A









Conclusions

1. Overall Timing had little effect on efficacy

   Slight effect for Field Mustard and B.F. Trefoil with Milestone VM alone at the December timing.

2. Excellent control of Russian Thistle with all rates of Milestone VM
3. Addition of Dimension 2EW, Spike and Gallery to Milestone VM increased spectrum of activity and control.

Liverwort (*Marchanta polymorpha*) Biology and Recent Research Results

Cheryl A. Wilen, University of California Cooperative Extension and UC Statewide IPM Program. 5555 Overland Ave. Suite 4101, San Diego, CA 92123 cawilen@ucdavis.edu

Liverwort is a serious weed problem in ornamental plant production, particularly in greenhouses where plants are typically grown using excessive irrigation and nutrients. These lower order plants (bryophytes) spread rapidly in the greenhouse and can cover the media surface resulting in strong competition with the crop for water and nutrients. Small plants and liners cannot get good root development in upper part of media. This weed cover also impedes water from reaching the media thereby increasing runoff and water use. The presence of liverwort in the container reduces salability of crop and increases the chance that the weed will spread to other containers and other areas of the nursery. Liverworts growing on the media and greenhouse floors and under benches provide excellent habitat for fungus gnats and snails.

The plant does not have flowers, seeds, leaves, or roots. The flat green organ is the thallus or gametophyte. The single cell rhizoids act similarly to roots attaching the thallus to the soil. Liverwort can spread vegetatively and by spores. There are two alternate forms in its life cycle: a gametophytic stage and a sporophytic stage. In sexual reproduction, the gametophyte produces male and female structures that look like little palm trees (sporophytes). The female form will produce spores that are propelled into the air.

In vegetative reproduction, new plants are formed when older plant parts die at the fork of a branch of a thallus. Gametophytes also produce gemmae cups that hold gemmae, often described as looking like a nest with eggs. These gemmae can spread by water splash and produce new young plants vegetatively.

We recently completed a greenhouse study[1] examining several treatments for their pre- or post-emergent control of liverwort.

Treatments[2] in the test were:

Inoculated check (control)
Broadstar 0.25G (flumioxazine) @ 50lb/A
Ronstar 2G (oxadiazon) @ 100lb/A
Ground Mustard Seed Meal (MSM) @ 2090 and 4180 g/100ft^2
Freehand (dimethenamid-P + pendimethalin) @ 150lb/A

Eight replications were used. Treatments were applied to 4" pots that had young plants on the media surface (POE treatments) or applied after the pots were inoculated with a solution that contained a suspension of gemmae (PRE treatments). The experiments were conducted in a

[1] Funded by a grant from the California Nursery and Garden Centers

[2] Products in these tests were for experimental use only. Their mention anywhere in this document does not constitute a recommendation or endorsement.

greenhouse at the UC South Coast Research Center in Irvine, CA and irrigated twice daily with overhead sprinklers. Pots were evaluated 7, 14, 29, and 42 days after treatment (DAT).

Results

The MSM treatments were quickly infested by an unknown fungus that covered the media surface. The media remained covered with the fungus for at least 14DAT, with the higher rate lasting longer, in some cases up to 42DAT.

Nevertheless, the MSM treatments provided excellent liverwort control, superior to that of Broadstar and Ronstar in both PRE and POE tests (Figures 1 and 2). The higher rate of MSM continued to maintain excellent control for the duration of the study while the lower rate started to lose liverwort control after 4 weeks. Freehand also provided excellent PRE control of liverwort for the duration of the study. In the Freehand treated pots in the POE test, there was no reduction in liverwort cover from the time of application but they had approximately 85% less green liverwort cover than the inoculated check even 42DAT (Figure 2). That is, while Freehand did not completely control liverwort, it did inhibit the growth of liverwort in the pots such that it did not increase on coverage.

Currently, there are no selective herbicides registered for use in enclosed greenhouses. Freehand shows excellent potential and could be used in non-enclosed areas such as open nurseries and shade houses that are open on both ends. Additional work needs to be done examining MSM rates, timing of reapplication, and crop selectivity.

Figure 1. Percent green cover of liverwort as affected by preemergent treatment.

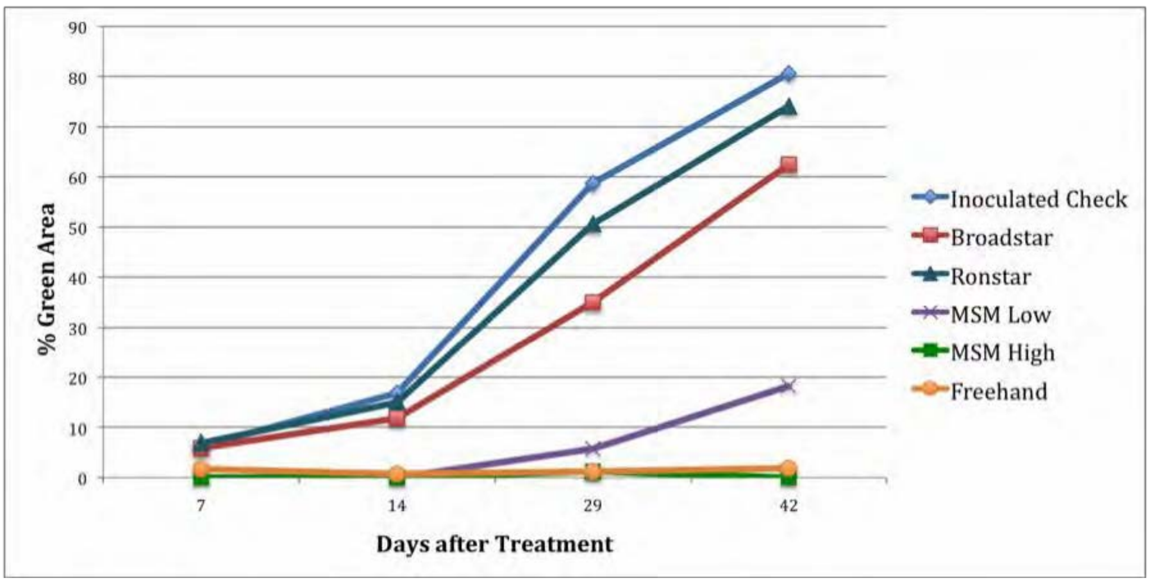
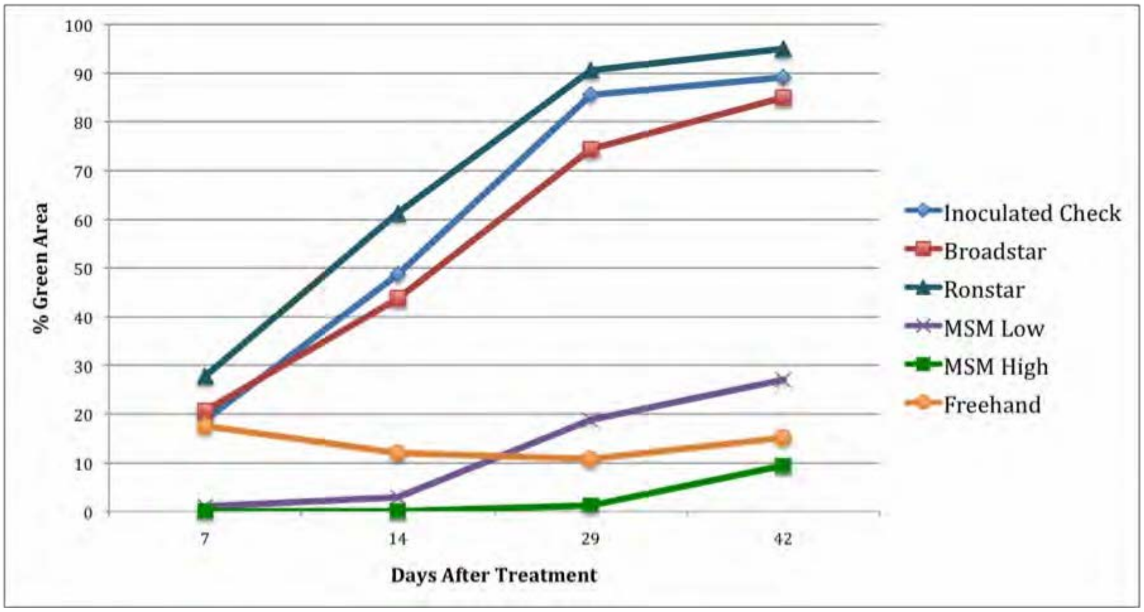


Figure 2. Percent green cover of liverwort as affected by postemergent treatment.



Post- and Pre-emergent Liverwort Control Trial

Steve Tjosvold and *Richard Smith*
University of California Cooperative Extension
Santa Cruz and Monterey Counties

Liverworts (*Marchantia* spp.) are non-vascular, primitive plants that form dense, matted, colonies (thalli) on the soil surface of containers in greenhouses and outdoor nursery stock. A mat of liverworts can impede water from overhead irrigations from entering the soil surface and sometimes liverworts can crowd slow growing ornamental crops. They are often a hard to manage nuisance. They spread by spores and are especially prolific in the cool, humid conditions of the central coast counties of California. This study was to test pre and post emergent applications of various conventional and biorational herbicides, and cocoa- shell mulch.

One gallon pots filled with Super Soil® potting mix were assembled on September 23 in the greenhouse at the UC Cooperative Extension greenhouse in Salinas, CA. Treatments included preemergent and post emergent applications of various materials (Table 1 and 2).

For pre-emergent treatments (Table 1), liverwort inoculum was prepared by blending 20 grams of liverwort thalli with 200 mls of buttermilk and 1 liter of water. All pots of pre-emergent treatments had 100 mls of this slurry added to them. They were then watered to settle the slurry and then the pre-emergent treatments were applied. In the case of the cocoa mulch treatments, the slurry was applied over the top of the mulch. The effectiveness of the treatments were determined by measuring the area of liverwort thalli that covered the pot surface 25 and 26 DAT.

For the post emergent treatments (Table 2), mature, heavily-matted, liverwort from infested propagation flats were cut into 2.5-inch diameter plugs and transplanted to 1-gallon pots on September 23 and post emergence materials were applied on October 7. In this two week period, new liverworts developed in the soil surrounding the transplanted plugs, apparently developing from gemmae that had splashed from the liverwort plug. The effectiveness of the treatments were evaluated separately on the mature plug and the young thalli by measuring the coverage of living (green) thalli 11 and 22 DAT.

The area of living (green) thalli was measured by photographing the pot surface, manipulating the color range of the image in Adobe Photoshop so that a lesion- area measurement software program (ASSESS, from the American Phytopathological Society) could be used to measure the area covered by the liverwort. All sprayed herbicides were applied at a rate of 72 gallons/acre. There were five replications of each treatment of 1-gallon pots and after the treatments were applied they were arranged in a randomized complete block design in a greenhouse bench covered with 40% shade cloth. The treated pots were misted three times per day for 2 minutes to provide a microclimate very favorable for liverwort growth.

Table 1: Pre-emergence Treatments

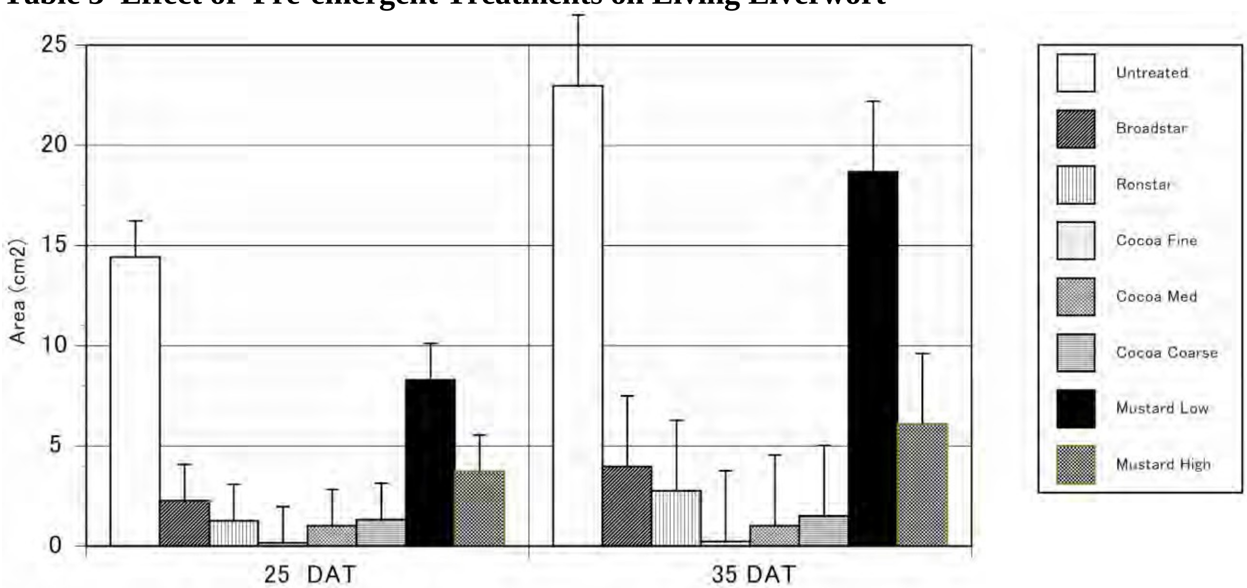
No.	Treatment	Manufacturer	A. I.	Rate	Liverwort Applied
1	Untreated			----	
2	Broadstar 0.25G	Valent Professional Products	flumioxazim	5.6 g / m^2	Before Treatment
3	Ronstar 50WSP	Bayer Environmental Science	oxadiazon	0.45 g / m^2	Before Treatment
4	Cocoa hulls – fine (2mm)	Bloomer Chocolate Company Chicago, IL		14.2 L / m^2 2 cm deep	After Treatment
5	Cocoa hulls – medium (4mm)			14.2 L / m^2	After Treatment
6	Cocoa hulls – coarse (8 mm)			14.2 L / m^2	After Treatment
7	Mustard seed meal – ground (2 mm)	MPT Mustard Products & Technologies Inc., Saskatoon, Canada		225 g / m^2	After Treatment
8	Mustard seed meal – ground (2 mm)			450 g / m^2	After Treatment

Table 2: Post-emergence Treatments

No.	Treatment	Manufacturer	Active Ing.	Rate Product / m^2	Comment
9	Untreated	----		----	
10	Mustard seed meal (2mm)	MPT Mustard Products & Technologies Inc., Saskatoon, Canada		225 g / m2	
11	Mustard seed meal (2mm)			450 g / m2	
12	Sporatec	Brandt Consolidated	botanical oils	1.15 ml / m^2	
13	Scythe	Gowan	pelargonic acid	4.41 ml / m^2	
14	Bryophyter	2% v/v	botanical oils	1.47 ml / m^2	
15	Shark 2EC	1.0 oz/A	carfentrazone	0.0075 ml / m^2	+ 0.25% Nonionic Surfactant
16	Weed Pharm	100% v/v	acetic acid	73.6 ml / m^2	

Cocoa mulch was the most effective in controlling liverwort germination, and there was a trend that the finer the mulch was more effective (Table 3). This was not expected because most mulches are most effective when they are coarse. Typically, coarse mulches dry out spores or seeds more effectively than finer mulches. Cocoa mulch may be working in a different way, perhaps leaching out toxic levels of a compound. Cocoa mulch is known to have very high levels of potassium and perhaps high levels of potassium are inhibitory to liverwort. Ronstar and Broadstar were moderately effective. MSM (mustard seed meal) at both rates provided uneven and a low level of control. The uneven and low control may have been result of the uneven application of either the inoculum or product. Perhaps the MSM was redistributed unevenly when the inoculum was applied overhead.

Table 3 Effect of Pre-emergent Treatments on Living Liverwort



MSM (low and high rates), Scythe, Bryophter, and Weed-Pharm completely killed all young liverworts, and the high rate of MSM completely killed all mature liverworts (Table 4 and 5). Sporatech and Shark were only moderately effective on young liverworts, and even less effective on mature liverworts.

There was no evaluation on plant tolerance in this study, so if the experimental products are used, insure that plant tolerances are first tested. For the registered products, consult the label for application information.

Table 4   Effect of Post-emergent Treatments on Living Young Liverwort

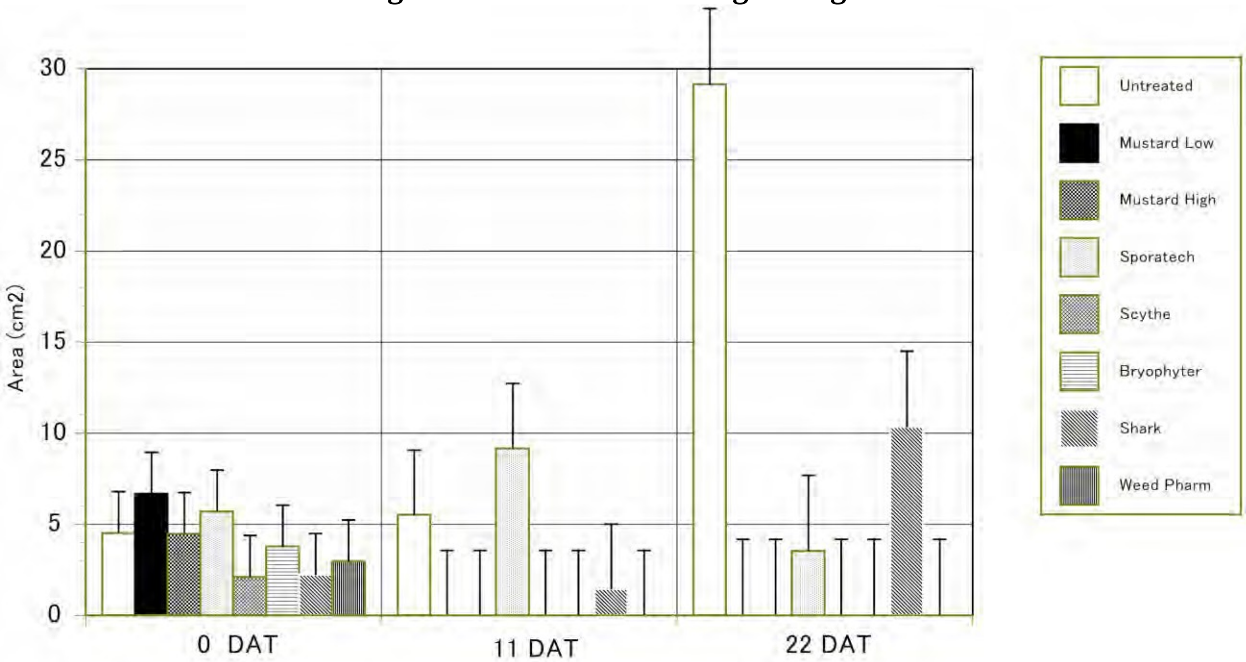
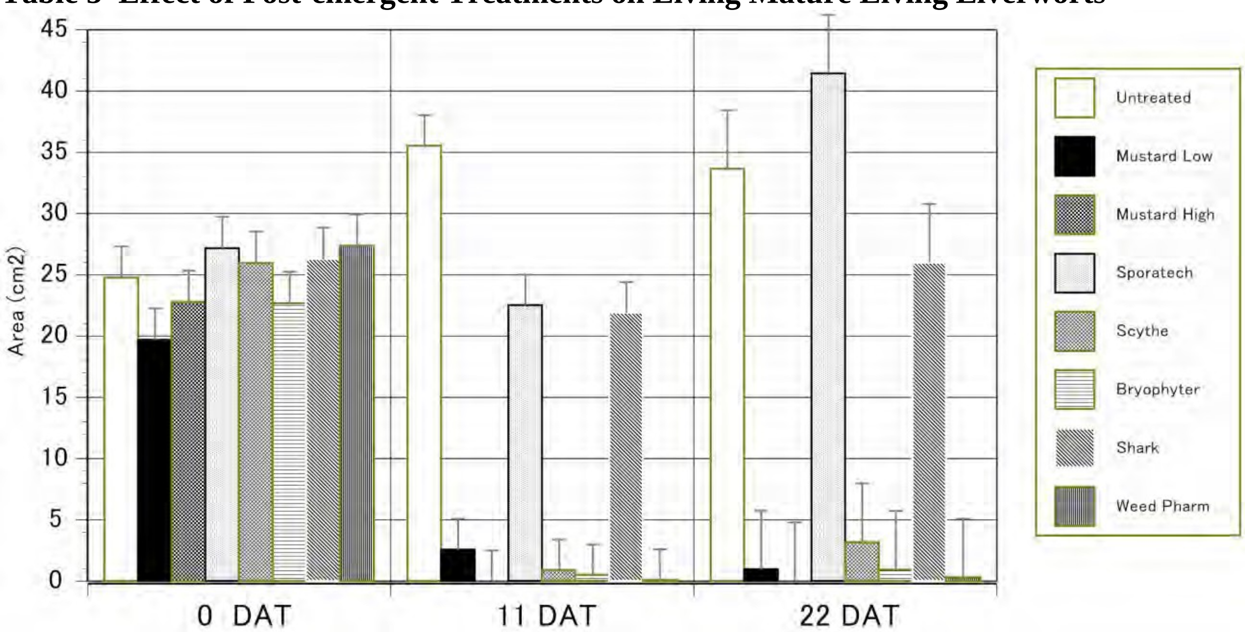


Table 5 Effect of Post-emergent Treatments on Living Mature Living Liverworts



Effects of Surface Seals on Fumigant Emissions and Pest Control

B.D. Hanson[1,2], S. Gao[2], J.S. Gerik[2], R. Qin[1,2], J. McDonald[2], and D. Wang[2]
[1]University of California, Davis and [2]USDA-ARS, Parlier, CA

Pre-plant fumigation with methyl bromide has been used for control of soil borne pests in many high value annual, perennial and nursery crops but is being phased out under the provisions of the US Clean Air Act and Montreal Protocol. Currently, 1,3-dichloropropene (1,3-D) is the only registered alternative fumigant that meets California nursery certification standards; however, this fumigant is under increasing regulatory scrutiny due to its release of volatile organic compounds (VOC). As part of a larger project, two trials were conducted to simultaneously evaluate the effects of surface treatments and two application shanks on 1,3-D emissions and soil borne pest control.

In this well-prepared field, nematodes (in a citrus nematode bioassay) were well controlled with all 1,3-D treatments regardless of application shank or surface seal technique. Pathogen control varied slightly among treatments but tended to be best with HDPE and VIF film and with a metam sodium sequential treatment. Similarly, weed control was usually slightly better in those plots sealed with either HDPE or VIF film or followed with metam sodium. Weed control efficacy with 1,3-D was reduced by intermittent water seals and the dual application technique.

There were no emission differences between the conventional shank and the Buessing shank application technique in this trial. Bare soil treatments (no film or water seal) had the earliest and highest emission flux and the highest cumulative emission (42% of the total). Intermittent water seals after fumigation delayed the peak emission flux but did not greatly reduce the peak; however, water seals did reduce cumulative 1,3-D emission to about 34% of the total applied. The conventional HDPE film reduced peak emission flux by 3-fold and cumulative 1,3-D emission by 50% compared to the bare soil plots. During the 10 d evaluation period, VIF film reduced emission flux approximately 10-fold compared to the HDPE film and reduced cumulative emission to less than 2% of the amount applied. However, results of a related study suggested that the highly retentive films such as VIF or TIF may retain fumigants so well that a surge in emissions will be observed when the film is cut for removal or planting holes. More work is ongoing to develop application techniques and timing to resolve the surging emission issue.

Tower Herbicide—New Herbicide Chemistry for Ornamentals

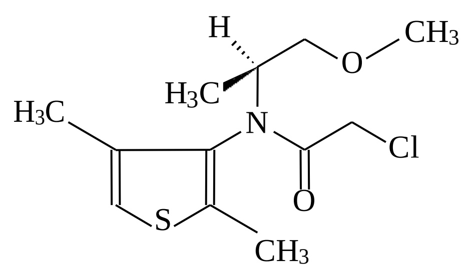
Todd Burkdoll, Turf and Ornamentals Market Development Specialist, BASF Corporation
James.burkdoll@basf.com Email: 559-906-4641

Product Information
Pending registration in CA - *Expected mid to late summer 2011*

- New active ingredient, broad-spectrum preemergence herbicide, for ornamentals - ***dimethenamid-p.***
- Spectrum of activity---
- Controls small-seeded broadleaf weeds, including emerging problem weed species like doveweed, eclipta, groundsel and liverwort
- Controls numerous grassy weeds and several sedges including yellow nutsedge
- Applied as a directed spray in field-grown nursery stock, landscapes and non-crop areas.
- Can be tank-mixed with Pendulum® AquaCap™ or other DNA herbicides for broader preemergence weed control

Dimethenamid-P: BAS 656H an Introduction

- **Toxicological Properties:** tech
  - Oral LD 50 rat: 1570 mg/kg
  - Dermal LD 50 rabbit: > 2000 mg/kg
  - Skin irritation (rabbit): slight
  - Eye irritation (rabbit): moderate
  - Teratogenicity: negative
  - Mutagenicity: Ames test negative
  - Reproductive: no adverse effects



Product Chemistry

- **Active Ingredient:** dimethenamid-p
- **Chemical Family:** chloroacetamide (Group 15)
- **Mode of Action:** Interferes with cell development
- **Behavior in Plants:** Inhibits seedling shoots, does not move readily in the plant
- **Control Symptoms:** Coleoptile growth is inhibited and emerged shoots are deformed
- **Half life** in soil 21-28 days

Tower Standard Information

- **Formulation:** 6.0 lb ai/gal EC (liquid)
- **Tank Mixing:** Can be tank mixed with Pendulum® AquaCap™, simazine, glyphosate, and other pre- and post-emergence herbicides (consult specific labels for uses and restrictions)
- **Reentry Interval:** 12 hours for agricultural workers

- **Caution Signal Word:** Warning

Application Timing

- Apply as a directed spray-application to the base of ornamental plants as pre emergent to weeds
- Do not apply to newly transplanted seedlings until plants have been watered and soil has settled and packed around root system
- Do not make applications at bud break, bud swell or at the first flush of new growth

Weeds Controlled by Tower Herbicide

Annual bluegrass	Hairy bittercress	Pigweeds
Barnyardgrass	Henbit	Ryegrass
Carpetweed	Fall panicum	**Sedges, annual &Yellow**
Chickweed	Florida pusley	Shepherdspurse
Crabgrass	Field sandbur	**Spurge spp.**
Dogfennel	**Fireweed (Am burnweed)**	Willowherb
Doveweed	Foxtails	Woodsorrel (Oxalis spp.)
Eclipta	**Kyllinga spp.**	
Goosegrass	Nightshades	

Use Sites

- Field Grown Nurseries
- Christmas Tree Plantations
- Landscape or Grounds Maintenance
- Mulch beds
- Ornamental Bulb production
- Noncrop Areas
- Jogging and Bike Trails
- Parking Lots
- Fence Lines
- Highway Rights-of-Way
- Golf Course Turf

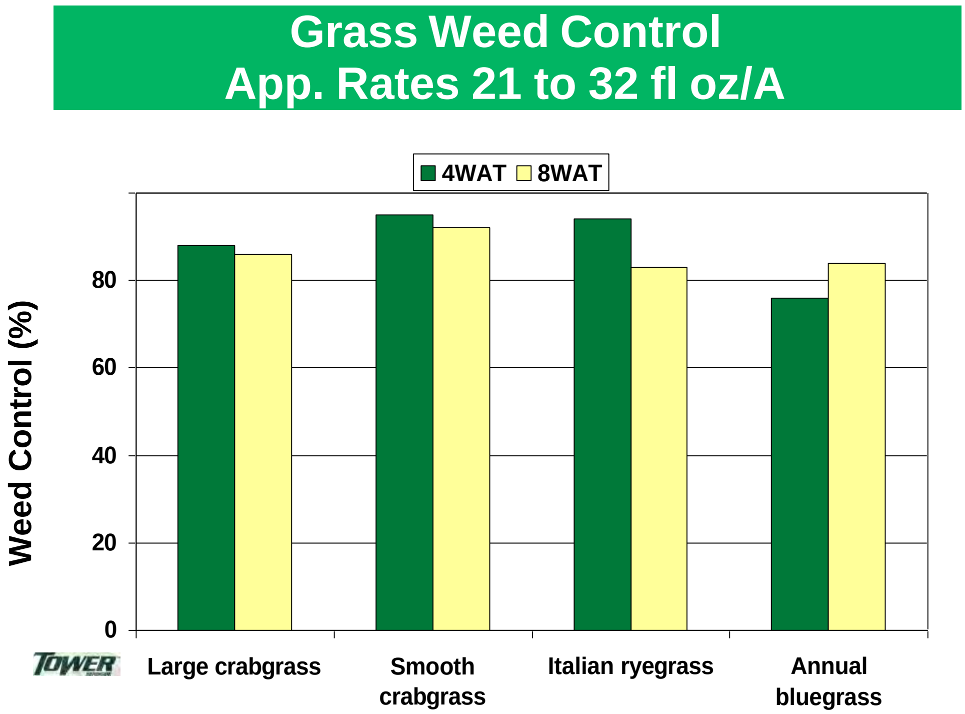
Ornamental Crops Tolerant to Tower Directed Sprays

- Red ash
- White cedar
- Crape myrtle
- Douglas Fir*
- Fraser Fir
- Southern Magnolia
- Red maple
- Western redcedar
- Azalea
- Boxwood
- Holly spp.
- Hydrangea
- Juniper
- Rhododendron
- RoseSpirea
- Yew

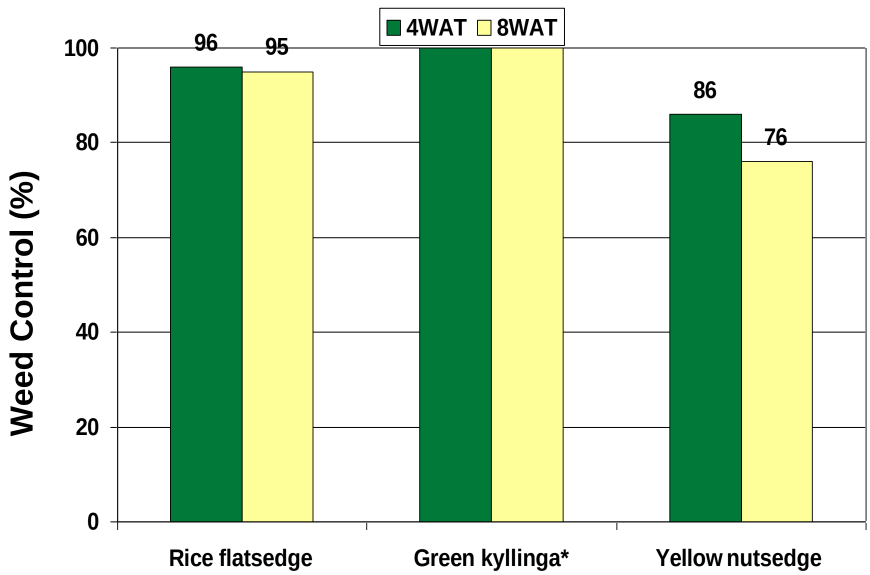
Key Features

- Excellent control of small seeded broadleaf weeds, including troublesome, new weed problems
- Controls yellow nutsedge more effectively that any available product
- Provides unsurpassed weed control when tank mixed with Pendulum AquaCap

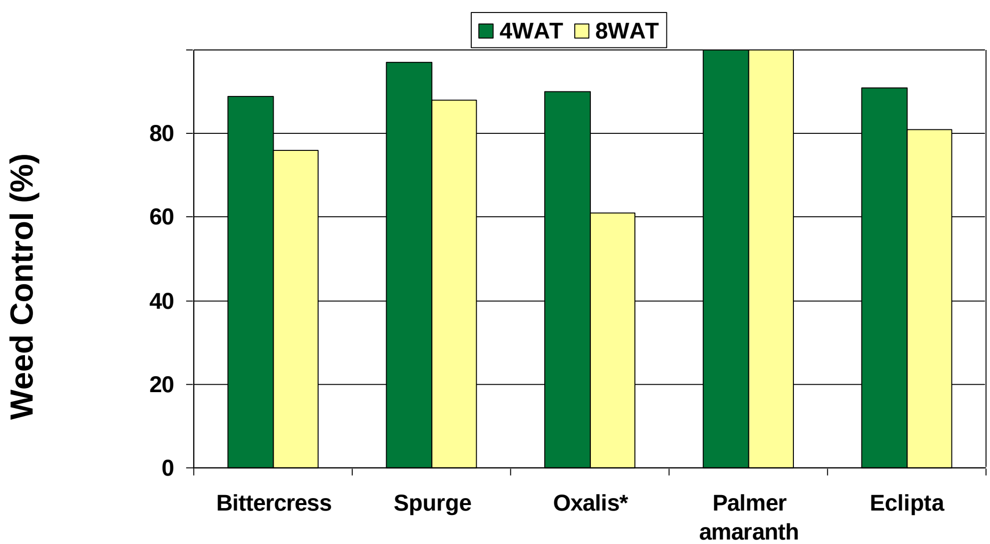
Tower Herbicide for broader spectrum Weed Control in Ornamentals and GC turf. Pending registration in CA (*Expected mid to late summer 2011)*



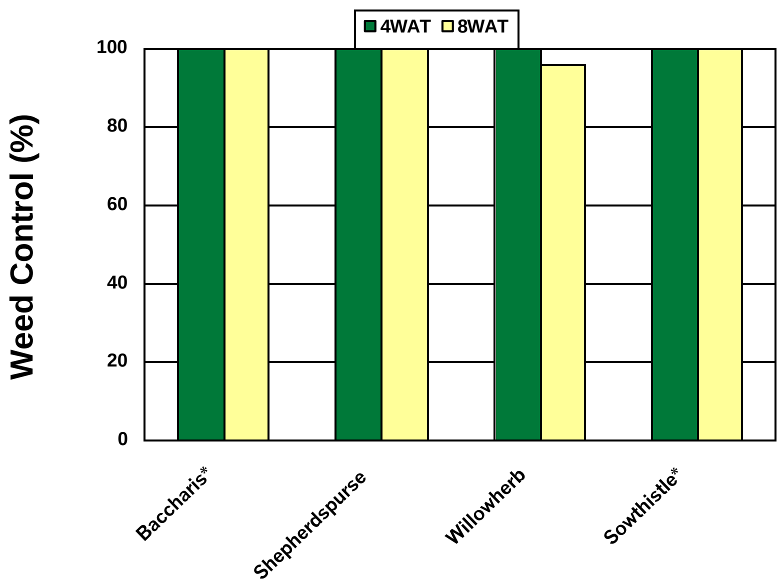
Sedge Weed Control (cont.)
App. Rates 32 fl oz/A



Broadleaf Weed Control
App. Rates 21 to 32 fl oz/A



Broadleaf Weed Control (cont.)
App. Rates 21 to 32 fl oz/A



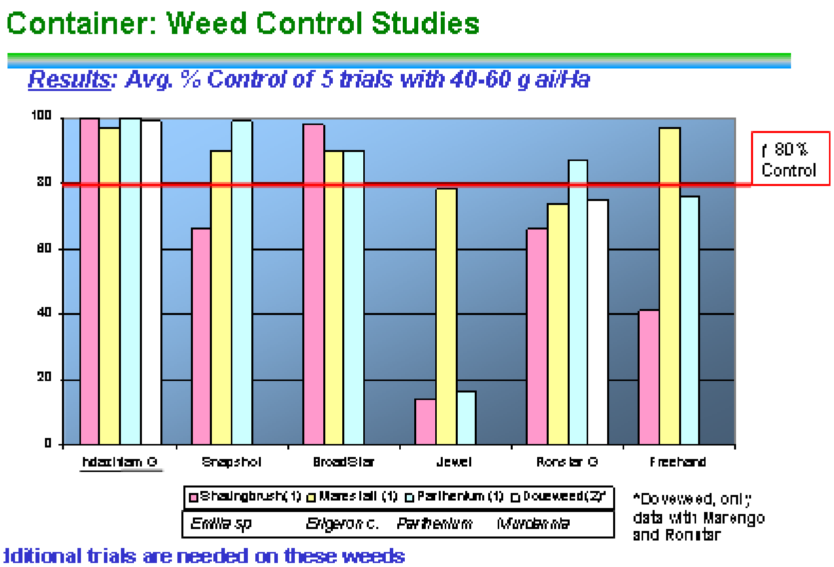
4WAT
8WAT
Weed Control (%)
100
80
60
40
20
0
Baccharis*
Shepherdspurse
Willowherb
Sowthistle*

Weed Control and Ornamental Tolerance with Indaziflam

Don Myers and Astrid Parker, Bayer Crop Science, 2 T. W. Alexander Drive
Research Triangle Park, NC 27709 don.myers@bayer.com, astrid.parker@bayer.com

Indaziflam is a new cellulose biosynthesis inhibitor (CBI) under development by Bayer Environmental Science for broadspectrum pre-emergent weed control. Indaziflam is classified as an alkylazine herbicide in WSSA group 29. It works by inhibiting crystalline cellulose deposition in the cell wall which affects cell wall formation, cell elongation and division; thus, only actively growing meristematic regions of roots and shoots of emerging weed seeds are affected.

Since 2008, indaziflam has been tested for weed control and plant tolerance in container ornamentals and around field grown nursery trees. To evaluate weed control in container ornamentals, multiple rates of indaziflam G were tested in various potting mixes. Indaziflam G was watered in following the application and weed seeds were surface-sown one to three days later. At rates of 40-60 g ai/ha, indaziflam G provided excellent weed control for 3-5 months against a large variety of weeds, including hard-to-control weeds such as Eclipta (*Eclipta alba),* prostate spurge (*Euphorbia maculata)* and common groundsel (*Senecio vulgaris).*



Ornamental tolerance studies were done by applying indaziflam G over-the-top, at rates ranging from 30-160 g ai/Ha, to mature liners transplanted into 1-3 gallon size containers. A second application was made two months later. Plant quality and marketability assessments were made throughout the studies; root quality was evaluated at the end of the studies. To date, 109 plant species/ cultivars have been tested and 40-60 g ai/Ha was safe on 100% of the conifers, 83% of woody ornamentals, 75% of herbaceous ornamentals, and on 70% of the ornamental grasses.

Indaziflam 20 WP, at 40-80 g ai/Ha, provided above 90% weed control around field grown nursery trees. Perennial weeds emerging from rhizomes or roots, such as nutsedge (*Cyperus* sp.) or encroaching bermudagrass (*Cynodon dactylon)*, were not controlled. Trees were about 3 years old and 5-6 feet tall; injury to trees was not observed.

Going forward, additional efficacy and tolerance studies will be conducted.

Weed Shifts in North Coast Grapes Due to Changing Weed Control Practices

John A. Roncoroni UCCE Weed Science Farm Advisor, Napa
Email : jaroncoroni@ucdavis.edu

Weed control practices in North Coast Vineyards, particularly those in Napa County have change in the last 20 years. Many vineyards have adopted ‘no-till’ or minimum tillage practices for weed control within the vineyard. Changing from tillage using herbicide under the vine has changed the weed composition. The herbicides used in that 20 year period have also changed. Some new herbicides have been registered for use in grapes. The biggest change in herbicide use is the shift by some managers to using postemergent herbicides exclusively.

We really don’t have any new weeds in the vineyard, but there has been a shift in their occurrence and density. The ‘old’ weeds: Filaree, Prickly Lettuce, Sowthistle, Mustards, Wild Carrot, Chickweed, Annual Bluegrass, and Wild Oats are still around and important problems in many vineyards. The ‘new’ weeds: Filaree continues to be a serious weed problem and is now joined by Sharpoint Fluvellin, Horseweed, Panicle Willowherb, and Hairy Fleabane that have been around in fairly low numbers for years. Hairy Fleabane is not a problem in vineyards in the North Coast, yet. It is now found on roadsides and in areas outside of and around the vineyard, but has the potential to move into the vineyard and become a very serious problem.

The characteristics that these new weeds share is that they are not well controlled by glyphosate (Roundup). The exception is Sharpoint fluvellin. Fluvellin is controlled by glyphosate but grows at times in the North Coast when glyphosate is not normally used. Germination is in mid-to- late summer, and continuing into the fall when vines are most susceptible to glyphosate drift.

The practice of ‘RoundUp’ only has gained popularity because of the relatively low cost of glyphosate products and a reduction in cultivation because of high cost and increased erosion potential. Many growers have chosen not to use pre-emergence herbicide because of the threat of off-site movement. Many growers are now re-evaluating their weed control practices to control these new weeds.

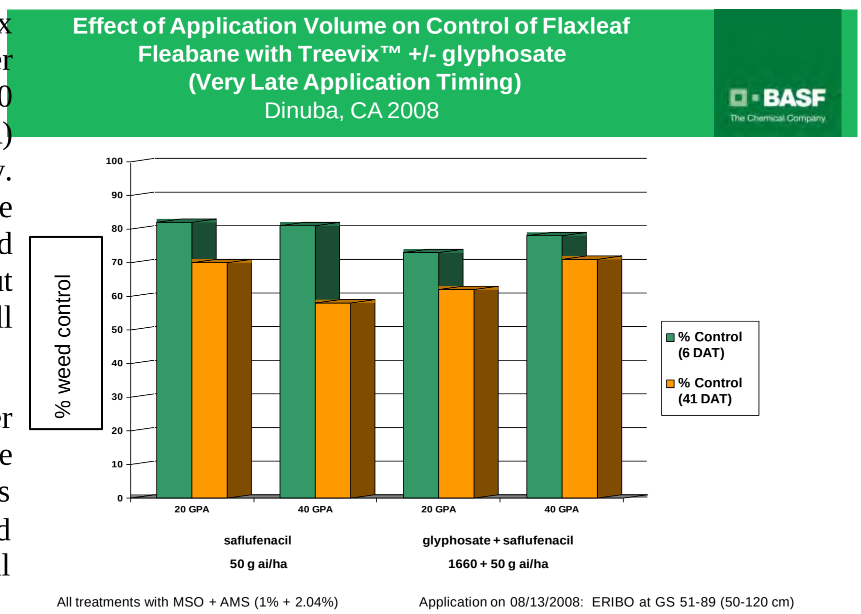
Efficacy of Treevix in Citrus and Tree Nut Crops

Curtis R. Rainbolt, BASF Corporation, Fresno, CA curtis.rainbolt@basf.com

Treevix herbicide was recently registered in California for weed control in citrus, almonds, pistachios, and walnuts. The active ingredient in Treevix, is saflufenacil (Kixor). Saflufenacil is a protoporphyrinogen-IX-oxidase (PPO) inhibitor belonging to the pyrimidinedione class of chemistry. Treevix provides postemergence burndown control of many key weeds including marestail, fleabane, cheeseweed, willowherb, sowthistle, and others. Because Treevix does not have grass activity it should be tankmixed with an herbicide that has grass activity.

Factors that influence efficacy with Treevix include weed size, carrier volume, and adjuvant selection.

- Similar to many burndown herbicides, Treevix herbicide works best on small weeds. Field trials have shown that 3 to 6 weeks after application control of flaxleaf fleabane that is less than 6 inches tall is 97% compared to only 82% when the fleabane is taller than 6 inches.
- When applying Treevix increasing the carrier volume from 5 to 20 gallons per acre (GPA) also improved efficacy. Increasing carrier volume from 20 to 40 GPA did not decrease efficacy, but did not improve it in all situations.
- Adjuvant trials over multiple years indicate that Treevix efficacy is greatest when com-bined with methylated seed oil (MSO).

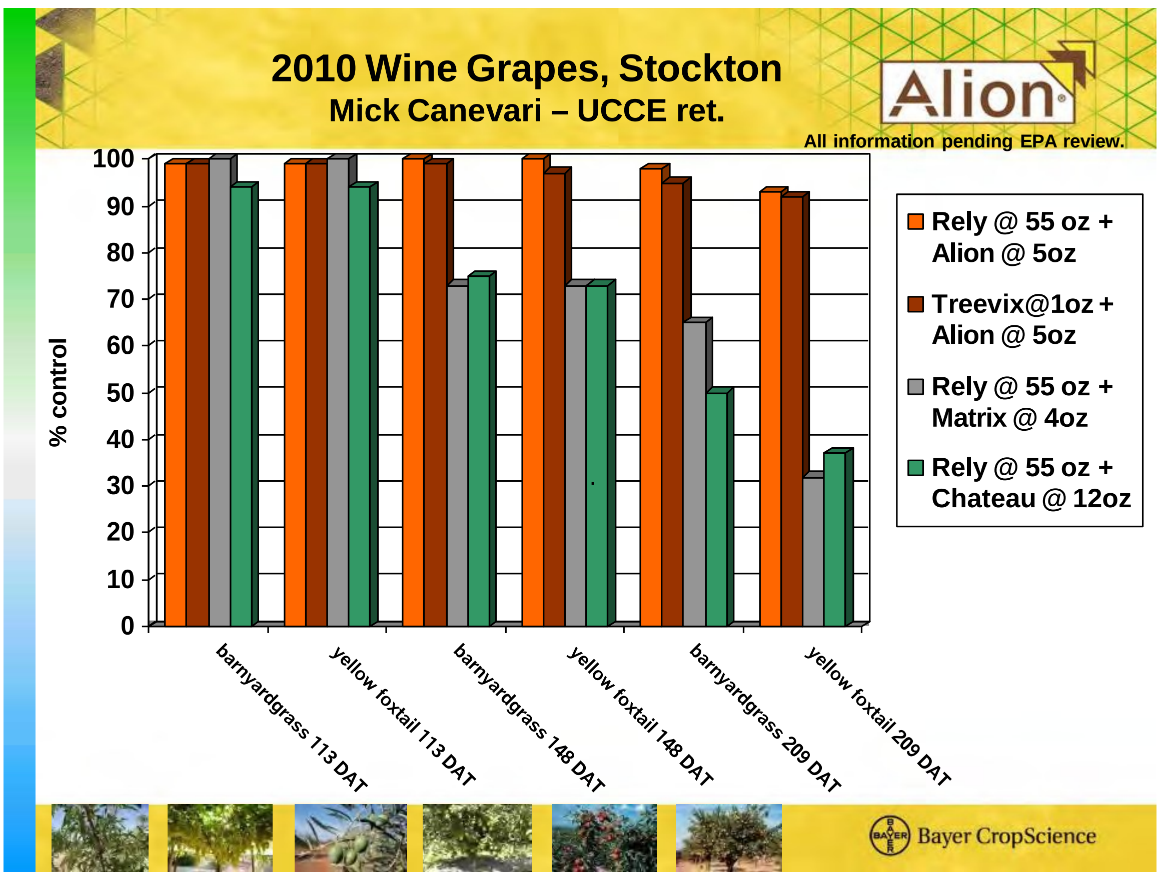


In summary, Treevix herbicide can provide excellent burndown control of broadleaf weeds when weeds are smaller than 6 inches, carrier volume is 20 GPA or greater, and MSO and AMS are used as adjuvants.

Indaziflam: A New Pre-emergent Herbicide for Residual Control in TNV Crops

Ryan Allen, Bayer CropScience, Roseville, CA.

Indaziflam, a new active ingredient from Bayer CropScience, has proven in numerous field efficacy studies to provide long-lasting residual control of many important broadleaf and grass weed species when applied preemergence. Indaziflam is a cellulose biosynthesis inhibitor, and classified by HRAC and WSSA as a group L and group 29 herbicide, respectively. Numerous rates and application timings of Indaziflam have been evaluated by University, private, and Bayer CropScience researchers, with the results confirming its broad spectrum and longevity of control. The results of these trials have also demonstrated the ability of Indaziflam to readily tank mix with most common adjuvants and herbicides. One application of Indaziflam at 73 g ai/ha (5 oz/A) can be expected to effectively control a wide range of broadleaf and grass weeds for up to 6 months, although control lasting much longer has been observed in some studies. Indaziflam will be sold as Alion™ in the TNV market upon EPA registration, which is currently anticipated in 2011.



Weed Management in Organic Vineyards and Orchards

Anil Shrestha[1], Marcelo L. Moretti[1], Kaan Kurtural[1], and Matthew Fidelibus[2].
[1]California State University, Fresno, CA 93740
[2]University of California, Kearney Agricultural Center, Parlier, CA 93648

Weed management in organic vineyards and orchards is a challenge due to the lack of registered herbicides that are available for use. Thus, growers usually have to rely on alternate tools for weed management in organic orchards and vineyards.

These tools include mechanical and thermal weed control methods, to name a few. Mechanical and thermal (flaming in particular) tools can generate dust and smoke and this can have implications associated with air quality regulations in the San Joaquin Valley (SJV).

There are a few new postemergence broad-spectrum herbicides labeled for use in organic systems. Similarly, there are new non-chemical weed control machines being designed. However, the efficacy and economics of these new tools have not been tested adequately in field studies.

Therefore, on-farm studies were conducted in 2010 in a transition-organic almond orchard at California State University, Fresno, a commercial organic raisin grape vineyard, in Selma, and in a commercial organic winegrape vineyard in Madera comparing several organic weed management options.

Treatments included

- steam (Batchen Stinger ®),
- flame (orchard only),
- French plow (raisin vineyard only),
- Bezzerides cultivator (vineyards only),
- and organic herbicides Greenmatch® (all sites), and Burnout® (orchard only).

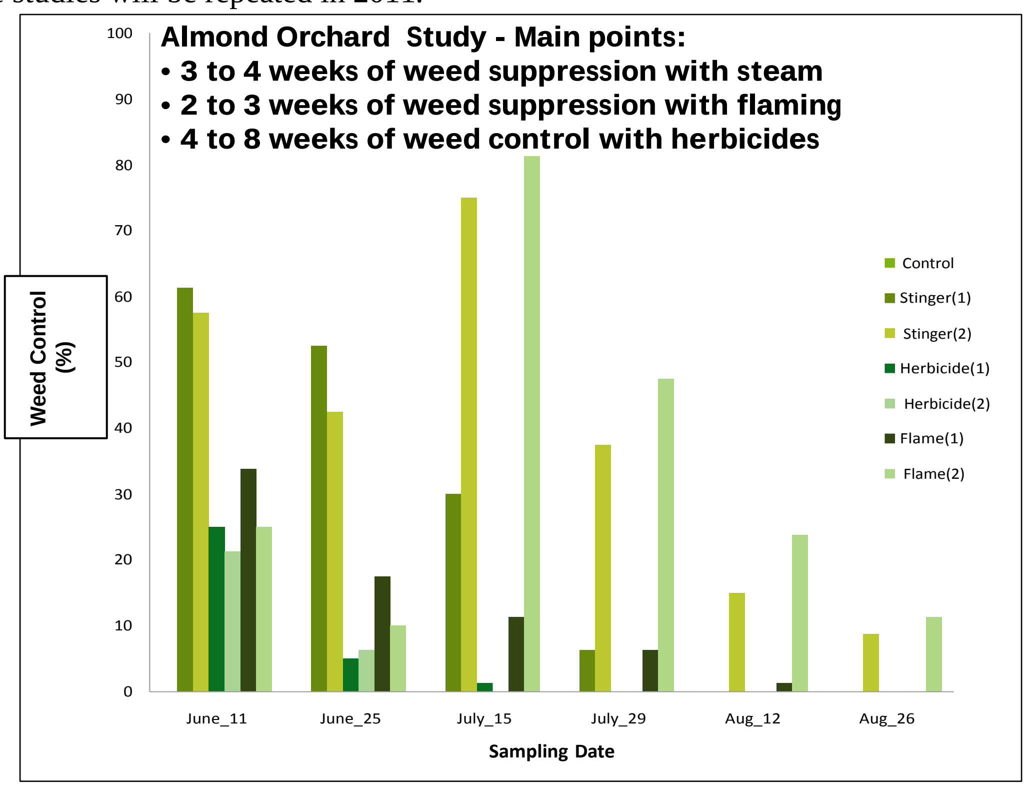
Non-treated control plots were also included at each site. The experimental design was a randomized complete block in the orchards and a split-plot in the vineyards. Each study site had four replicates of each treatment combination.

Weed densities by species, weed biomass, and visual estimates of percent weed control compared to the non-treated control were taken. In the vineyards, time required for hand weeding a month after the initial treatments were applied, and crop yield and quality parameters were also assessed. Yields were not taken for almond as it was a young non-bearing orchard.

In the almond orchard study, the steam treatment provided 3-4 weeks of weed suppression, flaming provided 2-3 weeks of weed suppression while the organic herbicides provided 4-8 weeks of weed suppression. The control with steam, flame, and organic herbicides was better when the weeds were at the seedling or early growth stages. The results were also affected by the type of weed species. For example, none of the treatments were effective against certain species such as puncturevine (*Tribulus terrestris*) and cut-leaf evening primrose (*Oenothera laciniata*), although some suppression was observed at earlier growth stages of these weeds. The *Conyza* sp. (horseweed and hairy fleabane) generally regrew soon after the thermal treatments. Therefore, monthly or bi-monthly applications of these treatments will be necessary depending on the regrowth of the weeds. It may not be safe to use a flamer in the orchards after early spring because of fire hazards in an arid environment such as that in the SJV.

In the vineyard studies, steam was less effective in the raisin vineyard but more effective in winegrape vineyards because, at the time of the treatment application, of weeds in the raisin vineyards were larger, at a later growth stage, and consisted of different weed species than weeds in the winegrape vineyard. As in the almond orchard, weed suppression by steam was limited to 2-3 weeks. Steam was not effective on nutsedge (*Cyperus* sp.). The organic herbicide provided selective bundown of certain broad-leaved weed species such as shepherd's purse (*Capsella bursa-pastoris*) but had no effect on nutsedge and other grasses. The mechanical weed control treatments (French plow and Bezzerides cultivator) provided the greatest amount of weed control (>90% control for almost 3 months). However, there may be disadvantages associated with mechanical weed control because of the soil disturbance process. For example, root injury was observed with the French plow. The mechanical treatments reduced hand weeding time by about 70% compared to the non-treated control. The steam and herbicide did not reduce hand weeding time. No effect of any of the treatments was observed in grape yield and quality.

The studies will be repeated in 2011.



Tangent™ and Pindar™ GT Herbicides for Weed Control in Tree Crops*

James P. Mueller, Dow AgroSciences, Brentwood, CA. jpmueller@dow.com

Pindar GT Herbicide (oxyfluorfen plus penoxsulam) combines two herbicidal modes of action into one product. Oxyfluorfen is a PPO (protoporphyrinogen oxidase) inhibitor in HRAC mode of action group E. For many years, it has been the standard for residual weed control in tree crops. Penoxsulam is a potent ALS (acetolactate synthase) inhibitor in HRAC group B. It provides extended residual weed control for tree crop orchards at 17.5 to 35 grams active ingredient per hectare (0.016 to 0.032 lb a.i./acre). This combination provides broad spectrum and long lasting pre-emergence and post-emergence control of difficult to control broadleaf weeds and some major grass species. Pindar GT controls weeds which are resistant to other herbicide classes, and is now registered for use in US tree nut orchards.

Tangent is an SC (suspension concentrate) formulation containing penoxsulam at 240 g/L (2 lb/gal). Like Pindar GT, Tangent is effective on a wide range of broadleaf and grass weeds. Tangent registration for tree nuts is expected in 2011. Its fit in tree crop herbicide programs is now being defined. As Tangent research currently is in progress, it will be reported next year.

More than 100 weed control efficacy trials were conducted with Pindar GT from 2004 through 2010 in US tree nuts and in open fields. These replicated experiments involved pre-emergence and early post-emergence application during tree dormancy (December through February). Based on this extensive research under a wide range of conditions, Pindar GT is known to control the most difficult broadleaf weeds infesting tree nuts: hairy fleabane (*Conyza bonariensis*), horseweed (*Conyza canadensis*), filarees (*Erodium* species) and mallows (*Malva* species). Pindar GT also controls at least 60 other weed species, including most broadleaf weeds of importance to tree nut growers. It also controls some of the major grass weeds, such as barnyardgrass (*Echinochloa crus-galli*), bromegrasses (*Bromus* species), large crabgrass (*Digitaria sanguinalis*), wild barley (*Hordeum leporinum*), wild oat (*Avena fatua*), annual bluegrass (*Poa annua*) and witchgrass (*Panicum capillare*).

From 2004 through 2010, a large and thorough research project was conducted to document the safety of Pindar GT to tree nut crops. In addition to the efficacy trials described above, Pindar GT was tested in 37 crop safety trials in all major tree nut production areas. Many of these sites received three years of consecutive applications at up to four times the maximum label rate. Tree growth, tree vigor and crop yield were assessed. Pindar GT was shown to be safe to bearing and non-bearing tree nuts when used according to label directions.

To validate these research results under commercial use conditions, Pindar GT was compared to grower standard programs in 23 large scale demonstration trials in tree nuts. Treatments were applied in the winter 2009 – 2010 dormant period in the San Joaquin and Sacramento Valleys of California. Demonstration trial participants used Pindar GT in one spray tank load and treated the rest of the orchard with flumioxazin (Chateau®) and/or rimsulfuron (Matrix® FNV) herbicides. Demonstration trial participants chose the spray adjuvant, a contact ("burndown") herbicide and a grass control product. Data collected were percent control compared to a nearby untreated area within the orchard.

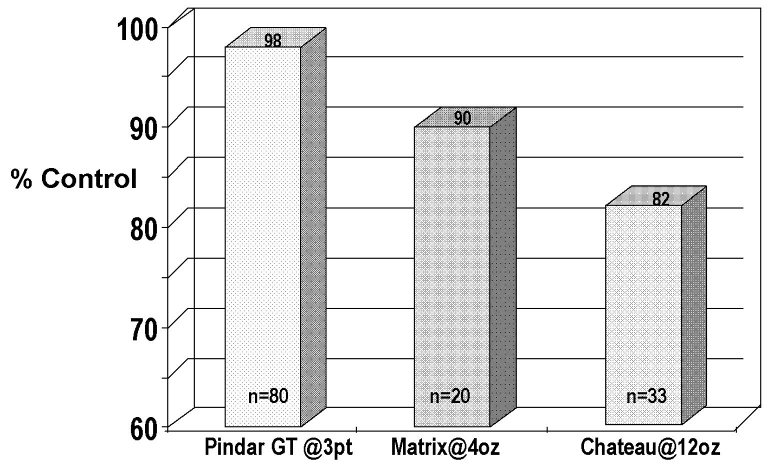
The relatively high rainfall amounts which occurred in 2010 provided a challenge for residual herbicide programs. Pindar GT was shown to deliver consistent weed control across a wide range of weed species, soil types and rainfall levels. In most trials, Pindar GT performed better than the standard residual herbicide program used by the growers. Pindar GT provided four to six months control of the major broadleaf weed species infesting tree nut orchards in California, including glyphosate - tolerant populations of *Conyza* (fleabane, horseweed). No crop safety, tank mixing or tank clean out issues occurred with Pindar GT during this commercial validation project.

Based on over 100 replicated research trials and 23 large scale demonstration trials, Pindar GT performance is consistent across soil types, geography and weather conditions. The high rate provides four to six months of residual weed control. The broad weed control spectrum and pre- and post-emergence activity of Pindar GT was illustrated in these research projects. The two modes of herbicidal action in Pindar GT will be valuable for weed resistance management. An extensive crop safety research program illustrated that Pindar GT has excellent crop safety when used according to label directions.

* The author would like to thank the many cooperators and co-workers who contributed to this project, especially Barat Bisabri, Marc Fisher, Rick Mann, Jesse Richardson Debbie Shatley, Monica Sorribas and Jagadeesh Yerneni.

Summary across trials: fleabane (*Conzya bonariensis*)

*Fleabane control 6 months after application**



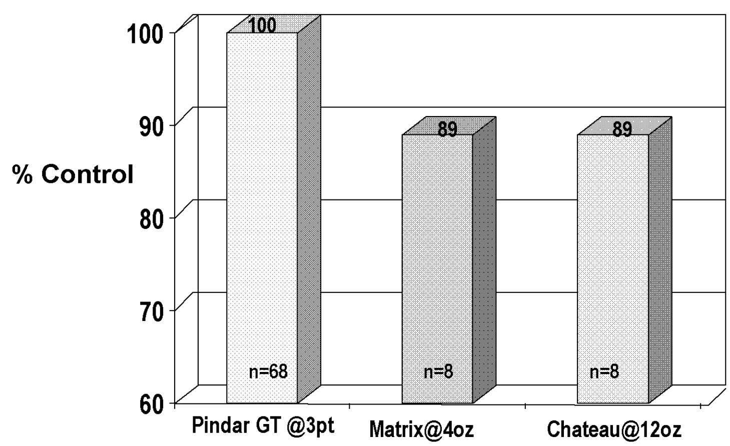
* n=number of observations

All treatments included glyphosate at 1.5 lb a.e./acre.

Summary across trials: horseweed (*Conyza canadensis*)

including glyphosate-tolerant populations

*Horseweed control 6 months after application**

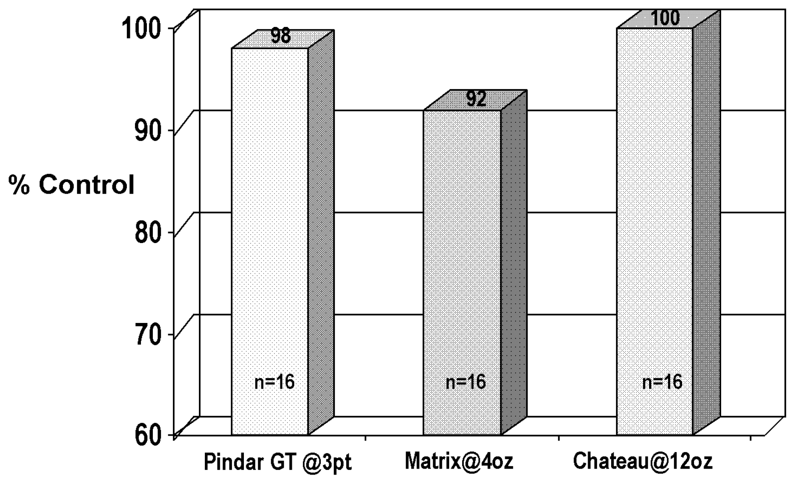


* n=number of observations

All treatments included glyphosate at 1.5 lb a.e./acre.

Summary across trials: filarees (*Erodium* species)

*Filaree control 6 months after application**

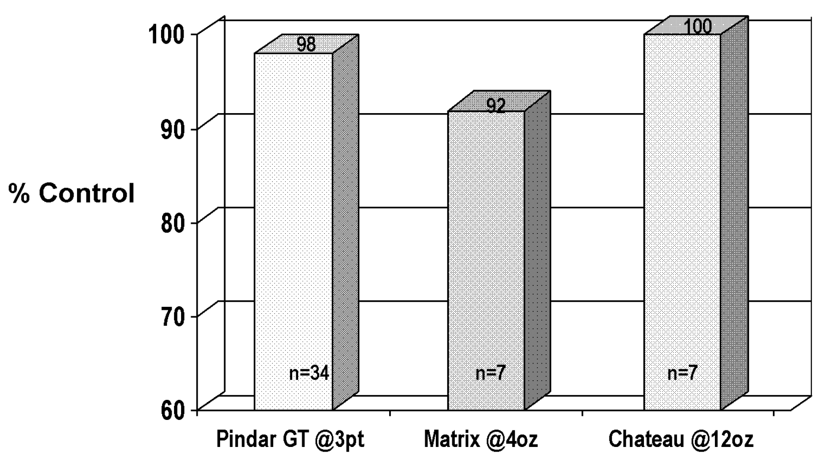


* n=number of observations

All treatments included glyphosate at 1.5 lb a.e./acre.

Summary across trials: *Malva* species

*Malva control 6 months after application**

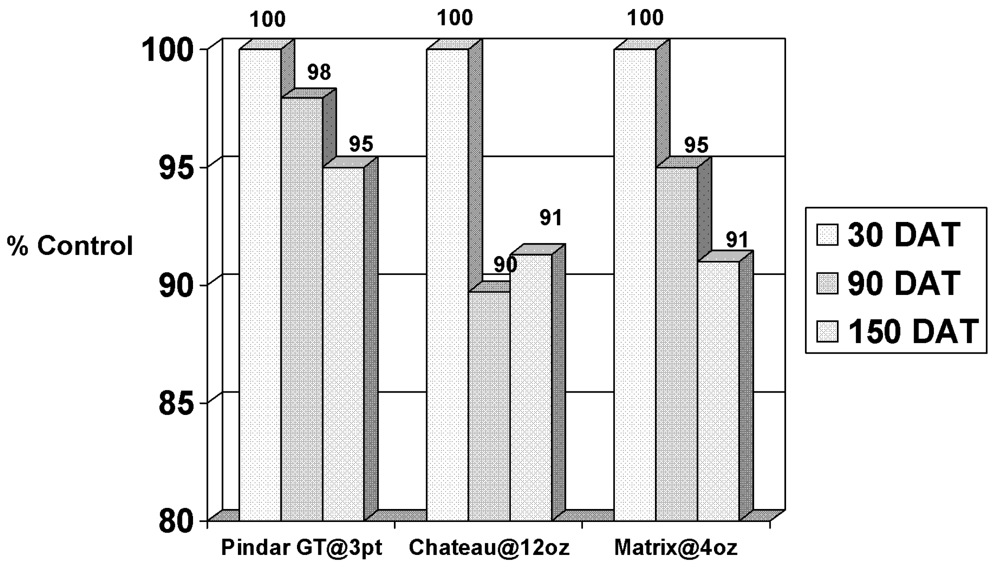


* n=number of observations

All treatments included glyphosate at 1.5 lb a.e./acre.

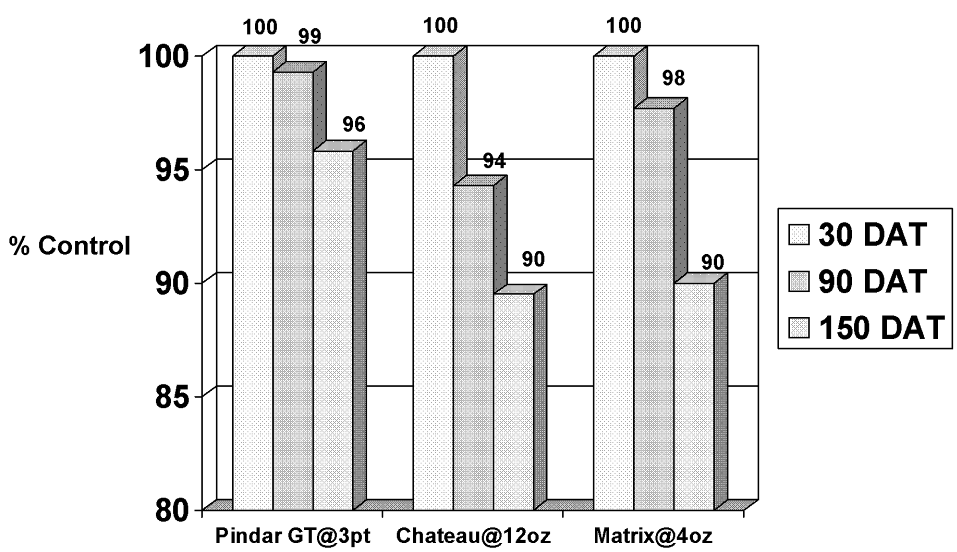
Pindar GT demonstration trials in tree nuts 2009-2010

Fleabane control 30, 90 and 150 days after application



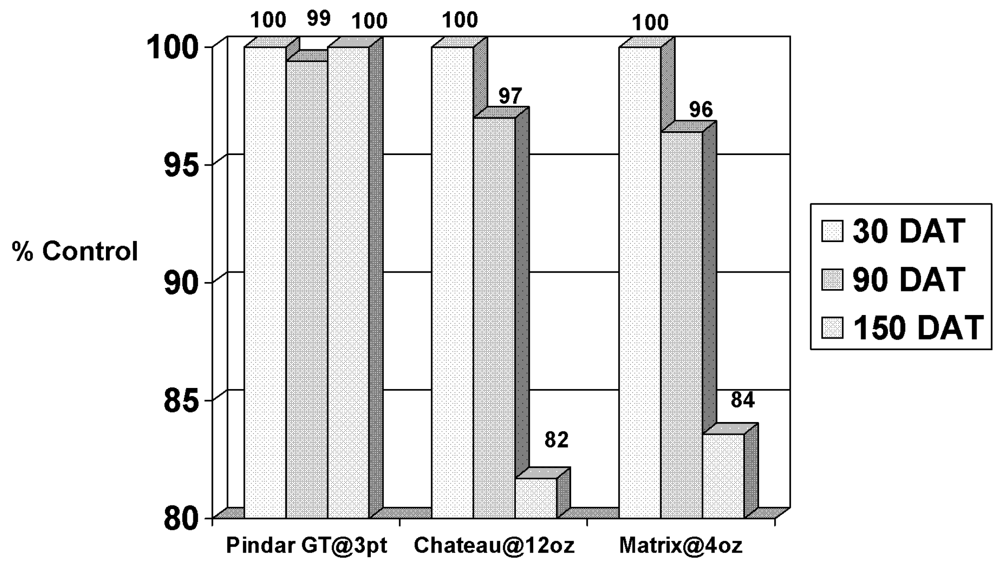
Pindar GT demonstration trials in tree nuts 2009-2010

Horseweed control 30, 90 and 150 days after application



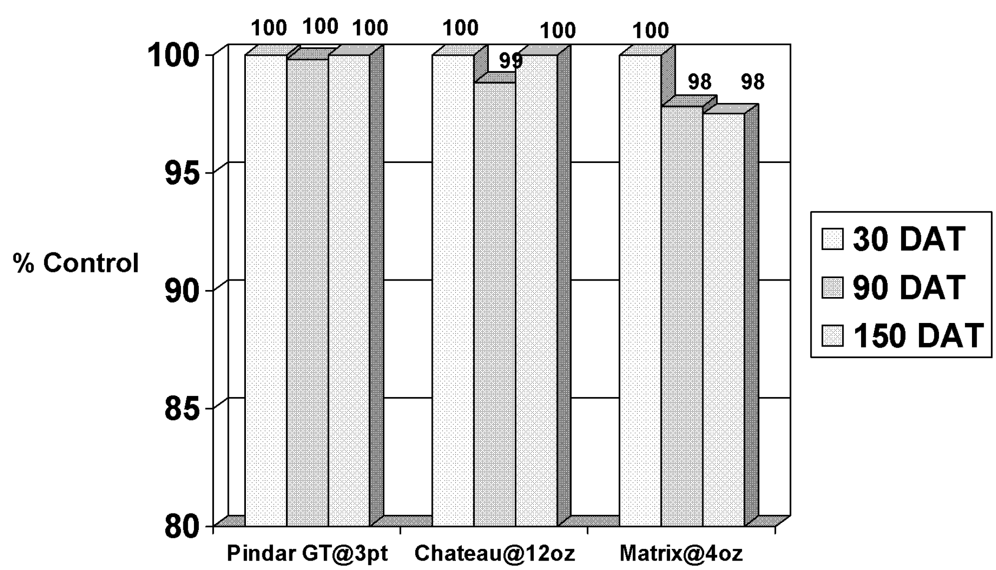
Pindar GT demonstration trials in tree nuts 2009-2010

Filaree control 30, 90 and 150 days after application



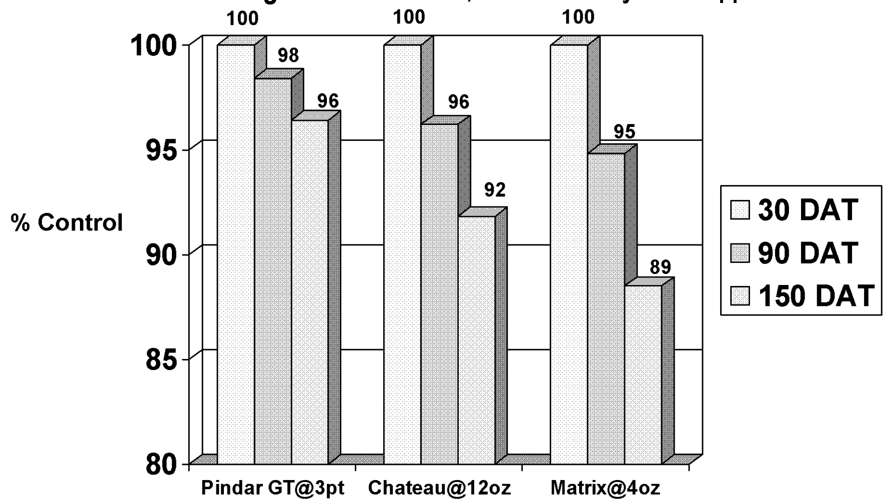
Pindar GT demonstration trials in tree nuts 2009-2010

Malva control 30, 90 and 150 days after application



Pindar GT demonstration trials in tree nuts 2009-2010

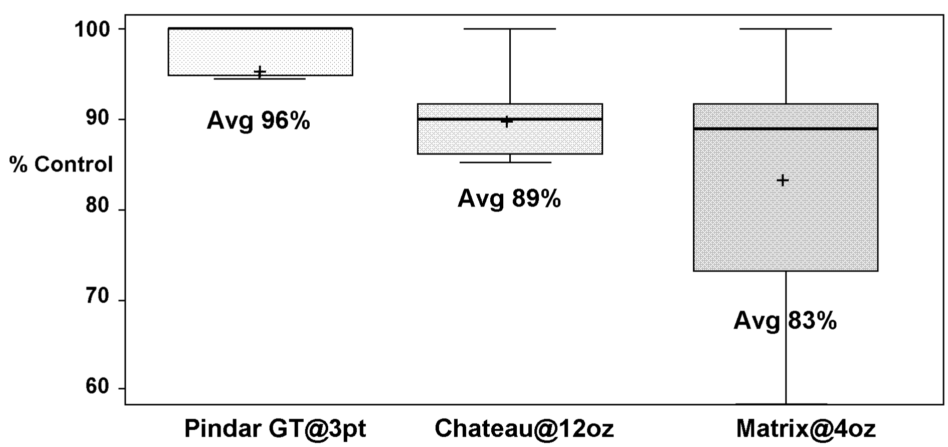
All broadleaf and grass control 30, 90 and 150 days after application



[A grass herbicide tank-mix partner was not included.]

Pindar GT demonstration trials in tree nuts 2009-2010

This box plot illustrates ***consistency of broadleaf weed control***
150 days after application, summarized across 23 locations



[A grass herbicide tank-mix partner was not included.]

New and Expanding Weeds in California

Dean G. Kelch, Plant Pest Diagnostics Laboratory
California Department of Food and Agriculture

Every year sees the introduction of new and the expansion of previously known noxious weeds in California. In 2010, the species discussed below have been chosen as notable.

Japanese dodder (*Cuscuta japonica*) is a vining parasite that attacks many woody plants. The plant is spread via humans (it is part of the Hmong pharmacopoeia) and birds. Although reproduction by seed has not been documented in California, partly mature seed capsules have been found on recently identified samples. Occurrences are widespread, but more than 90% have been in Sacramento County. Over 200 occurrences have been treated by CDFA so far. Host tree removal is the only known treatment.

Stinkweed (*Dittrichia graveolens*) is an annual, late-flowering, glandular herb first reported in California in 1984. It has spread so quickly along roads that it is now known in at least 26 California counties. Problems associated with this weed include inhibition of seed germination of other plants, toxicity to stock, and contact dermatitis in some people. Control is possible using glyphosate or repeated mowing.

Canary Island hypericum (*Hypericum canariense*) is a shrub to 2 m with large yellow flowers that is invading scrub habitat on coast. It is currently actively spreading in California. Control has been achieved with basal bark treatment with Garlon.

Capeweed (*Arctotheca calendula*) has long been confused with creeping capeweed (*A. prostrata)*, a common nursery plant sold as a ground cover. Capeweed differs in that it is an annual (vs. perennial) with dark disk flowers (vs. yellow ray flowers). It is currently known from Marin, Humboldt, San Mateo, Merced and Stanislaus Counties. Control is difficult, but there have been recent promising results using Milestone.

Star endive (*Rhagadiolus stellatus*) is an annual herb in the chicory tribe of the daisy family (Asteraceae) that prefers partially shaded habitats (although it is a grain-field weed in the Middle East). It can be distinguished from other chicory tribe weeds, such as sow thistle (*Sonchus*) and Cretan weed (*Hedypnois*) by its distinctive fruit that resembles a 6-8-pointed star. Currently, endive daisy is known only from Napa & Sonoma Counties, but it is often dominant in understory and seems to be spreading rapidly.

Figure 1. Star endive

Figure 2. Branched broomrape

Branched broomrape (*Orobanche ramosa*) that has been known as a parasite of tomatoes in California for many decades. In 2010 an old site was replanted to tomatoes and branched broomrape reappeared. The last known outbreak at this site occurred in the 1970s. This indicates long-term seed viability. As the seed is easily dispersed via footwear and field equipment, great care must be taken to prevent further spread. Control of large patches may not be possible, although soil fumigation has been used with some effect. The best control is to avoid planting host crops in known infestations.

Santa Maria feverfew (*Parthenium hysterophorus)* is a tropical annual herb. It is an important weed in Australia where it occurs in many tropical/subtropical habitats after disturbance. It is not currently established in California, but seedlings were found in a nursery greenhouse, presumably introduced via the coir component of the potting mix imported from Sri Lanka. Although most of California is not suitable for growth of this plant, it should be watched for as it is known to be toxic to stock, it inhibits germination of some crop plants, it causes contact dermatitis or pollen allergies in some people. It can be controlled via various herbicides used on broadleaf weeds.

Mexican feathergrass (*Nassella tenuissima*) is a short-lived perennial grass often used in gardens in California. It is not yet firmly established in California, but spontaneous plants in non-horticultural settings have been collected in 6 California counties.

False brome (*Brachypodium sylvaticum*) is a perennial grass in woodland in California, but it can occur in full sun in Washington and Oregon. In California, it was originally found when it was being vetted for a habitat “restoration” in redwood forest. It can be controlled with a multi-year herbicide program or by heavy grazing.

Figure 3. Yellow alyssum

Yellow alyssum (*Alyssum murale* and *A. corsicum*) are yellow-flowered perennial members of the mustard family (Brassicaceae) from Europe. As they are metal hyperaccumulators, they were planted as possible “bio-mining” crop in Southern Oregon. They were recently discovered to have escaped into USFS land in Southern Oregon. They have a high likelihood of spread in Northern California on serpentine soils and land managers should be aware of their potential spread.

CAPE IVY
US FOREST SERVICE LANDS - BIG SUR COAST

Jeff Kwasny, Los Padres National Forest, Big Sur, CA

The Big Sur coast is centrally located between San Francisco and Los Angeles. The travelers' link between these two metropolitans is Highway 1. This highway provides a major vector for invasive plants from San Francisco, the largest hub of invasive species in California. As a result, lands adjacent to Highway 1 are a menagerie of exotic plants.

Cape ivy (*Delairea odorata*) is currently the number one threat to heterogeneity and species diversity along the Big Sur coast. Alvarez and Cushman (2002) found in plots along the northern California coastal regions that habitats containing Cape ivy contained 36% fewer native plant species when compared to non-invaded areas. In addition, they found a 31% decrease in species diversity as well as 88% decrease in the abundance of native seedlings. Native to the moist mountain forests of South Africa, it was introduced in the 1850s as an ornamental in the eastern U.S. and to California by the 1950s (Elliot 1994); by the 1960s it had naturalized in Golden Gate Park, San Francisco and Marin County (Archibald 1995). Individual plants grow year-round and expand vegetatively through prolific stolon production. Cape ivy has no taproot, only shallow fibrous roots that sprout from the stolons where the vine comes into contact with soil. Typical habitat for Cape ivy is coastal scrub and riparian areas; tolerant to salt spray, it occurs along the immediate coastline right down to the high tide line.

COMPETITIVE ADVANTAGES of CAPE IVY

There are complex reasons why Cape ivy grows so well here; a few of the physiological competitive advantages discussed are: early flowering, growth form, and shading effect.

<u>Early Flowering</u>

Cape ivy flowers in December through February. Most native plants are dormant at this time or haven't sprouted yet. Seed is cast by March/April. This is a common advantage among many of California's nonnative invasive plant species.

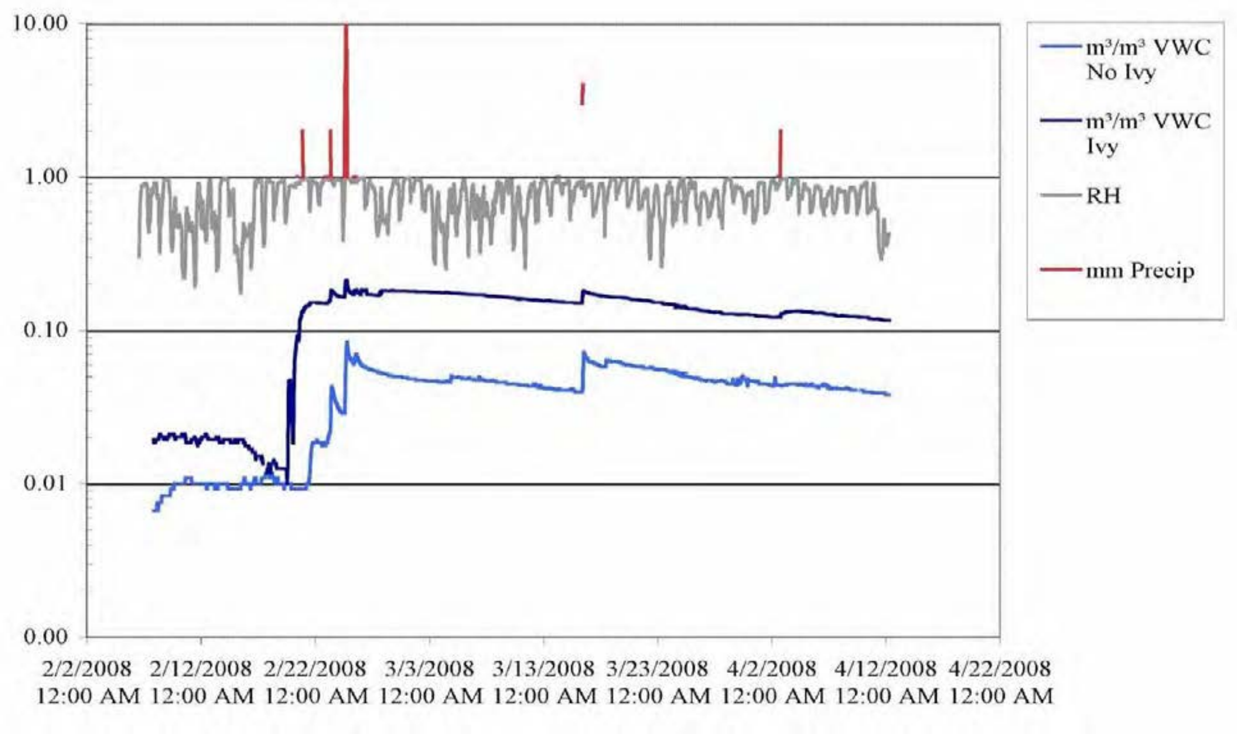
<u>Growth Form</u>

The invading vining growth form allows it to exploit resources by growing up shrubs and trees, while its stolons travel along the soil surface, sprouting roots on contact - a mobile and opportunistic system that is ideal for colonizing new areas.

<u>Shading Effect</u>

Cape ivy has the ability to protect the soil surface from loss of moisture by 'shading' the ground from sunlight and wind to keep the soil moisture higher than what is occurring naturally. This permits the soil under the ivy to store more moisture longer into the spring, and therefore give Cape ivy an advantage over natives in growing rate and seasonal growth duration. Figure 1 illustrates the results of soil moisture probes placed in the soil under Cape ivy and adjoining soil cleared of the ivy within ten meters of each other. The probes measured volumetric water content at a soil depth of 10 centimeters (Chris Potter, NASA Ames Laboratory).

Figure 1.



CONTROL METHODS

Physical

The two most common methods are: hand pull vines and stack in piles for disposal or desiccation and the "Scorched Earth" tactic of pulling and hoeing all vegetation (natives and exotics) allowing for free access to remove re-emerging Cape ivy.

Grazing with Goats

Goats have been used successfully on small sites. Recommended timing is between November and February before seeds ripen. The goats eat indiscriminately, consuming all vegetation equally, and generally leaving the root structure intact.

Green Flaming

Pioneered by Ken Moore of the Wildlands Restoration Team, Santa Cruz, a propane torch is used to heat the ivy just enough to produce wilting. Flaming is a good choice for follow-up treatment.

Chemical

Applied once a year as foliar spray in late-winter to early-spring when the ivy is photosynthesizing actively but past flowering. To achieve the desired efficacy, one to three consecutive years of treatment is necessary; three years for the older infestations and one year for spot treatment of new infestations.

In riparian areas, use 1½% solution of glyphosate (aquatic approved product) + 0.75% non-ionic nonylphenol polyethoxylate (NPE) surfactant [examples are R-11 (Wilbur-Ellis), X-77 (Loveland Industries)]. Non-target plants such as willows are dormant (some willow trees are leafless this time of year) during the winter months and are not affected by glyphosate. At Pfeiffer Beach in Big Sur the Forest Service treated Cape ivy with this solution. The first year we sprayed 600 gallons of solution, the second year we sprayed 500 gallons, and the third year we only needed to spray 18 gallons to seek and destroy new spot infestations.

In upland areas, there are two proven solutions to control Cape ivy: 1) 1½% solution of glyphosate (Roundup Pro®), or 2) a cocktail of 0.5% glyphosate (Roundup Pro®) + 0.5% triclopyr (Garlon 4®) + 0.1% silicone blend surfactant [examples: Sylgard 309 (Wilbur-Ellis), Silwet L-77 (Loveland and Helena), Freeway (Loveland Industries)]. The cocktail solution in some cases has shown to have less effect on non-target species than the glyphosate only solution. If there are no concerns about non-target species, Roundup Pro® is easier to use. Another product that I have heard is effective on upland sites is clopyralid.

Choice of control method depends on your site specific goals, strategy, issues/concerns, policy (if government agency), resource considerations, and funding/workforce.

Figure 2. Estimated cost per acre to treat Cape ivy

Manual	Goat Grazing	Chemical	Flaming
$1800	$1350	$1300	$1300

√ Manual based on actual costs incurred by USFS

√ Goat grazing based on contractor estimate

√ Chemical based on actual costs incurred by USFS

√ Flaming based on personal conversation with Ken Moore, Wildland Restoration Team (2006)

CONTROL STRATEGY

At a minimum, your control strategy should include the following:

1) Spot infestations should be first priority for treatment.
2) Funding – you must have funding and/or workforce available for a minimum of three years.
3) Establish control lines. For landscape control I recommend a map of the infestation and established control lines.

Figure 3

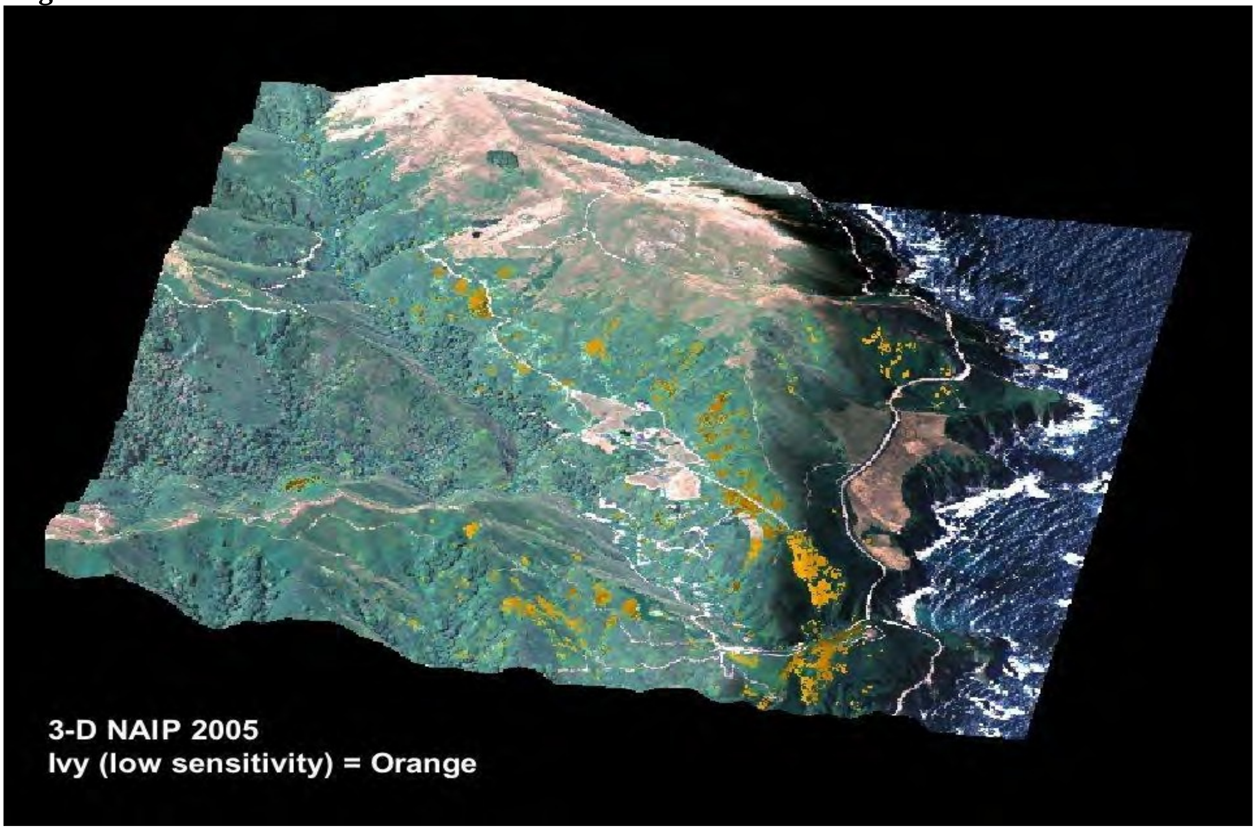


Figure 3 is an example of mapping Cape ivy infestations across the landscape using high-resolution satellite imagery (Seth Hiatt, San Francisco State University). In this example, roads are used as control lines.

Key to all non-native invasive weed control programs is persistence. Using the control strategies presented here today, the Forest Service has been and will continue to be diligent in their efforts to maintain native species diversity along the Big Sur coast.

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Weed Wars and Woes in the Far North

Carri B Pirosko, Integrated Pest Control Branch, California Department of Food and Agriculture, 37490 Toronto Avenue, Burney CA 95616 Email: cpirosko@cdfa.ca.gov

The far north end of the state is well known for land features such as: Mount Shasta, Mount Lassen and the Modoc Plateau. A lesser known story synonymous with the far north is that of the State of Jefferson. In 1941 a group of unsatisfied citizens along the southern Oregon and northern California border started a movement to create their own state, the State of Jefferson. The movement reached its peak in November of 1941 when an armed group stopped all traffic along U.S. Route 99 to distribute the group's Proclamation of Independence. These "Jeffersonians" pledged to stop traffic every Thursday there after until they were officially recognized. The movement came to an abrupt halt in December of 1941 with the bombing of Pearl Harbor. Efforts of all citizens went into the war effort. Today, the State of Jefferson is merely a state of mind.

At present, the California Department of Food and Agriculture (CDFA) has six designated weed districts across the state. Each District has a biologist that is responsible for A-rated noxious weed survey and eradication. A-rated noxious weeds are typically small, incipient populations and therefore are worked toward complete eradication. To this end, State Food and Agriculture Biologists work with County Agricultural Commissioner's Offices, Pest Boards, local Weed Management Area groups, as well ranchers and homeowners.

A large percentage of all A-rated noxious weeds are found in the State of Jefferson. The more typical central and southern California weeds such as: Arundo, pampas grass, sesbania and brooms are not found in the far north. A host of more obscure A-rated weeds that are found in the far north include:

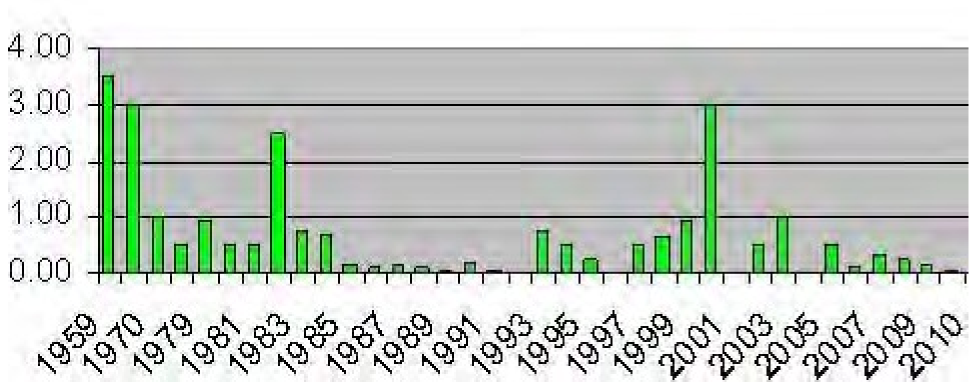
- **Scotch thistle** (*Onopordum acanthium*)
- **Taurian thistle** (*Onopordum tauricum*)
- **Musk thistle** (*Carduus nutans*)
- **Plumeless thistle** (*Carduus acanthoides*)
- **Perennial sowthistle** (*Sonchus arvensis*)
- **Smooth (long-leaf) groundcherry** (*Physalis longifolia*)
- **Yellowspine thistle** (*Cirsium ochrocentrum*)
- **Knapweeds** [spotted (*Centaurea maculosa*), squarrose (*C. squarrosa*), diffuse (*C. diffusa*), and meadow (*C. X moncktonii*)]
- **Dalmatian toadflax** (*Linaria genistifolia*)
- **Leafy spurge** (*Euphorbia esula*)

Fig 1. Musk thistle, Taurian thistle, Scotch thistle, Meadow knapweed, and Leafy spurge.

In Modoc and Lassen Counties, yellow starthistle is not widespread and therefore worked toward eradication. Perennial pepperweed is another weed that is still worked toward eradication in the State of Jefferson (currently only 2 populations exist in Susanville and Tule Lake).

Siskiyou County lies in the heart of the State of Jefferson. The County Agricultural Commissioner's Office maintains a data-set of weed acres treated (net acres) and weed acres worked (gross acres) that dates back to 1959. This data-set tells the story and exemplifies the weed wars and woes of an A-rated weed eradication program. Decades of data records for smooth groundcherry and taurian thistle show long stretches of no weeds found, a statewide eradication success story. However, on several occasions from 1959 to present, historic sites were disturbed and long-lived seed banks resulted in resurgence of these A-rated weed sites. The Siskiyou data-set establishes the importance of annual surveys when battling such long-lived seed producers, as is the case with most A-rated noxious weeds.

Figure 1. Taurian Thistle Acres Treated



Prevention is the key and therefore annual survey and detection is a high priority. Once weeds are established however the tool box for A-rated weed control in the far north is fairly simple. Herbicides include: Milestone, Transline, Telar, 2,4-D, and Perspective (Perspective or aminocyclopyrachlor has been used experimentally to date; registration expected in 2011). Milestone has become a great tool particularly in thistle and knapweed control. Milestone has been shown under high-desert conditions to provide season-long control and in some cases, control into the next season. Higher rates of Milestone can be hard on desirable grass species and therefore Transline is still a valuable tool. Telar remains the preferred tool for mustards, namely perennial pepperweed. Telar has also proven effective on thistles later in the season when thistles have already bolted and started branching out; seed development virtually stops upon application. Telar and 2,4-D are the preferred mix mid-to late summer on the tough A-rated noxious weeds like Scotch thistle.

Revegetation with Native Grasses, Sedges, Rushes, and Forbs
Competition and Control of Weeds, Soil Stabilization, and Enhancement of Biodiversity

John H. Anderson, DVM. janderson@hedgerowfarms.com
Elizabeth K. Goebel egoebel@hedgerowfarms.com
Hedgerow Farms, 21740 County Road 88, Winters, CA 95694
www.hedgerowfarms.com

Weeds impact thousands of acres of managed landscapes. These landscapes include:

- transportation corridors such as roadsides and highway interchanges
- drainage systems including ditches, swales, and sloughs
- storm water retention basins
- stream and rivers banks
- levees
- irrigation canals and reservoirs
- farmland edges and non-farmed corners
- parks and open space
- constructed wetlands and wildlife refuges

Management techniques used on these landscapes include tillage, herbicides, intensive mowing, burning, and in many instances an attempt to keep the ground free of vegetation. Left unmanaged, a huge number of exotic non-native weeds become established in a short period of time. Many miles of storm water sloughs and swales are now dominated with some of the worst weeds that have infiltrated California. These include perennial pepper weed, Johnson grass, and yellow star thistle and hundreds more.

When ground is kept bare, usually with herbicides, problems include soil erosion and the required continuous spraying. Bare ground also eliminates potential wildlife habitat for a wide variety of birds, reptiles, amphibians, small mammals, beneficial insects (including pollinators) and a host of others. The emergence of herbicide resistant weeds is another increasingly common problem.

Over the past 30 years we have been testing and implementing vegetation practices using California native plants on many of the areas listed above. After initially recognizing and using the weed-eliminating feature of some of the exotic perennial grasses (i.e. tall wheat grass, perla grass, berber orchard grass) we began exploring the potential of native perennial plants in our habitat restoration programs. Over the years we have identified a multitude of native perennials and annuals that, once established, provide excellent cover and wildlife habitat while suppressing and eliminating weeds. Most of the species are adapted to the Mediterranean climate of California and require no water during our dry season in late spring and summer.

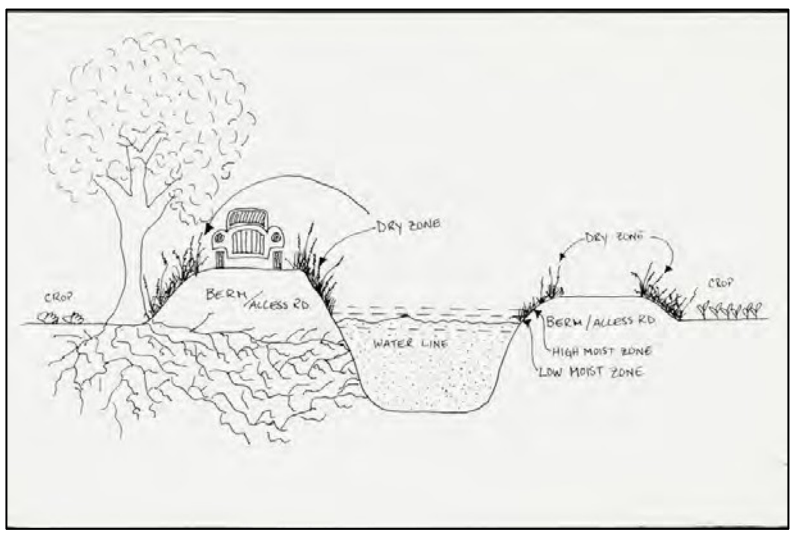
In addition, the ecosystem services they provide include:

- soil stabilization and erosion control
- enhanced water infiltration facilitated by extensive root systems that may go as deep as 6-8 feet or more
- bio-remediation of pollutants and pathogens
- carbon sequestration
- diverse habitat for many wildlife species

Over the past 10 years many of these plant species have become readily available either as seed or transplants. Now there are over 30 species of native grasses, 11 species of sedges and rushes, 40 species of forbs including many perennials available. There is also increased emphasis on using bioregional ecotypes in many projects, and origin-known seed and plants are more widely available. Included here (see end of document) is a list of the most commonly used species. For plant descriptions, see the USDA Plants Database (plants.usda.gov) or CalFlora (www.calflora.org). Information on what to use where and seed mixes can be found on some of the seed supplier web sites and on the California Native Plant Link Exchange (CNPLX) web site (cnplx.info). CNPLX also has a searchable database showing which seed companies and nurseries carry which species.

There are many implementation techniques that are beyond the scope of this manuscript. Re-vegetation sites vary considerably. A list of the practices that need to be considered include:

- tillage
- initial weed control
- seeding
    - hydroseeding
    - broadcast seeding
    - drill seeding
    - imprint seeding
- transplanting
    - plug planting
    - native sod
- follow-up management
    - herbicides
        - post emergent
        - pre-emergent
    - mowing and swathing
    - grazing



Pre-seeding tillage can be very important, especially on heavily compacted sites. Initial weed control and continued weed control during early establishment is very important. Exotic weedy species can rapidly overwhelm and eliminate slow growing native seedlings; these native perennials may take up to 3 or 4 years to become well established and provide weed control function.

While these vegetation practices are generally recognized as the right thing to do, they are only practiced on a very small percentage of the landscape. Pest Control Advisors could play a valuable role in recognizing where to establish native plant corridors and marketing the concept for the entities that can provide the design and implementation expertise.

Information on restoration and revegetation, as well as training workshops offered, are available from: the California Native Grasslands Association (www.CNGA.org), The California Society for Ecological Restoration (www.SERCAL.org), California Invasive Plant Council (www.CalIPC.org) and several of the Resource Conservation Districts (including the Yolo County RCD, www.yolorcd.org).

Commonly Used Species Common name (Botanical name, # of ecotypes available from Hedgerow Farms)

Grasses

Bentgrass (*Agrostis exarata*, 1)
Blue wildrye (*Elymus glaucus*, 12)
California barley (*Hordeum brachyantherum californicum*, 2)
California brome (*Bromus carinatus*, 3)
California Oniongrass (*Melica californica*, 5)
Creeping wildrye (*Leymus triticoides*, 5)
Deergrass (*Muhlenbergia rigens*, 1)
Foothill needlegrass (*Nassella lepida*, 3)
Idaho fescue (*Festuca idahoensis*, 1)
Meadow barley (*Hordeum brachyantherum*, 7)
Molate fescue (*Festuca rubra molate*, 1)
Nodding needlegrass (*Nassella cernua*, 6)
One sided bluegrass (*Poa secunda secunda*, 3)
Purple needlegrass (*Nassella pulchra*, 17)
Slender hairgrass (*Deschampsia elongata*, 1)
Slender wheatgrass (*Elymus trachycaulus*, 4)
Small fescue (*Vulpia microstachys*, 2)
Squirrel tail (*Elymus multisetus*, 2)

Sedges and Rushes

Baltic rush (*Juncus balticus*, 1)
Bulrush (*Scirpus americanu*, 0)
Common rush (*Juncus effusus*, 1)
Fox sedge (*Carex vulpinoidea*, 1)
Grey rush (*Juncus patens*, 2)
Santa Barbara sedge (*Carex barberae*, 1)
Slender sedge (*Carex praegracilis*, 3)
Spike rush (*Eleocharis macrostachya*, 1)
Torrent sedge (*Carex nudata*, 1)

Forbs

Bolander's sunflower (*Helianthus bolanderi*, 2)
California phacelia (*Phacelia californica*, 1)
California poppy (*Eschscholzia californica*, 1)
Common madia (*Madia elegans*, 1)
Gum plant (*Grindelia camporum*, 4)
Lupine species (*Lupinus*, 6 species carried each with 1 or 2 ecotypes)
Milkweed (*Asclepias fascicularis*, 1)
Mugwort (*Artemesia douglasiana*, 1)
Spanish clover (*Lotus purshianus*, 1)
Tomcat clover (*Trifolium willdenovii*, 1)
Turkey mullein (*Croton setigerus*, 2)
Vinegarweed (*Trichostema lanceolatum*, 1)

Herbicide Use Constraints in Vegetable Crops

Raymond A. Ratto Jr., Ratto Bros. Inc, 6312 Beckwith Rd, Modesto, CA
Email: rrattojr@RattoBros.com

Production. Ratto Bros is a vertically integrated large scale vegetable and watermelon farming operation with 40 different crops. Planting takes place continuously and an average of three to four crops per year are grown on the same parcel of ground. Weed control is essential in most vegetable crops due to their poor competitive ability with weeds and because weeds can be hosts of insect pests and pathogens affecting the crops.

Weed Management. Weed management is a challenge due to lack of registered herbicides for specialty vegetables. Kerb (pronamide) is an important component of weed control in leafy vegetables and current re-registration and potential loss of its availability is a big concern. For many vegetable crops only one herbicide is available and efficacy is poor (Table 1). Often times hand weeding is done with expenses up to $1000/acre.

Table 1. Herbicide use for specialty vegetable crops

Vegetable crop	**Herbicide availability**	**Comments**
Basil	Devrinol	Poor broadleaf control
Table Beets	Betanex, Dual Magnum	
Celeriac	None	
Daikon	Prefar, Dual Magnum	
Dandelion	Prefar	
Baby Dill	Prometryn	
Leeks	Dacthal	Potential residue issues
Lettuce	Prefar	
Parsley	Prometryn	

In the absence of effective herbicide programs for most crops, Vapam (metam sodium) fumigation has become a primary tool in weed control. After soil pre-irrigation (essential for good fumigant distribution) Vapam can be applied through the bedmulcher, blade, drench, drip, and deep shank chisel. However, restrictions on fumigant use such as increases in buffer zones, administrative requirements (preparation of management and emergency response plans) and applicator training make Vapam use difficult and costly.

IR-4 (minor use crops) Program is an important mechanism of securing herbicides for specialty vegetables and Ratto Bros. have been actively participating in it by conducting field efficacy trials. This helped the establishment of SLN (Special Local Needs) label for Dual Magnum (*S*-metolachlor) for root and tuber crops subgroups. IR-s program is especially important fit to California, since the greatest variety of minor crops is grown in the state, which produces more than 50% of the total specialty crops in the US.

About 30% of requests for IR-4 result in label development and herbicide availability (when registrant adds the material to existing labels). Table 2 provides an overview of herbicides that became available via IR-4 process from 2005 to 2010.

Table 2. Herbicides approved for minor crop use via IR-4 program, 2005-2010.

Herbicide	**Crop**
2,4-D *(Weedar 64)*	Wild rice
Clethodim *(Select Max)*	Asparagus, Bushberry subgroup 13-07B, Caneberry subgroup 13-07A, flax, globe artichoke, herb subgroup, leafy green subgroup, legume vegetable group, peach, safflower
Clopyralid *(Stinger)*	Bushberry subgroup 13-07B,Swiss chard, annual strawberry (FL)
Clorimuron-ethyl *(Classic Herbicide)*	Berry, low growing, except strawberry, subgroup 13-07H
Desmedipham *(Betanex)*	Garden beet (roots and tops), sweet corn, spinach
Dicamba *(WeedMaster)*	Sweet corn
Dichlobenil *(Casoron)*	Bushberry subgroup, caneberry subgroup, rhubarb
Dimethenamid-p *(Outlook)*	Grasses (seed), green onion, leek, pumpkin, radish, rutabaga, shallot (fresh leaves), turnip (roots and tops greens), Welsh onion, winter squash
Diuron *(Karmex)*	Mint, Prickly per cactus
Endothall *(Aquathol, Hydrotholl)*	Root and tuber vegetables group 1, Leaves of root and tuber; Bulb vegetables, Leafy vegetable (except Brassica), Legume vegetable, Fruiting vegetables, Cucurbit vegetables, Citrus fruits, Pome fruits, Stone fruits, Berry and small fruit group; Tree nuts group, Cereals grains group, Forage, fodder, and straw of cereal grains group, Grass, forage, fodder, and hay group, Non-grass, animal feed, group, grape, mint and rice
Ethalfluralin *(Curbit EC)*	Dill, mustard, potato, rapeseed
Ethofumesate *(Nortron)*	Carrot (PNW), garden beet, dry bulb onion, garlic, shallot (bulb and fresh leaves)
Fluroxypyr *(Starane)*	Dry bulb onion, millet, Pome fruit group
Fomesafen *(Reflex)*	Dry bean, snap bean
Flumioxazin *(Valor, Chateau)*	Asparagus, Bushberry subgroup, Cucurbit vegetable group, dry bean, Fruiting vegetable group, Leaf Petioles subgroup 4B, Melon subgroup, okra, strawberry, Tree nuts group

Herbicide	Crop
Foramsulfuron *(Equip, Tribute)*	Pop corn, sweet corn
Glyphosate *(Roundup)*	Dry pea, Indian mulberry, Legume vegetable group, safflower, sunflower
Halosulfuron-methyl *(Sandea)*	Apple, Bushberry subgroup 13-07B, Dried shelled pea and bean (except soybean) subgroup 6C, Succulent shelled pea and bean subgroup 6,Tuberous and corm vegetable subgroup 1c, okra, rhubarb
Lactofen *(Cobra)*	Fruiting vegetable group 8, okra
Linuron *(Lorox)*	Celeriac, rhubarb
MCPB *(Thistrol)*	Mint
Paraquat *(Gramoxone Inteon)*	Cucurbit Vegetable Group, dry bulb onion, ginger, okra
Phenmedipham *(Spin-AID)*	Spinach
Pendimethalin *(Prowl H2O)*	Artichoke, asparagus, Carrot, Citrus fruit Group, Fruiting vegetable group, Head and stem Brassica subgroup, grape, grasses (time-limited tolerance), green onion, juneberry, leek, mint, olive, Pome fruit group, pomegranate, shallot (fresh leaves), strawberry (perennial),Tree nut Group, pistachio, Welsh onion
Prometryn *(Caparol 4L)*	Carrot, celeriac, cilantro, coriander, Leaf petioles subgroup 4B, okra, parsley
Pronamide *(Kerb)*	Belgian endive, Berry group chicory, dandelion
Sethoxydim *(Poast)*	Borage, buckwheat, crambe, cuphea, echium, dill, gold of pleasure, hare’s ear mustard, lesquerella, lunaria, meadowfoam, milkweed, mustard, okra, oil radish, poppy, sweet rocket, turnip greens, Root and tuber vegetable group 1.
S-metolachlor *(Dual Magnum)*	Bushberry subgroup 13-07B, Caneberry subgroup 13-07A, carrot, cucumber, Fruiting vegetables group 8, Head and Stem Brassica subgroup 5A, Leaf Petioles subgroup 4B, Leafy Brassica Greens subgroup 5B, Lowbush blueberry, Melon subgroup 9A, Onion bulb subgroup 3-07A, and Onion Green subgroup 3-07B, pumpkin, okra, Root vegetables (except sugar beet) subgroup 1B, Sesame, sweet sorghum, Tuberous and corm vegetables subgroup 1C, turnip greens, winter squash
Terbacil *(Sibar)*	Watermelon
Thifensulfuron-methyl *(Harnony)*	Safflower
Tribenuron-methyl *(Ally, Canopy)*	Sunflower

Requirements for
Section 18 & 24(C) Registrations for Herbicides in Vegetable Crops

Anne Downs, Senior Registration Specialist, Wilbur Ellis Company
841 W. Elkhorn Blvd., Rio Linda, CA 95673 adowns@wilburellis.com

Access to pesticides for use on minor crops may be accomplished using two different sections of law within FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act). They include Section 24(c), (aka Special Local Need) registrations and Section 18 "permits to use".

Minor use of pesticides……

- Are those for which the total US production for a crop is fewer than 300,000 acres
- Also applies to pesticide uses which do not provide sufficient economic incentive for a registrant to support initial or continuing registrations

States have authority under Section 24(c) of FIFRA to register additional uses of a federally registered pesticide based on special local needs. A Special Local Need, or SLN, means an existing or imminent pest problem, within a state, for which the State Lead Agency (DPR), has determined that an appropriate federally registered pesticide product is not sufficiently available.

Section 24(C) SLNs

- Are for distribution and use only within a particular state.
- States may consider uses such as the following as candidates for SLNs:
    1. Adding a new method or timing of application.
    2. Adding a new crop (new site).
    3. Changing the rate of application.
    4. Application in a particular soil type.
    5. New product/different formulation.
    6. The new product will enhance resistance management.
- SLNs involving use on a food crop must have an established tolerance or be exempted from the requirement for a tolerance for that crop.
- Some crops are considered non-food/non-feed sites e.g. ornamentals and most seed crops.
- Generally SLNs are prepared and submitted by grower groups.
- SLN submission requirements vary by state.

  CA DPR's SLN form may be found, on line, at the following web address:

  http://www. cdpr.ca.gov/docs/registration/regforms/sec24/24app02.pdf

The SLN applicant must provide the following information:

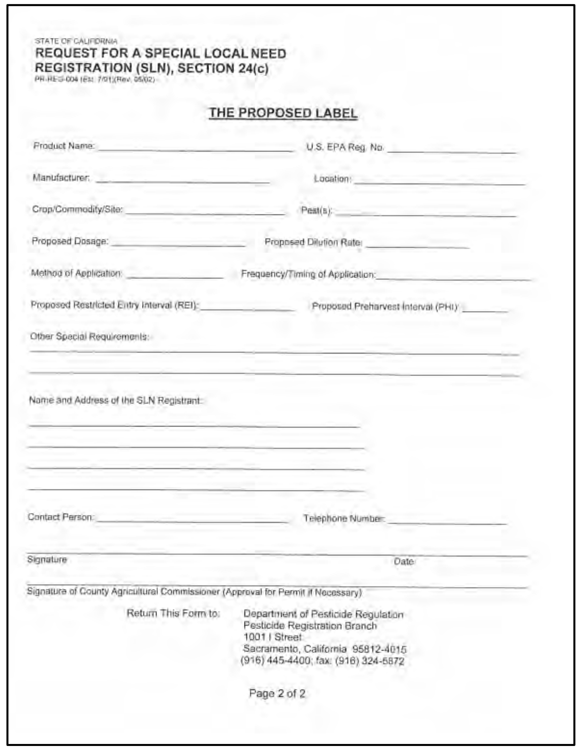
1. A complete description of the problem and submit evidence such as field data, copies of published articles, or written statements from qualified experts that a special local need exists.
2. Must list other products that are registered in California for this use and give reasons why the alternatives are not available or are not controlling the pest(s).
3. Must also report similar uses for which the product is registered.
4. Must advise whether the crop will be marketed fresh or processed and what, if any, are the anticipated hazards to bees, fish, wildlife or any non-target organisms?
5. Must estimate the total amount of acreage to be treated and whether or not a residue tolerance has been established for the food or feed crop?
6. Must submit efficacy and phytotoxicity data, as well as, a letter of authorization from the manufacturer.
7. And, finally, the applicant, in cooperation with the registrant, must develop label language.

- A state must notify EPA within 10 days of when they issue a SLN registration.
- EPA has 90 days from the date the state issued the SLN to make a final decision whether to disapprove the SLN.
- If EPA makes no objections, the SLN becomes a federal registration.
- SLN registrations remain in effect unless EPA, the State, the Registrant, or the Applicant, takes action to cancel the registration.
- Ideally, a registrant will move towards adding the SLN use to their Section 3 label as the nature of a SLN makes it vulnerable.

Common Questions

1. **Are there circumstances under which a §24(c), aka SLN, should not be issued?** Yes, if expanding the use triggers further data requirements, raises human or environmental risk concerns, etc.
2. **Can states issue SLNs which negate restrictions on §3 labels?** It depends. §24(c)s often allow new uses or new use directions which may differ from those on the §3 label. However, if the SLN provisions raise risk concerns, the use of the SLN would be inappropriate.
3. **Is offering growers a choice of products or a less hazardous formulation (to humans, NTOs, or other environmental component) an acceptable justification for a SLN registration?** Yes. This would enable pollution prevention and risk reduction as determined by the state. A clear explanation of the benefits and the data to support such a contention would be required.

4. **Can a state issue a SLN registration for the purpose of avoiding buildup of pest resistance?** Yes, however, the SLN pesticide must have a different mode of action from that already available.
5. **May a state issue a SLN registration for a use which has been voluntarily deleted?** Yes, but only if the registrant or SLN applicant submits any missing data required to register that use.
6. **Can more than one SLN registration be issued for the same use in the same state?** Yes, however, the state must ensure that the additional §24(c) registrations are necessary and adequate data have been submitted.
7. **Can a product be used up according to the SLN product label as long as it is in the possession of the user?** Yes, unless either the state or EPA has prohibited the use of the product as part of a cancellation order.


STATE OF CALIFORNIA
REQUEST FOR A SPECIAL LOCAL NEED REGISTRATION (SLN), SECTION 24(c)
PR-REG-004 (Est. 7/91)(Rev. 05/02)

THE PROPOSED LABEL

Product Name: ____________ U.S. EPA Reg. No. ____________

Manufacturer: ____________ Location: ____________

Crop/Commodity/Site: ____________ Pest(s): ____________

Proposed Dosage: ____________ Proposed Dilution Rate: ____________

Method of Application: ____________ Frequency/Timing of Application: ____________

Proposed Restricted Entry Interval (REI): ____________ Proposed Preharvest Interval (PHI): ____________

Other Special Requirements:

Name and Address of the SLN Registrant:

Contact Person: ____________ Telephone Number: ____________

Signature Date

Signature of County Agricultural Commissioner (Approval for Permit if Necessary)

Return This Form to: Department of Pesticide Regulation
Pesticide Registration Branch
1001 I Street
Sacramento, California 95812-4015
(916) 445-4400; fax: (916) 324-5872

Page 2 of 2

<u>Section 18 (Permit to Use)</u>

States may also request that EPA allow use of an unregistered active ingredient, or an additional use for a registered pesticide, to respond to emergency conditions, under Section 18 of FIFRA.

- Section 18 of FIFRA, authorizes EPA to allow an unregistered use of a pesticide for a limited time if EPA determines that an emergency conditions exists.
- An “emergency condition” is an urgent, non-routine situation that requires the use of a pesticide.

Four Types of Section 18s

1. Specific
2. Quarantine
3. Public Health
4. Crisis

Requests are made for pesticides needed for pest problems that impact production of agricultural goods when there are no alternatives for controlling the pest.

- Specific or Public Health Exemptions may only be issued for a year.
- Quarantine exemptions may be issued for no more than three years.

EPA generally takes approximately 60 days, from date of receipt, to make a decision regarding a Section 18 request. If the emergency is determined to be valid and the risks are acceptable, EPA approves the request.

- The majority of requests that EPA receives are for Specific Exemptions. Most Specific Exemptions involve the treatment of agricultural goods and EPA will, therefore, establish a formal tolerance (or maximum allowable residue level) for that active ingredient on that crop.
- Current Section 18's may be found at the following link on the EPA website: http://cfpub1.epa.gov/oppref/section18/search.cfm

In 2006, EPA published a final rule that revised the regulations governing emergency exemptions. They included:

1. A streamlining of the recertification application.
2. A redefinition of what constitutes significant economic loss and revision of data requirements for documenting the loss.

Components of a Section 18

Description of the Proposed Use including:

- Method and rate of application
- Maximum number of applications
- Total acreage to be planted and treated
- Use season
- Date first and last application needed
- PHI
- REI
- Earliest harvest date
- Any additional precautions, requirements, etc.
- Address registered alternative pesticides and alternative control practices.
- Include efficacy data which should include statistical data on comparative California registered products. The data should also compare the California registered products to the proposed product. Effects on crop yield and quality should be documented.
- A letter of authorization from the registrant must also be included.
- Address registered alternative pesticides and alternative control practices.
- Include efficacy data which should include statistical data on comparative California registered products. The data should also compare the California registered products to the proposed product. Effects on crop yield and quality should be documented.
- A letter of authorization from the registrant must also be included.

COMPARISON between SECTION 24(C) and SECTION 18

Section 24(c) aka SLN	**Section 18**
Applicant: Any person or group	Applicant: Must be a third party such as grower group, county, university, etc. (cannot be the registrant)
2 Types: First Party (the manufacturer) or Third Party (other than manufacturer)	4 Types: Specific Crisis Quarantine Public Health
Tolerance or Exemption from tolerance already established	No tolerance established.
Justification and lack of alternatives must be documented	Emergency, non-routine situation must be well- documented. Economics and lack of suitable alternatives must be verified
Data Needed Includes….. Residue Efficacy Phytotoxicity	Data Needed Includes….. Residue Efficacy Phytotoxicity Economic
Letter of Authorization from Registrant	Letter of Authorization from Registrant
Post for Public Comment is Required	Post for Public Comment is not Required
Issued generally without an expiration date	When issued, always includes an expiration date. Use period cannot exceed a 12 month period
Fees: - Must pay USEPA maintenance fees on an annual basis. - No DPR fees	Fees: None to either USEPA nor DPR

Weeds as Hosts (and Non-Hosts) of Vegetable Pathogens

Steven T. Koike, University of California Cooperative Extension, Monterey County
1432 Abbott Street, Salinas CA 93901   Email: stkoike@ucdavis.edu

Introduction

It is well known that weeds (defined here as non-crop plants) can be an important part in the epidemiology of vegetable diseases. Weeds can play the following roles: reservoirs or initial inoculum sources of the pathogens; means of pathogen survival between crops; reservoir or source of the pathogen vectors; possible mechanism for effecting genetic change and variation in the pathogen. Weeds perhaps are most noted as playing a part in virus diseases of vegetables but can also be important in several fungal and bacterial problems as well. In recent years there have been some important vegetable crop disease outbreaks that include a weed component in the disease epidemiology.

Case studies: recent vegetable disease/weed host interactions in coastal California

Impatiens necrotic spot virus (INSV) in lettuce. Historically and worldwide, INSV never was found to infect lettuce. However, beginning in 2006 and continuing through 2010, significant and damaging cases of INSV were experienced on numerous romaine, greenleaf, redleaf, butter, and iceberg plantings in Monterey and San Benito counties. Researchers wondered why INSV, which had been present in coastal counties for many years on horticultural crops and landscape plants, would now infect lettuce and cause such significant losses. Hypotheses about a novel INSV strain were discounted when molecular evidence indicated that the coastal INSV outbreaks are caused by a typical strain of INSV that does not differ significantly from ornamental INSV strains. A two-year survey indicated that the vast majority of thrips present in diseased lettuce fields are western flower thrips (*Frankliniella occidentalis*), showing that the vector is the usual and expected species. The source of virus inoculum also remained a mystery as field surveys conducted in 2007 and 2008 failed to find a widespread weed or alternate host candidate that could act as a reservoir of INSV. However, the summer 2009 and winter 2010 surveys revealed that cheeseweed (*Malva parviflora*) and shepherd's purse (*Capsella bursa-pastoris*) weeds were widely infected; such weeds were collected on and around ranches having a history of INSV outbreaks. At two lettuce-producing sites having chronic INSV problems, INSV-positive cheeseweed was readily found in vineyards adjacent to and upwind from the lettuce plots. It is notable that infected weeds appear symptomless and therefore do not give visual indications of being reservoirs of INSV.

Apium virus Y (ApVY) in celery. Starting in 2007 and continuing through 2010, striking disease symptoms were detected on celery grown in various locations in Santa Clara and Monterey counties. Affected plants could show extensive yellowing and deformity of the leaves, as well as distinct, large brown to tan lesions on the petioles. Such petiole lesions prevented the celery from being marketable and resulted in direct crop loss. The new disease was caused by *Apium virus Y* (ApVY), a virus not reported previously on celery in California. The virus appears to be host specific to plants in the Apiaceae. Because the virus was proven to not be carried in celery seed, attention was focused on finding alternative Apiaceae hosts as sources of viral inoculum. An extensive survey showed that poison hemlock weed in Monterey and Santa Clara counties was commonly infected (64%) with ApVY. Anise weed (only four collected) was negative. Positive poison hemlock was also found in Santa Cruz and Ventura counties; ApVY-infected parsley was later confirmed in Ventura County. The widespread infection of poison hemlock was an important finding and demonstrates that this weed can be a significant reservoir host for ApVY. Management of ApVY in celery likely depends on control of poison hemlock and the aphids that vector the virus.

When a weed host is not a "host"

Understanding the diagnostic process and disease epidemiology in crop/weed dynamics relies on knowing which diseases affect crops and weeds. Two valuable sources of this knowledge are host range and pathogen lists. On a host range list, for any particular pathogen there is listed all the plants that are known to be susceptible to that pathogen. On a pathogen list, for any particular plant there is listed all the pathogens that are known to cause disease on that plant. These lists are found in books, journals, other printed publications, and on-line sources. While host range and pathogen lists are essential tools, such lists also have their limitations. For example, white rust (*Albugo candida*) of crucifers and downy mildew (*Peronospora farinosa*) of chenopodium plants are two diseases listed as affecting a number of crop and weed species. However, the crops and weeds are actually infected by different races, so the race colonizing a weed will not infect crops. Therefore, one needs to evaluate and use such lists carefully.

Diagnostic implications

1. The infected weed host of a pathogen (especially pertaining to viruses) may be symptomless. Therefore, surveys and studies should account for this possibility.
2. Mis-diagnosis of virus pathogens can readily occur. Therefore, reliance on symptoms is not recommended. More robust diagnostic methods (ELISA, PCR) are required.
3. Host range lists should be used carefully. If crop and weed species are listed as hosts of the same pathogen, one must define "same." The existence of races and strains means that any one particular pathogen may not cross infect both the crop and the weed.

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Update on Chemical and Precision Weed Control Tools in Leafy Green Vegetables

Richard Smith, University of California Cooperative Extension, Monterey County
1432 Abbott Street, Salinas, CA 93901 Email: rifsmith@ucdavis.edu

INTRODUCTION

The central coast of California is a key area for production of leafy green vegetables such as lettuces, brassica crops, spinach, cilantro and many others. Weed control in these crops is achieved by a combination of cultural, mechanical and chemical control methods. There are nearly no new herbicides in the development pipeline for these crops, and as a result, many of these crops are dependent on old chemistries to provide effective preemergent weed control (Table 1). However, recent experience has indicated that reliance on old chemistries is not without risk. For instance, Kerb was removed from the market in 2009 for leaf lettuce, the number one lettuce type in Monterey County, and is not expected to return to the market until 2012-13 (Fennimore and Smith, 2009). In addition, RoNeet, the key preemergent herbicide for use on spinach was recently off the market, but fortunately has been returned. In addition to the loss of registered herbicides, there have been issues with new registrations of old herbicides. For instance, Dual Magnum was registered for use on spinach, but the registration has a preharvest interval and plant back restrictions that severely restrict its use on the majority of spinach acreage in California (Smith and Fennimore, 2009). And finally, the registration of prometryn for use on cilantro has been at the EPA awaiting clearance for over 10 years. All of these examples illustrate the challenges to providing useful herbicides to the leafy green vegetable industry.

Table 1. Year of registration of key leafy green vegetable herbicides.

Trade Name	Chemical	Representative Crop	Year Registered
Kerb	Pronamide	Lettuce	1972
Dacthal	DCPA	Broccoli	1958
Caparol	Prometryn	Celery	1964
Dual Magnum	S-metolachlor	Spinach	1976
Devrinol	Napropamide	Broccoli	1972

Adapted from Fennimore and Doohan, 2008

To further complicate the situation, the leafy green industry has changed by the transition to high-density 80 inch wide beds for the production of baby lettuces, spinach and cilantro; this has nearly eliminated the ability to effectively cultivate the beds (Smith et al, 2006). As a result, of these challenges, growers have had to place greater emphasis on basic cultural practices such as preirrigation followed by shallow cultivation to kill the initial weed flush in the production cycle and implement weed sanitation programs (e.g. removal of weeds from fields to reduce the weed seedbank). These practices are helpful, but have limits in their ability to provide excellent weed control. For instance, in 2010 growers faced the first year without the availability of Kerb in the spring when shepherd's purse and nettle are particularly problematic weeds. In general, there were higher weeding costs in fields impacted by these weeds because the alternative preemergence herbicides available for use on leaf lettuce do not control these weeds. Increased weeding costs varied from greatly, but in some cases were as much as $400 more than normal costs (personal communication from various Monterey County growers).

Lettuce in Monterey County is predominantly direct seeded (>95%). However, the use of transplants provides opportunities to better control weeds. Prowl H2O and Dual Magnum are both in the registration process for use on transplanted lettuce. When these materials are approved growers will have an option to deal effectively with fields with high weed pressure. However, there are two key problems with the use of transplants in lettuce production that limit their use: 1) transplants cost over $200 more per acre to produce than direct seeded lettuce, and 2) there are issues with post harvest longevity of transplanted lettuce. It will be interesting to see how growers weigh the negative aspects of the use of transplants with the positive weed control that can be achieved.

Robotic weed control technology, for example the Tillet Cultivator, is now available from Garford Corporation in England (http://garford.com/). The cultivator operates best where the crop is larger than the weeds, such as in transplanted crops. It is guided by a camera that looks down on the seedline and looks for green plants; a computer analyzes the images and directs spinning blades to cultivate between crop plants (Figure 1). This technology does not eliminate the need for hand labor but is capable of reducing the weeding time of subsequent hand weeding operations (Table 2). As technology improves in the future, it is expected that this technology will also improve in efficiency and efficacy.

Figure 1. Tillet cultivator. Note blade on the right is elevated to show the pie shaped design that allows the blade to spin around the crop plant as it travels down the seedline.

Table 2. Weeding time and yield evaluations on October 7, 2010.

Cultivation treatment	Total weeding time Aug 7&14 hr/A	Stand count Aug 7 Plant/A	Yield stand count Oct 7 Plant/A	Yield mean head Oct 7 lbs/head	Yield total Oct 7 tons/A
Standard	15.3	31,245	29,628	0.84	12.4
Tillet	11.6	30,721	29,119	0.88	12.7
Pr>F treat	<0.001	0.318	0.278	0.448	0.657
Pr>F block	0.156	0.221	0.073	0.251	0.447
LSD 0.05	**1.3**	**NS**	**NS**	**NS**	**NS**

CONCLUSIONS

Weed control in leafy green vegetables is as challenge. Using a combination of cultural, mechanical and chemical weed control strategies can provide acceptable weed control. It is critical to maintain curre ble weed control in an econo

Figure 2. Finger Weeder from Kress Co., Germany

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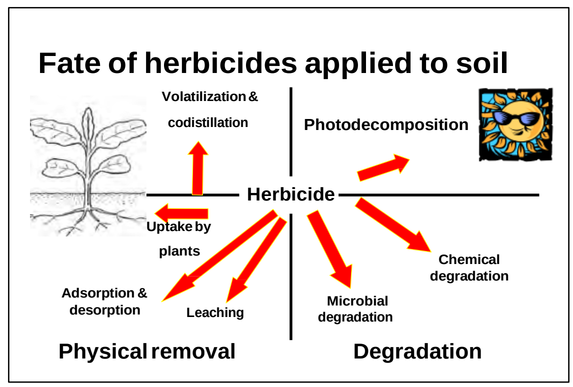
Herbicide Carryover in Vegetables

Steven A. Fennimore, U.C. Davis, 1636 E. Alisal St., Salinas, CA 93905
safennimore@ucdavis.edu

Summary. Vegetable crops are often sensitive to the presence of herbicide residues in the soil. Because of the intensive cropping system here in California, two or more vegetable crops can be grown on the same field in a given 12 month period. Some herbicides are more likely to persist than others and injure a rotational crop. Similarly, some crops are more sensitive to herbicide residues in the soil than other crops. Many of the California direct-seeded vegetable crops such as lettuce and spinach are among the most sensitive of any crops, and so special care must be taken with these and other crops. In this presentation we will examine the potential for several common vegetable herbicides to carryover, and steps that can be taken to minimize herbicide persistence such as applying herbicides in band applications.

Principal vegetable herbicides and crops. The most common vegetable herbicides used in California are Balan, Caparol, Dacthal, Devrinol, GoalTender, Kerb, Lorox, metam sodium, Poast, Prefar, Roundup, Ro-Neet, Sandea, Select Max and Treflan. Vegetable crops considered here are beans (snap), carrot, celery, cole crops, cucurbits, lettuce, onion, pepper, spinach, and tomato (fresh and processing).



Herbicide carryover and loss of herbicides. Ideally we apply an herbicide at the time of vegetable planting, and by the time of harvest the herbicide residues in the soil are gone so that we can rotate to any crop we chose. Unfortunately, not all herbicides degrade this rapidly and many rotational crops are very sensitive to the persistence of some herbicides. There are many means by which herbicides degrade in the soil, and degradation varies by herbicide chemistry. Principle means of herbicide loss are: volatilization, photodecomposition, adsorption to the soil, leaching, microbial and chemical decomposition.

Methods to minimize herbicide carryover.

1. Apply less herbicide by applying band applications over the crop seedline;
2. Apply herbicides accurately to avoid overdosing;
3. Till the field after harvest to dilute the herbicide treated soil profile;
4. After harvest keep the field moist to enhance soil degradation by soil microbes and water;
5. Maintain the soil pH near optimum levels for the crop;
6. Select herbicides that are less persistent – if a choice is available;
7. Soil additives such as activated charcoal can help adsorb excess herbicide.

Literature citations

California Department of Pesticide Regulation. 2008. Summary of Pesticide Use Report Data 2008. Department of Pesticide Regulation, Sacramento, CA. http://www.cdpr.ca.gov/docs/pur/pur08rep/comrpt08.pdf.
Crop Data Mgmnt System. 2011. Herbicide specimen labels http://www.cdms.net/LabelsMsds/LMDefault.aspx?t=

Pesticide Label and Container Disposal Requirements

Natalia Bahena, Agricultural Inspector/Biologist
Monterey County Agricultural Commissioner

Summary:
The pesticide label states the requirements for what Personal Protective Equipment (PPE) is required in order to mix/load and apply the pesticide. PPE required by the pesticide label must be worn by all persons handling that pesticide, as well as provided by the employer. The employer shall assure employees wear gloves unless prohibited by label when required by pesticide labeling, mixing or loading, (some exceptions) and/or adjusting, cleaning or repairing contaminated equipment.

Under California Code of Regulation, Title 3 (3 CCR) Personal Protective Equipment (PPE) is Regulated through Requirements and Exceptions, such as application by hand or using hand-held equipment, however these exemptions do not apply when the applicator is applying: vertebrate pest control baits using long handled implements that avoid actual hand contact with the bait or potentially contaminated areas of equipment.

Service Containers are defined as any container, other than the original labeled container of a registered pesticide provided by the registrant, which is utilized to hold, store, or transport the pesticide or the use-dilution of the pesticide. In no case shall a pesticide be placed or kept in any container of a type commonly used for food, drink or household products.

When Pesticides are being transported on public roads, they must be labeled with the name and address of the person or firm responsible for the container, identify of the economic poison in the container and the word "Danger," "Warning," or "Caution," in accordance with the label on the original container.

Decontamination Facility provided by the employer shall assure the applicators have available sufficient water for decontamination, single-use towels, soap, and an extra set of coveralls (even if coveralls not required by label). If the label requires the applicator to wear eye protection then 1 pint of eye wash must be immediately available. For Ag uses, the decontamination site shall be at the mixing loading site and no more than ¼ mile (or nearest point of vehicular access). For Non Ag uses, the decontamination site shall be within 100 feet of the mixing/loading site, if the applicator uses pesticides with the signal word DANGER or WARNING.

In order to dispose of Pesticide Containers applicator must triple rinse the container at the use site to be able to recycle the containers at the marina Landfill. Recycling is free, all that's required is that the containers are triple rinsed, labels are removed as well as the caps.

U.S. EPA Regulatory Updates

Patti L. TenBrook, Ph.D.
U.S. EPA Region 9, 75 Hawthorne Street, San Francisco, CA 94105
Email: tenbrook.patti@epa.gov

The U.S. EPA Office of Pesticide Programs (OPP) is currently working on many pesticide registration issues. Soil fumigants have been reregistered and OPP is now working with EPA Regions and States to implement extensive new mitigations measures which will be phased in 2010 and 2011. OPP has developed a Soil Fumigant Toolbox that provides fact sheets, fumigant labels, training materials, fumigant management plan templates, and other information that will help fumigant users understand and implement the new use restrictions (http://www.epa.gov/pesticides/reregistration/soil_fumigants/).

Beginning April 9, 2011 applications of pesticides to, over, or near water will have to be permitted under the Clean Water Act National Pollutant Discharge Elimination System (NPDES) program. NPDES permits are required for discharges of pollutants from a point source to a water of the United States, and a series of court rulings has determined that certain pesticide applications will require permitting. A draft Pesticide General Permit (PGP) was issued by EPA in June 2010 and was to be finalized by December 31, 2010, but will likely be issued in January 2011. The EPA permit will cover States, Tribes, U.S. Territories that do not have NPDES permitting authority, as well as federal facilities. Applications that will be covered by the EPA PGP include mosquito and other flying insect pest control, aquatic weed and algae control, aquatic nuisance animal control, and forest canopy pest control. States with NPDES permitting authority will have to put their own permits in place by April 9, 2011. The CA State Water Resources Control Board has permits for similar categories. It is important to note that pesticides applications that are not covered by an EPA or State general permit may still need NPDES coverage, but may require an individual permit.

In November 2009, EPA issued a draft Pesticide Registration Notice (PRN 2009-X) that proposed new label language regarding pesticide drift. The draft language included the statement, "…do not apply this product in a manner that results in spray [or dust] drift that *could cause* an adverse effect…" [emphasis added]. Many commenters noted that the term "could cause" would establish a no drift standard that was not consistent with the Federal Insecticide, Fungicide, and Rodenticide Act standard of "reasonable certainty of no harm". EPA is now proposing the following language: "…do not apply this product in a manner that results in a spray [or dust] drift that *harms* people or any other non-target organisms or sites" [emphasis added].

Registration of new pesticide chemicals or new uses of existing chemicals has historically been a process without opportunities for public participation. In 2010, EPA began a program to involve the public in registration of new chemicals, registration of first food, outdoor or residential use of an existing chemical, or in other new registration actions of significant interest.

When registration packets are received, EPA publishes a notice in the Federal Register (FR) and takes comments for 30 days. EPA then proceeds with its risk assessments and other registration processes. The completed risk assessments and proposed registration decision are posted to the public docket and a 30-day comment period is opened. No FR notice is issued when the proposed decision is posted. New registrations can be tracked at http://cfpub.epa.gov/pesticides/comments.cfm, or interested parties can subscribe to EPA Pesticide Updates at http://www.epa.gov/oppfead1/cb/csb_page/form/form.html. A final registration decision is announced in the Federal Register.

The Office of Pesticide Programs has also been working on many other issues including disclosure of inert ingredients, risk assessment for volatile and semi-volatile chemicals, and pollinator protection. The EPA Office of Water and OPP are working to develop a common approach to assessment of pesticide effects on aquatic life. If you have questions about any of these topics, please contact me.

Crop Protection Industry Assessment of EPA Spray Drift PRN and Calculation of spray drift buffers using FIFRA methodology

M.F. Leggett[1], Mark Ledson[2], Scott Jackson[3]
[1]CropLife America, [2] Syngenta, [3] BASF

Spray drift is pesticide droplet and particle movement that occurs during the initial application resulting in deposition onto non-target sites. This presentation reviewed spray drift policy, current practice in risk assessment of non-target plants exposed to drift and current research to improve exposure estimates were discussed. The EPA has sought to improve the language on labels with respect to drift. A draft PR Notice introduced in 2009 included a new standard that, if adopted, would effectively hold affected stakeholders to an unachievable "zero drift" policy.

The regulated industry opposes the proposed rule since it; undermines FIFRA, places an unreasonable burden on applicators, results in unpredictable liability, and establishes unattainable goals.

The EPA and state pesticide policies have long acknowledged that small levels of pesticide drift is unavoidable and, when used according to the product's label, does not pose a risk of 'unreasonable adverse effects' to humans or the environment. EPA's risk assessment and registration process include spray drift considerations, and label requirements include drift reduction considerations. These considerations are based on estimates of potential exposure from drift and hazard evaluation of the chemical being applied. The potential exposure from drift is estimated using models. Stakeholders are currently sponsoring research to improve model estimates so that they more accurately reflect potential for drift with consideration of available technology.

U.S. EPA Re-registration Eligibility Decision of Fumigants Pertaining to California Uses

Kevin J. Solari, Senior Environmental Scientist
California Department of Pesticide Regulation, Worker Health and Safety Branch

This presentation is an overview of new changes that apply to the use of soil-applied fumigants in California. The changes apply to fumigants that contain Metam sodium, Metam potassium and Dazomet (all Methyl Isothiocyanate-MITC producers), Methyl bromide, Chloropicrin and Methyl iodide. These changes have been implemented because of recent label revisions made by the U.S. EPA and by California Department of Pesticide Regulation (DPR) regulations, restricted material permit conditions and California only mitigation strategies.

USEPA is making these label changes to help better protect workers and bystanders while maintaining key use benefits of these fumigants across the country. Results stemming from USEPA's comprehensive re-evaluation (the RED) of these fumigants largely determined how exposure risk is mitigated through each fumigant label. USEPA labeling changes for each of the aforementioned soil-applied fumigants is being carried out in two phases. The first phase was implemented as of December 31, 2010 and effects new labeling for 2011. The second phase is currently being developed by USEPA and the states and is proposed to be implemented sometime in late 2011 or in 2012. Key components to mitigating risk for workers and bystanders required on the new labels include Respiratory Protection and Stop Work Triggers for handlers, Good Agricultural Practices and the Fumigant Management Plan (FMP).

California currently has registered products containing the active ingredients Metam sodium/potassium, Dazomet, Methyl bromide, Chloropicrin and Methyl iodide. USEPA label changes affect the use of all of these products. Additionally, DPR has other means available to mitigate the risks associated with exposure to these fumigants. For instance, DPR has developed templates for the FMP that are available on DPR's website (see below). DPR has also developed application method-specific recommended permit conditions for Metam sodium/potassium and Dazomet that are now available to County Agricultural Commissioners. DPR's Methyl bromide regulations have recently been revised to clarify respirator language, township cap limitations, and maximum work hour allowances for respirator use. DPR is currently in the process of developing interim and regionally-specific suggested permit conditions for Chloropicrin only soil-applied fumigants. For Methyl iodide, DPR determined that placing all California mitigation measures and conditions on a label for state use only is the best means of keeping the possibility of exposure to a minimum and within safe levels.

References:

California Fumigant Management Plan (CA FMP): http://www.cdpr.ca.gov/docs/enforce/prenffrm/prenfmnu.htm

Application method-specific recommended permit conditions for Metam sodium/potassium and Dazomet: http://www.cdpr.ca.gov/docs/county/cacltrs/penfltrs/penf2010/2010022.htm

Fumigant Resource Center: http://www.cdpr.ca.gov/docs/emon/methbrom/mb_main.htm

Respiratory Protection Regulations for Pesticides

Harvard Fong, Senior Industrial Hygienist
California Department of Pesticide Regulation, Sacramento, CA

The regulations concerning respiratory protection when using pesticides in California are found in Title 3 of the California Code of Regulations, Section 6739. The general information covered in this regulation are as follows:

(a) General Requirements of the Regulation
(b) Voluntary Use of Respiratory Protection
(c) Selection of Respirators
(d) Medical Evaluation of Employees Required to Wear Respirators
(e) Fit Testing
(f) Facepiece Seal Protection and Fitting Requirements
(g) IDLH (Immediately Dangerous to Life or Health) Environments
(h) Cleaning and Disinfecting
(i) Emergency Respirators
(j) Inspection and Repair
(k) Breathing Air Quality for Air Supplying Respirators
(l) Identification of filters, cartridges, and canisters
(m) Training of Employees Required to Wear Respirators
(n) Program Evaluation by Management
(o) End of Service Life and Change-outs for Filters and Cartridges
(p) Recordkeeping Requirements
(q) Medical Evaluation Form
(r) Voluntary Use Information Posting Form
(s) Medical Recommendation

Must develop a ***written program*** with ***worksite-specific procedures*** when respirators are necessary or required by the employer

Written programs must incorporate all of the following elements:

Respiratory Protection Program Elements

- Selection
- Medical evaluation
- Fit testing
- Proper use for routine and emergency
- Maintenance, cleaning and care
- Ensure breathing air quality
- Training in respiratory hazards (IDLH if applicable)
- Training in donning, doffing, limitations
- Program evaluation

Stipulated Injunction and Order to Protect Red-Legged Frog (and Other Recent Injunctions)

Rich Marovich, Staff Environmental Scientist, California Department of Pesticide Regulation

Three recent injunctions have invalidated registrations of certain pesticides in certain areas that are occupied or potentially occupied by federally listed species. The injunctions are outside of FIFRA and are not enforced by EPA, DPR or county agricultural commissioners, but they could expose applicators to third-party lawsuits. The injunctions pertain to California Red-Legged Frog, Salmonids (Chinook Salmon, Coho Salmon and Steelhead); and eleven Bay Area Species collectively referred to as the "Goby Eleven." The plaintiffs are anti-pesticide groups that are exploiting a technicality in the federal Endangered Species Act. The injunctions are based on alleged failure of the Environmental Protection Agency to consult with the U.S. Fish and Wildlife Service or (for salmonids) the National Marine Fisheries Service (Services). They are not based on documented harm to listed species, only the potential for harm. Almost all federally listed species were listed because of loss of habitat, some were never abundant and are naturally limited to small geographic areas. The best defense against claims of adverse effects of pesticides (or any other stressor) is a thriving local population of listed species. Informed applicators can help to protect local populations of listed species.

Older classes of pesticides, especially the organochlorines and DDT in particular caused well documented harm to federally listed species, notably Bald Eagle, Peregrine Falcon and Brown Pelican. As these pesticides were phased out the species have recovered. These cases have influenced a generation of wildlife biologists who view even relatively benign pesticides as harmful. Whereas the U.S. Fish & Wildlife Service exhibited restraint in finding jeopardy in only 1% of all non-pesticide consultations, they found jeopardy in 99% of all pesticide consultations.

The key to protection of listed species (or any other non-target species) is selective exposure. The injunctions specify absolute buffer zones regardless of site specific conditions and measures applicators can take to control exposure. Buffer zones are essential to define distances beyond which exposure is unlikely but they are misused as indiscriminant distances within which all use is prohibited.

The injunctions rely heavily on computer models that screen pesticides against worst case exposure scenarios, even in preference to field monitoring data. These models are useful to discern pesticides that pose no threat to listed species even under worst case conditions, but failure to pass this screen does not mean that a likelihood of harm exists, only that additional precautions are warranted. The EPA Endangered Species Protection Program allows for development of local plans as alternatives to default buffer zones. Local plans present an opportunity for communities to come up with alternative measures to protect listed species. When the Services accept these proposals with a "not-likely-to-adversely-affect" determination then the injunctions end as does the threat of further injunctions. A dialogue with the Services is needed to move beyond injunctions and absolute buffer zones toward more reasonable solutions. For more information, see: http://www.cdpr.ca.gov and select "Endangered species."

Surface Water Protection Concepts for Pesticides

Mark Pepple, Staff Environmental Scientist
CA Department of Pesticide Regulation, Email: mpepple@cdpr.ca.gov

The Food and Agricultural Code requires the Department of Pesticide Regulation (DPR) "To protect the environment from environmentally harmful pesticides by prohibiting, regulating, or ensuring proper stewardship of those pesticides." DPR's Environmental Monitoring Branch samples air and water to determine whether pesticide residues are moving offsite at levels of concern, and develops pesticide use mitigation practices. Sampling conducted by DPR as well as federal, state, and local agencies, private industry, and environmental groups has shown that pesticides contaminate surface water. This contamination can primarily cause toxicity to aquatic organisms, but occasionally exceeds levels protective of human health.

Based on monitoring data, DPR adopted regulations in 2007 to reduce levels of dormant insecticides in surface water. Pesticides have also been found in surface water during the growing season, as a result of both urban and rural use. As a result, DPR is now planning to adopt regulations that address both urban and rural sources of contamination by these pesticides that can occur year-round.

California's Pesticide Use Reporting (PUR)

Larry Wilhoit, Research Scientist III
California Department of Pesticide Regulation

California regulations require that all agricultural pesticide use and some non-agricultural uses be reported to the Department of Pesticide Regulation (DPR). The data are stored in the Pesticide Use Reporting (PUR) database. Since 1990, there has been an average of 2.5 million records per year in the PUR. The PUR contains two types of records: applications in production agriculture and all other uses by commercial pest control businesses, which include postharvest and non-agricultural applications. Each production agricultural record represents a single application and includes the amount and name of pesticide applied, date and location of the application, crop or site treated, area treated, acres planted, application method, grower ID, and field ID. The second type of record represents the total use of a pesticide product by a company on each site treated in each county during each month.

Each year's data is available in a summary report giving use in pounds of active ingredient (AI) and acres treated by crop and pesticide active ingredient. To get more specific or detail information there are several interactive web sites (calpip.cdpr.ca.gov/main.cfm, www.pesticideinfo.org, and www.ehib.org/page.jsp?page_key=135,). The full database is available in text format on DPR's ftp site (/pestreg.cdpr.ca.gov/pub/outgoing/pur_archives/).

The data is extensively checked for errors, but errors, of course, still exist. Two common errors are incorrect units of measure and product registration number. When doing an analysis it is important to check for possible errors, especially rates of use because even one or two big errors can have a huge effect on results. It is also important to read the documentation since some of the meaning of some the database field names are not obvious.

The PUR is used by many different individuals and organizations for a wide range of purposes. Pesticide use reports help DPR estimate dietary risk and ensure compliance with clean air laws and ground water regulations. Site-specific use report data, combined with geographic data on endangered species habitats, help County Agricultural Commissioners resolve potential pesticide use conflicts. DPR also uses the data to analyze how, when and where pesticides are used on different crops. Reduced-risk pest management alternatives can then be developed considering the different regions of the State and the commodities grown in these regions.