2007 Proceedings of the California Weed Science Society

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These Proceedings contain contributed summaries of papers presented at the annual conference; year-end financial statements; and information on new honorary members, award of excellence recipients, student poster winners, and scholarship recipients.
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The Society’s Honorary Member for 2007 is Steve Wright. The Honorary Member is the highest honor awarded by the Society, and is awarded annually to weed scientists or weed practitioners who are considered role models for the profession. Wright is a Past President of the Society, and has served faithfully many times as Session Chair and Presenter. Currently, Wright works for the University of California Cooperative Extension in Tulare and Kings County. He specializes in weed control in field crops, range, non cropland and herbicide resistance management. Wright has published numerous articles in popular and peer-reviewed journals about weed control and agronomy, and is an internationally recognized expert in weed science.
The Society awards two Awards of Excellence in 2007, one to Cheryl Wilen and the other to Barry Tickes. The Society presents this award annually to weed scientists or weed practitioners for a long track record of accomplishments in weed science and/or management.

Dr. Cheryl Wilen has served the Society for many years as Session Chair and Presenter. Currently, Dr. Wilen works at the University of California Cooperative Extension office in San Diego County but also serves Orange and Los Angeles Counties as IPM Advisor. She specializes in weed science and management in ornamental horticulture, including greenhouse, nursery, and landscape situations. She is a member of the University of California Weed Workgroup. She gives over 40 presentations each year and has published numerous popular and peer-reviewed publications about weed science and management.

Barry Tickes has also served the Society for many years as both Session Chair and Presenter. Currently, he works for the University of Arizona Cooperative Extension as Area Agricultural Agent for Yuma, La Paz, and Mohave Counties. He specializes in weed control and management in vegetable crops, small grains, and alfalfa. He has been a pioneer in developing many herbicides and weed control solutions in Arizona’s desert production areas. He gives numerous presentations each year, and has published extensively about weed science and management.
2007 CWSS Student Scholarship Winners

$2000 graduate scholarship – L. Scott Scheufele, California State University Fresno

Having grown up in an agricultural community I always knew I would find a future in agriculture. In 1992 I graduated from California State University-Fresno with a Bachelors Degree in Agricultural Business. At the recommendation of a friend I continued for one more semester to gain courses in Plant Science so I could obtain a Pest Control License (PCA). Within one or two years of employment as a research biologist at a small research company I realized I wanted and needed more education. Today, I continue to manage a small research group (consisting of four vital personnel) within the company and can operate 70 to 90 research studies a year. I have completed half of my journey to obtaining my Master’s Degree in Weed Science. With the help of my advisor, Dr. Brad Ramsdale and my thesis committee (Kurt Hembree and Dr. John Bushoven) I have complete the first phase of my thesis. The purpose of my thesis is to evaluate control of horseweed (Conyza candensis) and flaxleaf fleabane (Conyza bonariensis) with glyphosate in respect to growth stage and rate. I am currently starting the second phase of my thesis this spring and plan to graduate from CSU-Fresno Spring 2008.

$1500 graduate scholarship – Louis G. Boody, University of California Davis

I was born in Peru, grew up in San Diego, and have also lived in Canada, Bolivia, Nicaragua and Washington State, where I completed an undergraduate degree in Biology. My graduate research at UC Davis is focused on developing a model to predict the impacts of Late Watergrass infestations on yields based on early season weed counts; this model will also take into account the presence of herbicide resistant strains. I now hope to expand this line of research and to explore the effects of anoxia on seed bank dynamics as a PhD student in Agronomy and Horticulture at UCD. I look forward to producing research that will make positive contributions to the California Rice industry and California agriculture as a whole. My wife and I have two young boys and have lived in Davis since 2004.
$1000 graduate scholarship – Claudia E. Marchesi, University of California Davis

I have a MSc in Agronomy and currently I am an Agro-ecology PhD student at UC Davis. My project focuses on vegetation management from a landscape perspective: the problematic of herbicide resistant weeds (*Echinochloa* spp.) in rice cropping systems of the Sacramento Valley, CA. I am studying the origin and spread patterns of herbicide resistance weeds and the implications of different management practices in them. I am willing to continue working on vegetation management (weed prevention and control) projects as a researcher after I finish my PhD.

$1000 graduate scholarship – Paolo Sanguankeo, California State Polytechnic University San Luis Obispo

I received my undergraduate degree in Environmental Horticulture Science at Cal Poly, San Luis Obispo in 2005. I started pursuing a graduate degree in Plant Protection Science at Cal Poly, San Luis Obispo, in 2006. My thesis project involves the effects of integrated weed management in vineyards on ecosystem functions and economic viability. My study includes field and laboratory weed seed predation, field weed diversity effects on epigeal arthropods activity density, analysis of wine grape quality and yield, and economic viability of a developed integrated weed management program. I'm expecting to graduate this year in fall.

$1500 undergraduate scholarship – James M. Johnson, California State University Fresno

Throughout the last 6 years, I have become greatly interested in all aspects of plant science. This began with my involvement in FFA and has flourished throughout the years. I find great interest in the research and developments in plant physiology and pathology. I have become quite interested in research as an intern at the USDA ARS for the last 3 years. I now hope to get my degree in plant science and go to graduate school to obtain a doctorate in plant breeding and genetics.
$500 undergraduate scholarship – Earl Lavagino, California State University Fresno

I am currently a junior at California State University of Fresno, and pursuing a degree in Plant Science. I grew up in Aromas California where I would sometimes work summers on the family farm. I am currently working in affiliation with one of the professors at CSU Fresno and Monsanto looking at the effects of timed applications of Roundup on Roundup ready alfalfa. I plan to finish my degree by next fall, and obtain my Certified Crop Advisors license and Pest Control Advisors license and work in the field of either seed research or weed management.

2007 Conference Student Poster Winners

1st place $500 – Morgan A. Denzendorf

2nd place $300 – Gerardo Banuelos
THE WEED EXPO
David Haskell

Mother Nature went shopping at the Weed Expo.
She had new niches she was trying to fill.
And with all these genetically modified crops,
Starting new infestations was a real test of skill.

A growing method of organic weed control,
Had the poor lady up against the wall.
Because the native tarweeds she tried to fill in with,
Are now covered with a new shopping mall.

She checked out the Composites Pavilion.
Their booth is usually the largest at every show.
She was a firm believer in wind-blown dispersion,
With an unhardened seed that is ready to grow.

The 2006 groundsel looked good this year.
She needed a winter annual to infest dormant hay.
And with toxic alkaloids and wind-borne seed,
It was guaranteed to cause any good farmer dismay.

She walked past the Shady Solanaceae’s booth.
How can you trust their trade-show claims?
Harry and Black were peddling the same old genetics,
Riding on the shirtdails of the family name.

She was impressed with the new puncture vine.
The hardened spine could now puncture a four-ply tire.
And they added a year’s dormancy to the seed.
She could start infestations that were bound to inspire.

The “What’s New” Booth was really popular this year.
Everyone is claiming resistance to glyphosate salt.
And with a few shaky trials to back their claims,
It just a new “snake oil”, who could find them at fault.

She’s been trying to promote new native weeds,
Because the foreign invasives were getting such bad press.
Mother Nature is concerned about her public image.
She didn’t want any tabloid headlines causing her distress.

But Conyza was the talk of the Weed Expo.
Better known by its street name as “Marestail”.
Was it true resistance or just good niche work.
This annual is taking the Valley on a grand scale.

So the farmers and ranchers have to understand.
A lady can’t make a fashion statement with bare ground.
Mother Nature dresses to make an impression.
And will use any designer that leaves them spellbound.
There are three previously published weed identification books or manuals that have been widely used in California. The first was published around 1951 by W. W. Robbins, M. K. Bellue, and W.S. Ball and was entitled *Weeds of California*. A second edition of this book was published in 1970. Dr. Robbins was considered the first Weed Scientist in the United States and the Weed Science program at the University of California, Davis, is housed in a building named in his honor. In 1977, a second three-ring-binder weed guide to California was developed by the Fresno County Farm Advisor Bill Fisher, with help from June McCaskill and Dr. Art Lange. This guide, entitled *Growers’ Weed Identification Handbook* (Fisher et al. 1977) primarily covered agricultural weeds of California. Most recently, the book entitled *Weeds of the West* by Tom Whitson and other western Weed Scientists (Whitson 1996) has become widely used. All of these books cover the most common weeds of the region.

While at Cornell University, my colleagues Drs. Rick Uva, Joe Neal and I published the *Weeds of the Northeast* (Uva et al. 1997). This book provided considerable detail on the identification and biology of about 300 weeds of the northeastern United States. In early 2007, in collaboration with Evelyn Healy, we published the most comprehensive weed identification guide yet produced in California or the United States entitled *Weeds of California and Other Western States* (DiTomaso and Healy 2007). This book was modeled after the *Weeds of the Northeast*. The production and statistics associated with this book are the focus of this paper.

**Timetable and Collaborations**

In 1997, the preliminary organization of the *Weeds of California* was initiated at the California Weed Science Society (CWSS) conference in collaboration with many UC Farm Advisors, Specialists and other faculty. At this meeting we determined what weed species to include within the book. Later that summer, the CWSS Board of Directors agreed to assist in the funding of the project by providing two years of support to hire a writer (Evelyn Healy). As a result, they are officially recognized as the sponsor of both this and the first aquatic book. Initially it was felt that the book would be completed by 2001. In reality, the book took considerably more time than was estimated. In this particular case, my naivety on the time commitment was probably an advantage, as I may not have initiated the project with early knowledge that the book would not be completed until the end of 2006.

To undertake such a massive project requires a considerable amount of good fortune and many outstanding individuals to assist in the process. In the case of this book, I was extremely fortunate to be surrounded by high quality professionals. To complete this project required that all the stars line up, and I had many stars to help in the process.

The financial support by the CWSS Board was imperative to the preliminary work. Employing someone as dedicated and with the perseverance of Evelyn Healy was critical to the success of the project. Evelyn researched each group to be included in both the *Aquatic and*
Riparian Weeds of the West and Weeds of California and Other Western States book. Each entry required about a week to research and write and she wrote approximately 300 separate entries for the two books combined.

In addition to Evelyn’s skills, we were very fortunate to be able to work with and learn from the nationally recognized talents of the UC DANR principal photographer Jack Kelly Clark. Jack not only taught me the basics of photography, but also provided many of the slides, and processed most of the photos using Photoshop. Jim O’Brien was also temporarily employed by UC DANR to do the close-up photography of most of the seeds and his photos are spectacular.

Dr. Ellen Dean, the director and now curator of the UC Davis Herbarium, was a tremendous help to Evelyn and me on the identification of many weeds in the state. Our access to the herbarium was invaluable. The UC Davis Herbarium is known for its collection of weeds specimens, which was exactly what was necessary to carry on this project.

In addition to the photographers, the staff at DANR, including Bob Sams (Director), Ann Senuta (Publications Production Manager), Steve Barnett (Senior Editor), Celeste Aida Marquiss (Principal Producer Art Director), Steve Lock (Senior Photographer), Cynthia Kintigh (Marketing Coordinator), and Mike Poe (Media Services Manager) are, in my opinion, the best in the country in their professionalism and quality.

Book Statistics

To produce a book of this size and magnitude required a considerable amount of funding. For example, I procured $350,000 in funding support and DANR invested more than that to produce the book. In total, the book required about $1 million to produce.

It was decided in early 2001 that we would divide the project into two, with the first book published as the Aquatic and Riparian Weeds of the West. The widely used Weeds of the West book did not include aquatic species and, thus, the aquatic book was felt to be a counterpart to this publication.

In its final form the Weeds of California and Other Western States is two volumes, 1808 pages long. The book contains 262 entries (many of which cover several species). The main entries are organized alphabetically by family then genus. In addition, the book contains shortcut identification tables, two keys to grasses (one to vegetative characteristics), a list of non-native plants rarely or occasionally naturalized in California, a glossary, and a 65 page index that covers all common names, scientific names and synonyms. The list of non-native plants rarely or occasionally naturalized plants in the back of the book lists 722 additional species, of which 281 are not listed in The Jepson Manual: Higher Plants of California (Hickman 1993).

Up-to-date information is presented for 812 species. Of these, 451 are discussed in detail in the main entries and an addition 361 are discussed as related species at the end of the main entries. In total, 1534 species are included in the book.

There are over 3,000 color photographs in the two volume set. Of these, most were taken by me on trips across the western United States. I visited every county in California photographing weeds, collecting seeds in the field for later photography and to germinate for seedling photographs. Many of the photos in the book were taken by Jack Kelly Clark from previous outings and slides were also borrowed from several people, particularly Clyde Elmore,
Joe Neal, and CDFA. In the two volume book, there are a total of 657 close-up photographs of seeds, 326 seedling photographs, and 737 total species photographed. Most species are represented by multiple photos.

When the book was completed, it was reviewed by many people. The acknowledgements section of the people that assisted in this project is over a page in length. Each of the 262 entries was reviewed by two to three individuals for a total of between 550 and 600 individual reviews. All these comments had to be incorporated into the final version of the text. When all the changes were made, the book was submitted to DANR in November 2003. This submitted form of the book was a 900 page single spaced document that was accompanied by five large binders with the 3000+ slides. The document with just the photo captions was 72 pages long. DANR further sent the completed book and many of the photos to two or three anonymous reviewers for final changes.

The process of designing the books, finalizing the slides presentations, editing and rereading took an additional three years until its publication date of 2007. The *Aquatic and Riparian Weeds of the West* and the *Weeds of California and Other Western States* compliment the production of the diagnostic CDs to weedy grasses and broadleaf species of California. This combination allows for diagnostic identification of nearly 1000 species and detailed information in the beautifully produced books. All these can be found on the calweeds.com website.

There are so many people to thank along this long road to completion, which required a total of nine years, including all the past and present CWSS Board members, the UCCE Farm Advisors and Specialists in Weed Science, UC Davis field staff, and particularly my research associate Guy Kyser, all my former graduate students, Dr. Andy Sanders at UC Riverside, and the CDFA botanists and staff that provided me with so much support. This is only a short list of all the people that helped in this effort and Evelyn and I are grateful to each and every one of them.

**Literature Cited**


Weeds in Paradise; A Journalist’s Perspective

By Harry Cline
Editor, Western Farm Press

I am definitely on the wrong side of the microphone.

My proper place is on the front row; note pad in hand and tape recorder close by, making the person behind this microphone feel uncomfortable with each scribble on the note pad. I now know how many of you feel up here with me down there.

It is an honor to be here at the 59th annual California Weed Science Society conference. I am not sure how many of these I have covered. However, there is one I missed, and I want to take this opportunity to offer the society an apology for not attending your annual meeting a few years back in San Jose. It was there that the California Weed Science Society honored me with its Award of Excellence. I was truly honored. And to all who had a hand in that nomination, thank you very much.

I am also embarrassed—to this day—for not being there to accept that gracious honor. There was one of those mix-ups in communications, and I was not aware in advance of the award presentation. Had I been aware, I would have been there to humbly accept it before the society. Again, I apologize for the mixup.

When Carl Bell asked me to be part of this afternoon’s program to offer a journalist’s perspective on Weeds in Paradise, it gave me an opportunity to reflect back on the three decades of reporting on California agriculture.

It has been three decades of writing about weeder geese in cotton and herbicide-resistant transgenic crops; articles on the vineyard French plow and implements called Optimizers and Eliminators that do in one pass what once took maybe six trips across a field and writing about availability of hoe crews and electronic-eye cultivators capable of following a row of seedling lettuce without touching the smallest leaf.

I recall the first article I did on the electronic-eye cultivator. It reminds me of how far technology has come in just a short 30 years. The row-following cultivator did a great job, but the Salinas Valley lettuce grower who was using it complained that he had it set to come too close to the plants because it was disturbing the ground too much around the seedlings. This is a Millennium away from weeder geese cotton.

It has been a remarkable 3-decades of vegetation management stories I have been privileged to cover as an ag journalist. It is detailed well in a Power Point Ron Vargas put together a few years ago that is still available on the UC Cooperative Extension Cotton production website. The presentation is entitled, *Cotton Production and Weed Control Revisited*. It’s more than the story of cotton weed control. It is a history of vegetation management in California agriculture and well worth a website visit.
When Western Farm Press began publishing in the late 1970s, the publisher and owner then was insistent that the men and women in the land grant university system and its Cooperative Extension services were the first stops to gather unbiased, third-party information for publication. It was a tenant I have never forgotten. I saw early-on what that trust and integrity was all about going on a farm call with the legendary Fresno County farm advisor Bill Fischer. Before he retired, Bill would call, wanting to show me something he had discovered in one of his herbicide trials. On the way out to the trial he said he had to make a farm call. A grower wanted him to look at some stunted sugar beets.

Some of you know where I’m going.

We stopped at the beet field. Areas of the field were yellow and stunted, including plants all around the field’s edges. A couple of swaths through the field were also noticeably shorter and yellow.

It took Bill what seemed like only moments to assess the problem. And he was not happy about the farmer wasting his time trying to get Bill to blame the problem on a chemical so the farmer could collect damages.

I was clueless. Bill pulled up a beet. It looked like a corkscrew.

“Too much Treflan!” Bill proclaimed, explaining to the novice ag journalist that a doubled rate of Treflan was responsible for the beet field problems. I cannot recall if the problem was the result of over application of the herbicide in the cotton crop grown the year before or an over application of the herbicide on the beet field. Either way, the damage was caused by a well-meaning tractor driver who had made some double passes around the field edge and through the center where he thought he had not gone with the herbicide rig. It was a double application of herbicide that damaged parts of the beet crop.

There was no product liability here, proclaimed Bill as we jumped back in the pickup and headed for his test plot. The farmer may have thought Bill would back up his damage claim. He could not have been more mistaken.

That was at least 25 years ago, and it remains a vivid reminder of just one example the integrity of the UC agricultural system and its vital role as an unbiased, respected third party.

Weed control specialists and farm advisors have kept the weeds out of paradise as evidenced by the amazingly clean fields, orchards and vineyards in California. They are clean because of the vegetation management systems developed by you all.

It is a daunting task as Leonard Gianessi detailed recently at the Southern Crop Production Association annual meeting in Florida. Leonard is director of the Crop Protection Institute, a research unit of CropLife America Foundation.

There are more than 400 million weed species in the U.S. with the potential to slash yields if not controlled.

Today as much as 95 percent of all U.S. cropland—about 220 million acres—is treated with herbicides each year with an estimated 550 trillion weeds killed.

Use rates, application technology and the most efficient way to use these herbicides and other vegetation management technology was developed by you.
Unfortunately, the public does not realize that. They do not realize what you do to protect the food and fiber production of this state and this nation. And no one is going to tell them unless you do. The information pipeline that once hailed agriculture as the noblest profession in America has been choked by weeds of ignorance and deception. These are the true Weeds in Paradise. Newspapers and television talking heads are not going to tell the public what you do and the value of it.

We all realize this is not a new problem. It began at least a generation back when I began my career it was as a newspaper reporter. I was not raised on a farm, but I had uncles and aunts who farmed. And there were many others in the newsrooms where I worked who had similar backgrounds. We all had at least an appreciation of agriculture if not the memory of spending summers working on the farm.

Today, there are few, if any, in the newsrooms of television stations and newspapers who have that understanding. And, unfortunately, most of them do not care to understand it. One reason is facts and objectivity have fallen out of the journalist’s code of ethics. I spent the earlier part of my career in newspapers, but left when facts, unbiased reporting and integrity no longer were the foundations of news gathering.

I started my journalism career more than 40 years ago as a copy boy on a major Texas newspaper. Right out of high school and a freshman in college, I was living my dream of working for my hometown, daily newspaper. Great memories are still with me from those years. One memory still vividly lingers. It is of a small-statured, red-haired city editor. Johnny King was his name.

He had a temper and a very, very short fuse. Newsrooms in those days were big open rooms filled with desks. No wall. No cubicles. Johnny would often would stand up after reading a story he did not deem worthy of printing and would bellow: “Who in the hell wrote this?” and then call out slug line or title of the article. The silence in that bustling newsroom was deafening after he yelled. Everyone waited for the reporter who wrote the story to start walking toward the city desk to retrieve his story for rewriting. It was no doubt covered with red pencil marks.

When I read some of the agricultural stories in the local newspapers, I want to stand up and yell just like that city editor did a few years ago. I have suggested such a management practice to the publisher of the Fresno Bee after reading some of the stuff that gets in print. He did not like my suggestion. I guess my suggestion was politically incorrect.

One of my most recent tirades to the Bee publisher and editor came after reading an article that stated that organic farming was “the only regulated agriculture in California.” I could not believe that made it into print. I wrote the Bee to tell them that the California Department of Food and Agriculture, CalEPA and DPR, Department of Water Resources, all county agriculture commissioners and countless other agencies and people would glad to learn they do not regulate California agriculture. There was no clarification or retraction in the Fresno Fish Wrap.

Unfortunately, there is no dinitroaniline or glyphosate to weed out ignorance and bad journalism. However, as you have heard others say, as scientists you need to cultivate the news...
media to get your story and the story of California agriculture told. Not all will listen. However, some will.

Be willing to send your newsletters and bulletins to the local paper. If you read something in the paper that you think was well-done, call or e-mail the reporter an attaboy. Offer yourself as a resource for articles. Even suggest an article.

And there is no need to apologize for what you do.

Economist and futurist Jay Lehr speaking at the recent CAPCA conference said 100 years ago the public perception of California agriculture was that it was everything great about the state and nation. After World War II, the advent of farm chemicals allowed farmers to improve food quality, increase yields, and eliminate pests that infect food.

All of a sudden a target was painted on our backs by environmental advocacy groups like the Environmental Working Group. Lehr said. The farmer became the bad guy with a black hat on a black horse, he said. The problem in the pesticide industry is not that pesticides are bad, which they aren’t. The problem is that people don’t know what the farmer, weed scientist, entomologist and pest control adviser do and how these products are used.

“You guys are doing incredible work, but you are slinking around because the media says you are using bad stuff. I challenge you to stand taller, be proud of what you do and explain the benefits to society,” Lehr admonished PCAs. I suggest the same thing to you as weed scientists.

Lehr provided the PCAs with a toolbox of facts to share with consumers. He said chemical use has tripled farm yields on almost every acre in America over the last 40 years. Without herbicides, pesticides, fungicides and other products, food costs would double. He referred to fertilizers as plant nutrients and farm chemicals as medicines. Pesticides are to a plant what antibiotics are to humans. Herbicides kill the negatives that interfere with plant health.

Lehr’s message is one we seldom hear today. We are too busy apologizing or defending ourselves against the likes of groups like the Environmental Working Group, Organic Consumers Association and groups with warm and fuzzy-sounding names with war chests from foundations to hire lawyers whose goals are largely not to protect the environment, but to raise more money to self-perpetuate themselves.

Many of these have the keys to the front door of the newspapers and television stations because they sound like they know what they are talking about. You know that by reading what they often palm off on the mass media. Most reporters today are not interested in finding out if what they have been told is true. What is even worse, they do not seek out those who would challenge incorrect information or offer another perspective.

I had a few dealings with this crowd during the round of county anti-biotech initiatives a year or so ago.
I don’t want to categorize all of the people involved in the anti-biotech movement as kooks. Some are well-meaning and sincere in their conviction, even if they are based on false and misleading information. However, most, including the leaders are basically socialists who want our democratic society to dissolve. They do not care about the environment. Their calling is to destroy democracy and capitalism. Harsh? Perhaps, but I sincerely believe that.

Many of those involved in the anti-biotech movement in California are involved in many other anti-business, anti-societal protests.

One of those I communicated with during the anti-biotech campaigns was a very bright young man who lived in the Sierra foothills. He was articulate and an excellent writer. We communicated over several months until he told me he would be away for several weeks visiting family in the Northeast. When he returned, I asked if he enjoyed his visit and it was then he admitted he did not visit family. He finally admitted he had been in Chicago directing protests at the Republican National Convention.

The Occidental Arts and Ecology Center (OAEC) in Sonoma County was the headquarters of the anti-biotech crowd during the round of county initiatives. The man who heads the center is Dave Hensen.

To his credit, he called me and asked that we visit concerning what I had been writing about the anti-biotech movement.

He cited obscure scientific papers as we talked about the issue. He was very articulate and sounded convincing and well-educated. He also sounded very condescending as if I were some one he could snow with what I call pseudo-scientific babbling.

When he walks into a newsroom, reporters love him. If he calls a news conference, the radio station and television microphones are lined up in front of him. He is very good at grabbing headlines with his pseudo science. After we had visited, I asked him about his educational background. He hesitated and responded “I have taken classes on the subject.”

Let me read his bio from the ecology center’s website:

Dave Henson is a Sowing Circle Community member and Director of OAEC. He also directs our Ecological Agriculture and Sustainable Food Systems Program and co-directs our Intentional Communities Program. With a background in environmental studies, sociology and law, Dave has worked for 27 years with many environmental organizations, including the Environmental Project on Central America, the Highlander Center, the National Toxics Campaign, and Greenpeace. He has lectured and led activist workshops around the US and in over 20 countries. Dave currently serves on the steering committees of the Wild Farm Alliance, the Genetic Engineering Action Network, Californians for GE-Free Agriculture, and the Program on Corporations, Law and Democracy.

As far as I can ascertain, Henson does not even have a bachelor’s degree yet he was the driving force in the so-called science-based anti-biotech campaign in California. Fortunately, farmers in Butte, San Luis Obispo, Sonoma and Humboldt counties banned together to turn back this anti-
biotech initiative. About a dozen other county boards of supervisors also rejected any attempts to initiate anti-biotech bans their counties.

Not all of agriculture’s detractors are uneducated. Let me give you an example. In the midst of my “bullying” of the anti-biotech crowd, I was asked to moderate a discussion on biotechnology in Phoenix.

The head of the Maricopa Farm Bureau put the panel together and she had a very difficult time getting someone from Sierra Club or other anti-biotech groups to send a representative to join with representatives of biotech companies, the University of Arizona and private consultants. Finally the Sierra Club agreed to send a “PhD environmentalist” from Texas to participate.

To put it bluntly, he was an embarrassment. He opened his presentation by reading antidotal comments about calves eating biotech corn and getting sick. It as from a non-scientific booklet put out by the anti-biotech crowd. And he went downhill there. The more he talked, the more it became apparent he knew little about biotechnology. However, he railed on an on about how the evils of biotechnology. He even accused the panel members of endangering society with their work and/or support of biotechnology. That drew an immediate response from one panel member who objected to be accused of putting his family in danger by conducting biotech research.

Jeannette Fish from the Maricopa County Farm Bureau said as she took the doctor to the airport for his flight back to Texas he asked her if she thought he had been convincing in his anti-biotechnology presentation. She did not have the heart to tell him he only embarrassed himself. I felt sorry for the man. I later checked out the doctor on the internet. He was a PhD who had taught classes at the University of Texas, although I do not believe he had a faculty position there. His professional career with a state environmental agency was in the field of the environmental effects of burning tires to dispose of them. From what I could ascertain, he had absolutely no background in biotechnology.

I relate these incidents to you to hopefully help you understand who is opposing much of the work you do. These people do not have the credentials to challenge what you do, yet they have the ear of the media.

As scientists, you are trained to discuss your profession from scientific perspectives. Unfortunately, many of the people who oppose modern day agricultural technology cannot or will not play fairly in a scientific debate.

When biotech cotton was nearing introduction, former UC extension cotton specialist Tom Kerby was perplexed by rising opposition to this technology.

“It’s only proteins,” Tom would proclaim. He was puzzled by the opposition as he explained scientifically biotechnology to me.

After listening to Tom’s impassioned argument, my comment was that the debate about biotechnology or any other new agricultural technology will not be won arguing science with radicals. You are going to have to be a junkyard dog, I told Tom.

Tom said he couldn’t be a junkyard dog. And because a lot of scientists tried to debate the issue with these radicals citing science, we have lost the battle. The biotech war will eventually be won, but I am convinced one of the reasons biotechnology has lagged behind is that agriculture
did not get down and dirty early on with the radicals who now lead such organizations as
Greenpeace.
Unfortunately, these two-legged weeds are all over paradise. And the only way to get rid of them
is with the hoe, not herbicides.
One thing I did learn from my “bullying” the anti-biotech crowd was the same thing a lot of
farmers in Butte, San Luis Obispo and Sonoma county learned; if you go toe-to-toe with radicals,
they turn tail and run. You can defeat them on their own turf.
It is not comfortable, but necessary. One of the tactics the farmers successfully used in Butte
County was to openly challenge the anti-biotech crowd in their own so-called public forums.
These radicals do not handle public challenge well.
If we are to continue to provide food and fiber for the world, we must get down and dirty with
those who have little or no concern about what you and I consider vital to California and
America’s future.
Thank you for your attention and thank you for allowing me to share my thoughts.
Weeds in Paradise: The View from the Farm

Steve B. Orloff
Farm Advisor, UC Cooperative Extension, Siskiyou County
1655 S. Main St. Yreka, CA 96097 email: sborloff@ucdavis.edu

This topic is not an easy one to address for several reasons. First, what is Paradise? Is California Paradise, or for that matter has California ever really been a Paradise? Secondly, presenting “the view from the farm” from a statewide perspective is challenging, especially for someone who lives at the very northern edge of the state. Without a doubt California has the most diverse (and the most productive) agriculture in the country. In fact, greater diversity exists within California alone than occurs in most other countries. Evaluating the status of agriculture in relation to weeds for the entire state is a daunting task.

A logical first step to present this topic is to consider the meaning of the word paradise. The Merriam-Webster dictionary defines paradise as: 1 a : EDEN 2 b : an intermediate place or state where the souls of the righteous await resurrection and the final judgment c : HEAVEN 2 : a place or state of bliss, felicity, or delight.

While California is probably one of the better places to live and farm from many people’s perspective, the word paradise is not an accurate description—especially taking into account current conditions California farmers confront. However, the truth is California probably never was paradise. On the other hand, it is undeniable that California has a nearly ideal combination of weather and soils that make it the leading state in the nation for agricultural production. With these favorable environmental conditions, weed populations thrive as well and weed control is a continual battle for crop producers. Are we making headway in the battle with weeds or are the weeds getting the upper hand?

When Program Chair Carl Bell asked me to make this presentation, the specific questions he wanted addressed were:

1. What is the status of weeds in crop Ag? Are they getting better or worse?
2. How is the crop Ag business doing overall?
3. Is there a crisis ahead or just more of the same?
4. Is CA still paradise even with the weeds?

To answer these questions from a broader perspective, I contacted several UC colleagues from throughout the state. I wish to acknowledge the assistance I received from Oleg Daugovish, Steve Fennimore, Kurt Hembree, Tom Lanini, Richard Smith, Rob Wilson and Steve Wright.
Weed science is a constantly evolving discipline and major advances continually surface to better enable farmers to manage weeds in crops. Whether weed problems are being resolved or getting worse depends to a large degree on the commodity and the availability of herbicides. Regardless, weeds are amazingly adaptive. It seems we solve one problem and another arises. No new technology is a panacea and typically comes with some kind of a price. The initial problem may be solved but oftentimes another one is created. This is apparent in some of the advances described below.

**Weed Management Status in Agronomic Crops**

Generally speaking most weed problems in agronomic crops have lessened. Several herbicides were released over the last decade that have either broadened the spectrum of weed control or made weed control easier to achieve. Just a few of the relatively recent advances are described below. Raptor (imazamox) has had a major impact on weed control in seedling alfalfa. It is broader spectrum than the previous standard treatments controlling a wide array of both broadleaf and grassy weeds. Previously registered herbicides for use in seedling alfalfa typically controlled broadleaf weeds or grasses but not both. Fiddleneck has long been a significant problem in small grains. A relatively new herbicide, Shark (carfentrazone), has provided an economical and effective way of controlling broadleaf weeds in small grains. In addition, registrations for Puma and Osprey have made it possible to control problematic grassy weeds such as wild oats, canarygrass and ryegrass in cereal crops. Nightshade is much easier to control cotton now with Staple herbicide significantly reducing hand labor. Corn has had a large arsenal of herbicides with Eradicane, Duel, and Lasso controlling most weeds as a preplant incorporated treatment, and dicamba and 2,4-D controlling most broadleaves post-plant directed. Two new corn herbicides have improved control of some troublesome weeds; Sempra (halosulfuron) for control of nutsedge and Accent (nicosulfuron) for control of Johnsongrass.

Without a doubt the most significant breakthrough in weed control in agronomic crops in the past decade has been the development and commercialization of transgenic herbicide-resistant crops. Glyphosate resistant cotton, corn and now alfalfa are commercially available. Roundup resistant corn and more recently alfalfa are also now available. These crops have already or are expected to have an enormous impact. The adoption rate for this technology has surpassed expectations. In most cases it has simplified weed management and improved broad-spectrum control of both annual and difficult-to-control perennial weeds—all while virtually eliminating crop injury. In addition to improved weed control, this technology has made it possible to grow ultra narrow-row crops and has facilitated reduced-till and no-till systems. This technology has resulted in less tillage, with a concomitant fuel savings, and a significant reduction in costly hand labor. For example, hand weed labor in crops like cotton has gone from $100-200 per acre down to approximately $50 per acre.
As mentioned above, there are some risks or downsides to some of these technological advances. For example widespread damage from Shark drift occurred in the Central Valley resulting in application restrictions. Some of these new herbicides are so effective that many growers rotate less, an example being an endless rotation of small grain forage and corn. The fields often receive considerable applications of non-composted manure and now have serious problems with stinging nettle and canary grass. Because of the effectiveness of current small grain herbicides, grain growers in some dryland areas grow grain continuously and have moved away from sound cultural practices resulting in new weed problems.

Herbicide resistant crops are believed by many to be the silver bullet when it comes to weed management. Even though these are cost effective tools and a great benefit to growers, this technology is not without risks. The primary concern is the occurrence of weed shifts and weed resistance. The Roundup Ready weed control system is so effective and easy that it can make growers complacent in their weed control practices facilitating the evolution of weed shifts and resistance. Two weed species already have documented resistance to Roundup in California—annual ryegrass and marestail. Neither of these cases is the result of growing a transgenic crop but increased continual use of Roundup with transgenic herbicide-resistant crops increases the likelihood of weed shifts and resistance. Roundup-resistant ryegrass was first found in California orchards where there was a long history of continual Roundup use. Roundup resistant marestail originated in the southern San Joaquin Valley of California in orchards, vineyards, and ditch banks where tillage was no longer used and Roundup was used continuously for several years, oftentimes with multiple applications per season. Roundup-resistant crops have provided growers with an easy-to-use, low-cost, and effective weed management program but its effectiveness may be reduced in the long term if it is not used wisely. The key is to reduce selection pressure by not relying on a single herbicide repeatedly for weed control.

**Weed Management Status in Vegetable Crops**

With a lower tolerance for weeds and fewer herbicide registrations, weed control in vegetable crops has been more challenging compared with agronomic crops. Matrix (rimsulfuron) in tomatoes and Sandia (halosulfuron) in tomatoes, peppers and cucurbits has improved control of nightshades and nutseed. Overall, however, new herbicide registrations for vegetable crops have been few and far between because of limited market potential and higher risk of liability. In fact, most of the new registrations are not new chemistry—rather a new use for old chemistry. For example, there is a 24(c) for Prowl H2O (pendimethalin) in onions and a 24(c) registration is expected for GoalTender (oxyfluorofen) for onions at the one leaf stage. This early application will help growers significantly with early-season weed control. GoalTender has other new uses as well such as over-the-top applications on broccoli and other cole crops. It has also proven useful in strawberries to control mallow, filaree and at the highest use rates clover—all weeds with hard seed coats typically not controlled by soil fumigation. Another older herbicide, Stinger (clopuritalid), has received registration for use on cole crops. A 24(c) was also granted for the
use of Kerb (promamide) via chemigation for mustard control in fall lettuce in Fresno, Imperial and Riverside Counties. Work is underway to develop data for coastal vegetable production areas. Dual Magnum (s-metolacholor) has been beneficial in spinach, celery and tomatoes, especially for nutseed suppression.

One of the most significant advances, or at least changes, has been the shift to buried drip irrigation in vegetable crops (tomatoes primarily). It has resulted in reduced weed emergence, since there is less surface soil moisture. The downside of this change is that herbicides that require irrigation for incorporation are rendered ineffective (or only partially effective).

Fumigants play a large role in weed control in many high value vegetable crops. There has also been a move toward 80 inch beds for some vegetable crops, which presents additional challenges for weed control and greater reliance on preplant fumigation. However, the phasing out and use restrictions imposed on methyl bromide are going to have a major effect on weed control in some crops. Strawberries are a prime example, and weeds like yellow nutseed will be far more difficult to control. Use of other fumigants is expected to become more problematic as well due to VOC restrictions, buffer zone requirements, and the fact that some neighbors will no longer tolerate them.

Organic food, primarily produce, is an ever increasing market. The organic food market has grown by approximately 20 percent each year from 1997 to 2005. While this is still a relatively small share of the entire market (organic production accounts for only about 1-2 percent of total food sales in the US in 2003), it is becoming increasingly important. Weed control in an organic system is especially difficult to achieve and costly. A shortage of labor for hand weeding, tighter restrictions on hand weeding, and increased cost (minimum wage increases) has made hand weeding even less attractive.

The time may be ripe for the adoption of precision guidance systems for cultivators and intelligent sensing systems for precise application of herbicides. There could be significant developments in computer assisted weeders (such as split knife system for tomatoes and the weed recognition system developed by Dave Slaughter with UC Davis Biological & Agricultural Engineering Department). Although this technology will be expensive, the lack of herbicides and increased cost for hand weeding may make this technology a viable option. The move to transplants may also open options for other herbicides or weeding techniques.

**Weed Management Status in Tree and Vine Crops**

There have been more new herbicide registrations for trees and vines than for vegetables. Chateau (flumioxazin) has made major inroads in the tree and vine market and has been effective for controlling some of the more difficult to control weeds in these perennial crops including fleabane, marestail and malva (cheeseweed). Visor (thiazopyr) also gained registration for
nonbearing bearing orchards and for bearing citrus. Rely (glufosinate) received registration for grapes and many orchard crops and, like Chateau, controls marestail. Shark (carfentrazone) was the most recent new herbicide registered for bearing and nonbearing trees and vines.

Weed management in trees and vines seems to be largely dictated by commodity prices. When the prices are profitable, weed management improves, but when commodity prices are poor weed management becomes a lower priority. This creates a buildup of the weed seed bank thus causing future problems. Many growers rely primarily on postemergent sprays with Roundup. This often results in less than perfect weed control. Timing is important but is often problematic in wet years. Hairy fleabane has been one of the most difficult weeds to control. Ground Water Protection Area (GWPA) regulations with limitations due to soil type have prevented some of the important preemergent herbicides (simazine, diuron, bromacil) from playing a stronger role like have in the past.

Agricultural Profitability

One of the issues Program Chair Carl Bell asked each of us to address in this series on Weeds in Paradise was an overall assessment of the profitability of the industry we represent. This is nearly an impossible task with the diversity of commodities represented in the agricultural sector. Profitability is extremely crop specific.

As always, there have been tough times in some markets while other commodities have faired well. The standouts have probably been almonds and walnuts. Grape prices are still fairly low and peaches and nectarine prices have been mediocre. Cotton, sugar beets and beans have all lost acreage over the last few years. Alfalfa has remained at over a million acres as prices, while not the record prices we saw the previous year, have still been strong. Vegetable markets continue to be volatile with the biggest news being the food safety concerns related to E. coli and the devastating effect it had on the spinach market. The state’s $258.3 million spinach industry came to a screeching halt, as growers plowed under fields and worked with health officials to determine the source for the contamination.

There is no doubt that weeds are a significant problem and keeping them under control is a major cost for producers. I do not wish to minimize their importance, but frankly in my opinion there are other issues that are far more threatening to the future viability of farming in California than weeds. The increasing costs of farming in California make it difficult to compete. Imports from China and other countries are, and will likely remain, an issue. The availability of labor and the cost of labor with the increase in minimum wage are major concerns. High fuel costs and their effect on the cost of other inputs greatly increase the cost of doing business. Because of the slim profit margins for most agricultural enterprises, “start-up” farms rarely survive past 2 or 3 years. Family farms are consolidating and getting bigger to remain competitive. Even the big farming companies are consolidating into bigger ones. High value crops push out the lower
values crops as land becomes more expensive. Farm acreage continues to be devoured by urban sprawl as profits from selling the land far exceed the potential income from farming.

Existing and pending regulations and how they are enforced are major concerns for farmers. At times the list seems endless. The Endangered Species Act can affect all aspects of farming and resulted in complete withdrawal of irrigation water in the Klamath Basin in 2001. Water availability in the future is tenuous and farmers fear the next drought year and what it might bring in terms of water for agricultural production. The federal Clean Water Act and Ground Water Protection Area Regulations can have a significant impact on farming practices and how we control weeds. Similarly, air quality regulations related to drift, agricultural dust (especially particulate matter of less than 2.5 microns in size), and required reductions in Volatile Organic Compound (VOC) Emissions will have a major impact. The major pesticide contributors of VOC’s are fumigants and pesticides with emulsifiable concentrate (EC) formulations. These regulations will shape how we do business and control weeds. The degree to which these regulations will impact profitability, production practices and specifically weed management has yet to be seen.

A Crisis Ahead?

Is there a crisis ahead in the crop agriculture industry when it comes to our ability to control weeds? It depends on what you consider a crisis. Crisis is probably too strong a word, but there is absolutely no question that there are significant challenges ahead. The rate of herbicide development has slowed markedly since the golden era of herbicide discovery in the 70’s and early 80’s. The cost to bring a new herbicide to market has been quoted by some to be $187 million (research and development, regulatory costs, toxicology studies, residue and soil dissipation studies, etc.).

The development and overwhelming popularity of herbicide tolerant crops, primarily the Roundup Ready technology, has stifled research and development on new herbicide chemistry. With herbicide development costs so high, there is little incentive for manufacturers to develop truly new products when the remaining market share is so small. This is especially a problem for vegetable crops where it is questionable whether herbicide tolerant crops will ever be commercialized and the industry relies on chemistry developed for the major agronomic crops eventually trickling down to the vegetables. With fewer herbicides available and a greater reliance on single herbicides (like glyphosate), weed shifts and weed resistance will become increasingly prevalent. When the profit margin declines, so does a grower’s willingness and ability to spend for weed control. Growers cut cost by using less expensive herbicides and/or reducing hand weeding.

Weeds have always been and will continue to be a challenge for farmers and crop protection professionals. Through the development of improved technologies and diligence on the part of
farmers we have dealt with weeds in the past and will continue to do so in the future. There are still growers willing to take risks, and to remain profitable they will take higher and higher risks. We, as crop protection professionals, researchers and educators, need to be right there with them. I am reminded of a quote by Lou Holtz, one of the winningest college football coaches. Life is ten percent what happens to you and ninety percent how you respond to it. A lot is going to happen to us in agriculture over the coming years. We need to be proactive and innovative in our approach to the challenges that await us.
Summarizing the changes I have seen in California vegetation management over the past thirty or so years is a challenging assignment. After speaking with CWSS Program chairman Carl Bell, we agreed that this would be more of a philosophical retrospective than a technical presentation. Thus, I decided to subtitle my talk, “Rates, Radicals, and Resistance” — a convenient mnemonic of some of the major changes I have experienced in my professional work. I will delve more into these terms later in this paper. Suffice to say for now that herbicide rates have generally decreased; concerned citizen involvement has increased; and herbicide resistance has emerged as a significant issue to be considered when designing our vegetation management programs. These issues have definitely affected how we manage “Weeds in Paradise”. I will start by discussing what we name our weed work, as well as where and why we do it.

**What Do We Call This?**

One of the first things that has obviously changed is the name we give to what we do. When I started in the early 1970’s we called this work “Industrial Weed Control” and our tools were “Sterilants and Weedkillers”. I would say, looking back, that this term reflected an inwardly focused management objective that had little or no consideration of off-target or long-term effects of our work to the site or the environment.

In the late 1970’s and early 1980’s we started using the term “Non-Crop Weed Control”. This term meant that we acknowledged that our work could impinge on the health of nearby crops. One of my suppliers told me his philosophy had become “Non-Crop is All-Crop”. This may have happened after one of his clients mis-applied a soil-active herbicide along a county road that damaged multiple crops. The concept of product stewardship and drift management started to appear at this time, in crop agriculture, as well as non-crop settings.

In the 1990’s professionals switched from term “Non-Crop Weed Control” to “Non-Crop Vegetation Management”. This change reflected the reality that we really were not killing all the weeds on any given site. Additionally, management objectives has switched from having a bare ground result to variable objectives, including invasive weed management, native grass release, erosion control and slope stabilization, fuels management, type conversion, and storm
water management. Our goals now often included encouraging certain plant species after the removal of the undesired species, Thus we were no longer only doing “weed control”.

Since the mid-1990’s some of my utility, right-of way, and wildland clients have used the terms “Integrated Vegetation Management” and “Habitat Restoration”. These terms reflect a more holistic view of weed management that uses multiple tools and tactics to achieve goals that are often landscape (watershed-scale) in scope. One multiple-stakeholder project I have advised on for the past several years encompasses two major creek systems in three counties. Management objectives include removal of invasive brush and forbs, type conversion to native species (including Native American basket-weaving plant materials), and slope stabilization to reduce streambed sedimentation for the possible return of historical salmon spawning. This is not your old-fashioned weed control.

Where Do We Do This?

While Carl Bell asked me to give “The View From the Road”, there are many more places where we do vegetation management. Using the “Three R’s” device again, I will group our major work areas into “Roads, Rangeland, and Rivers”.

Roads

When I speak to my crop agriculture Pest Control Adviser colleagues, they often think that I just do weed control on roads and highways. This certainly is a major part of our work. There are, though, many fine gradations of this term. “Rights-of-ways” or “easements” are often a more accurate description for where we work. Utility power lines are the major example of sites where a client’s need to manage unwanted plants on land that the utility does not own. The utility’s objective of service reliability may clash with the adjacent landowner’s objective of having a privacy screen made up of conifers that could fall into the power line, or a walnut grower who want to plant trees under the wires. Maintaining roadbed integrity, site access, and fire prevention are major objectives on these sites.

Rangeland, as well as…

Rangeland managers have an increasing number of management objectives. On our ranch in the Glenn County foothills of 1960, we sprayed the brush with 2,4,5-T, burned it, and planted grass for cattle feed. Today, ranchers still do this, albeit without their favorite tool, which took on the name Agent Orange in Vietnam, and was eliminated from their toolbox. Range managers, especially on government-owned land, have added the objectives of invasive weed control, native species establishment, habitat restoration, and environmental mitigation banking.

Forest vegetation management is a major aspect of growing conifers, just up the mountain from the rangeland areas. Many research studies have proved that proper site preparation of conifer plantation and early release from weed and brush competition allow pines, firs, cedars,
and redwood to grow faster and achieve a merchantable size earlier than without weed management.

Parks are increasingly targeted for conversion from large tracts of invasive non-native species, to native plant species. This land may be under city, county, state, or federal ownership. These projects often incorporate a significant public education component, which will hopefully lead to voter support of this type of restoration project.

“Wildland” is a term that includes any other land not mentioned above. Wildlife areas and games refuges, as well as desert preserves are included in this land base. The usual vegetation management objective is, again, either invasive plant control or wildlife habitat restoration.

Rivers

Aquatic vegetation management is a better name for this topic area. It does include rivers, but also creeks, marshes, swamps, bogs, lakes, ponds, and any other imaginable body of water. The biology and ecology of this type of weed control is quite different from terrestrial vegetation management. This has been especially problematic over the past few years, if the water is contiguous with “the Water of the United States”, where an NPDES permit to apply aquatic pesticides is often required to do work. That permit is the subject of a completely different laws and regulation presentation, but there is hope that the NPDES issue may be cleared up in the next few years.

Riparian areas, or those areas along or immediately adjacent to water, are a sort of hybrid or cross-over area that may or may not have regulatory challenges to vegetation managers. My impression is that many riparian management restrictions are self-imposed by overly cautious agency land managers. My view is that if you are not aiming for the water, it is a terrestrial application. My recommendations in riparian areas, though, often include numerous mitigation measures to keep herbicides out of the water.

Rates — The First “R”

Generally, herbicide rates have gone down over the past thirty years, as new active ingredients have replaced old ones. Liquid rates have gone from gallons to quarts to pints to ounces per acre. Dow AgroSciences’ pyridine herbicides, clopyralid and aminopyralid, are good examples of this trend. Dry formulation rates have gone from many pounds to few pounds to one or two pounds to a few dry ounces per acre. DuPont’s sulfonylurea herbicides are, of course, major examples of this change.

Impacts of Lower Rates in “Paradise”

The trend to lower herbicide use rates has had both positive and negative impacts — some real, but some perceived. A major positive is that there is less chemical put into the environment.
A logistical positive is that there is less material to store, ship, and mix, as well as fewer containers to dispose of or recycle.

Unfortunately these lower herbicide rates have resulted, in some concerned citizens, the perception of greater toxicity. They say, “That’s all it takes?!?! It must be too toxic to use safely”. I once had to replace 20 pounds of a sulfonylurea herbicide with over 400 pounds of an old triazine herbicide in order for a North Coast conifer release project to proceed.

This low-rate technology also places a greater stewardship responsibility on applicators, PCAs, and land managers. Since these products are active at low rates, there is a greater potential for off-target plant damage if they are improperly mixed, mis-calibrated, spilled, or drifted. These risks are different from the perceived hazards mention in the paragraph above.

**Shotgun vs. Rifle**

Changing technology has led to an increasing use of selective herbicides, especially in sensitive sites. The old “shotgun” is still good, e.g., Roundup/glyphosate for many weed management objectives. There are now, though, “rifles”, that is selective herbicides, that have been added to our arsenal for specific uses. Broadleaf products for invasive weeds, e.g., Dow pyridines (triclopyr, clopyralid, aminopyralid) are now major tools for woody plant or thistle control. Grass herbicides, e.g., “fops” and “dims”, are excellent for management of many grass weeds.

Woody plant control in forestry and habitat restoration sites is a sort of hybrid between the two approaches. Some herbicide generally thought of as non-selective may be selective on woody species. Imazapyr controls oaks, but not rubus or legumes. Triclopyr controls rubus and poison oak, but not redwood. One glyphosate formulation, with a particular surfactant, can be applied aerially over the top of hardened off pines in the late summer to selectively control ceanothus, manzanita, and even some oak (*quercus*) species. These properties allow for customized wildlife habitat restoration.

**Hammer vs. Scalpel**

We see a similar trend with pre-emergent herbicides. When I first started doing “Industrial Weed Control”, we always wanted the “Hammer”, i.e., non-selective herbicides for bare ground site establishment and maintenance, fire safety, and access. While we still often need bare ground control, we also need a “Scalpel” for selective for sensitive sites and some habitats.

Native grass safety is available with selective broadleaf herbicides, such as Telar (chlorsulfuron) and Gallery (isoxaben). We also can get woody plant safety with products like Dimension (dithiopyr) and GoalTender (oxyfluorfen).
Registration

No California Pest Control Adviser can discuss his or her career without at least some mention of the impact of government laws and regulation on the availability of pesticides and govern their use. We are well-used to “ABC” (Anywhere But California) or “49er” registrations. Registration of pesticide in the Golden State is tedious, but thorough. There are over 120 tests for safety and efficacy done on each formulation. It can be difficult. California has often required California-generated data, in addition to USEPA-required data. It is expensive, costing from 120 to 180 million dollars to pay for the process. It is also lengthy, taking 7 to 10 years from synthesis to market.

Regulations

We have always dealt with many regulations in California from the California Department of Pesticide Regulation, and its predecessor, the California Department of food and Agriculture. We are now dealing with many additional agencies getting into the business of telling us what to do and how to do it — or not do it.

The many areas of regulation include various topics, including licensing, use enforcement, worker safety, and environmental monitoring and groundwater rules. The laws include acronyms, such as NEPA, CEQA, CWA, ESA, FAC, and CCR.

The many agencies, in addition to CDPR and Ag Commissioners, include state, federal, local water boards, as well as multi-acronym wildlife agencies, such as , CDF&G, USFWS, NOAA Fisheries/NMFS, etc.

Radicals — The Second “R”

The word “Radicals” is my politically incorrect name for the more correct (and accurate) term “Concerned Citizens”. The fact is, as it should be, that all citizens have a right to comment on something that affects their lives, whether perceived or real. This is especially true if a project is planned on public property. While some of these folks have caused frustration to me and my clients over the past thirty years, I have to say that their efforts have made me become a better listener and better communicator.

No vs. Know Why — Reason vs. Religion

In the past, people opposed to herbicide project often adopted the anti-drug motto, “Just Say No!”. These people just didn’t like chemicals. They opposed their use on “principle”. There was little science involved and a lot of emotion.

Now, most project opponents know “why” they are appealing a project. They know the system, especially the federal NEPA process and California CEQA. Process, NEPA is the
National Environmental Policy Act and CEQA is the California Environmental Quality Act. These appeal documents purport to use “science” to appeal pesticide projects. My experience is, though, that it is often bad science, unsupported by more than anecdotal reports. The unfortunate results is that even if the appeal is denied, the biological treatment window has passed. This often results in the delay or cancellation of the project.

The following comment is totally personal on my part. I often call dialog with anti-herbicide folks as cases of “Reason vs. Religion”. While they are frustrating to deal with, I have come to realized that we can never stop communicating with them and trying to build trusting relationships.

**Resistance — The Third “R”**

Herbicide resistance, the third “R” in this paper, is not my areas of expertise. As a practitioner of weed science, though, I have seen it increase over the past thirty years. Other more qualified people will speak on resistance at this and other meetings. I just know that it must be considered when developing vegetation management plans. It must be considered everywhere, even if there is no past evidence of resistance on a particular site. We must do this to maintain all tools in tool box. Research shows that using rates that are too low, or applying at the wrong time, are some of the causes of weed resistance to herbicides.

**Summary:**

**Relationships — The Fourth “R”**

In closing, I wish to mention that relationships are an essential part of successfully managing “Weeds in Paradise”, that is in California. There is now a third party involved in the process. In the past we have had a two-party relationship between the regulators and the regulated. The regulators are CDPR and the county agricultural commissioners. The regulated are growers, foresters, wildland and habitat managers, other public agencies that use pesticides, farm workers, applicators, and PCAs. The third party in this relationship is now the “radicals”, that is the concerned citizens I discussed earlier. They have a right to be involved — get used to it and keep talking!

Things have changed a lot in the last thirty-some years I have worked in California vegetation management. We have gained some tools and lost some tools. Herbicide rates are lower. The public is more involved in decisions. Herbicide resistance is growing. Vegetation management is a challenge, but it can be done!
The average Southern California neighborhood bears little resemblance to anything that might be called “natural”. Paradise was lost centuries ago, after all of us began to arrive and make changes. Our benign Mediterranean climate plus the miracle of irrigation allows urban Californians to enjoy growing plants from all over the world. Our yards and gardens feature Australian shrubs, African turfgrasses, European trees, Chinese groundcovers and jungle tropicals from Brazil. With these plants come weeds from all over the world that are suited to growing along with those plants. Regardless of how many natives the community master plan calls for, the view from the street is not of the native landscape. The view from the street is largely of non native turf and ornamentals and the non native weeds that travel with them.

The sources of weeds in the urban landscape are varied. It might be accurate to say that humankind has been growing and selecting weeds in our yards and homes since before the dawn of agriculture. In modern times, dryland weeds such as Russian thistle (*Salsola tragus* L.) and Telegraphplant (*Heterotheca grandiflora* Nutt.) may dominate prior to development but tend to disappear in irrigated culture as do natives in general. New and smaller weeds such as Spurge (*Euphorbia* sp.), creeping yellow woodsorrel (*Oxalis corniculata* L.) and sowthistle (*Sonchus* sp.) arrive and become established. Often these weeds are introduced in soil transfers or with nursery ornamentals as the new site is landscaped. Woodsorrel seed is spread quickly from lawn to lawn by mowing crews, while sowthistle seed blows in on the wind. The weeds first occupy and then defend niches where they elude control measures by the landscaper and other pests. Small populations of weeds go unnoticed at first, or control measures are reactive and incomplete. A few seasons go by while the weeds reproduce and become resident on the site. It becomes clear that the weeds are as well or better adapted to the site than what we’re trying to grow. After all, they volunteered to be there. Sooner or later, mixed in with everything else, weeds begin to look “natural”.

Weed populations change seasonally and over the years. Weeds that are present in new landscapes may disappear seasonally as better adapted species move in. In winter lawns, annual bluegrass (*Poa annua* L.) occupies shady areas that six months later may be in full sun and filled with crabgrass (*Digitaria* sp.). When crabgrass dies out in November, the annual bluegrass returns. A dense infestation of crabgrass is not typical in new lawns, but is common in older lawns where the desired turf has suffered. In low maintenance lawns and parks, weeds may be the turf, providing green vegetative cover at a mowing height even when the original turfgrass has dwindled to a small percentage of the total. Kikuyugrass (*Pennisetum clandestinum* Hocst.) is an invasive perennial weedgrass that outcompetes all other turfgrasses under coastal conditions. Although not considered to be a high quality turf, kikuyugrass is so competitive that some golf courses have given up fighting it and started cultivating it. The weed has been domesticated, just barely.
Weed control in the ornamental landscapes of California is accomplished through multiple means. Weeds like nutsedge (*Cyperus sp*) can be reduced through shading with competitive plants and keeping irrigation on the light side. Conversely, nutsedge is almost impossible to eradicate when soils are constantly wet during warm weather and direct sunlight reaches the soil. A variety of pre-emergence herbicides are available in sprayable and granular forms to control annual weeds in turf and ornamentals, but they will not control all weeds and may be ineffective against perennials. After weeds emerge, hand weeding, hoeing, mowing, and weed whipping are part of the regular maintenance at many commercial and residential properties. Non-selective, post-emergence spraying with glyphosate is a standard practice for weed control almost any time of year.

With herbicides, applicators need to know how to measure and apply them accurately and at the right time. Timing applications for maximum effect is one of the great arts in weed science. Simply put, applications should be made when the weed is or soon will be at a susceptible stage of growth for maximum effect from the herbicide, usually when the weed is a seedling or young plant. Applications made outside this window of opportunity may miss the weed or catch it at a stage when it is no longer as susceptible to the treatment, resulting in decreased weed control. Application timing must also consider any effects on the turf or ornamentals, which may not be tolerant of the treatment at all times of the year.

**A Generalized Annual Herbicide Application Plan for Turf and Landscapes in Southern California**

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<td><strong>Irrigated Landscapes</strong></td>
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<td><strong>Non-Irrigated Landscapes</strong></td>
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<td><strong>Cool Season Turf</strong></td>
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<td>(tall fescue, perennial rye)</td>
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<td><strong>Warm Season Turf</strong></td>
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<tr>
<td>(bermudagrass, Kikuyugrass, not overseeded)</td>
<td>pre</td>
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Pre = good time to apply pre-emergence herbicides
Post = good time to apply post-emergence herbicides

32
Urban weed management programs often follow a generalized plan for herbicide use. The concept is that windows of opportunity for weed control occur with a predictable frequency during the year. Over the years, applications made during these windows stand a better chance of success than do applications made outside the window. This is based on weed behavior, growth stage or condition of the turf and ornamentals, climate patterns, and synergy with other plant care operations. Over the long term, weed control programs always outperform weed control treatments.

Application accuracy is a major challenge among the irregularly shaped terrain of a golf course or landscape. Where booms cannot go, applicators spread granules or drag hoses and power spray with various guns and nozzles. Preparing to spray, herbicides are often mixed in the tank as a percent solution or at a fixed rate per volume of water. This makes things simple for the applicator, but does nothing to address the question of how much product is being applied over a given area, which is how the label sees it. Applicators who mix the same way but apply widely differing amounts of spray per area will often get widely differing results. So, is it best to spray to glisten, to wet, or to drown? The answer varies with the herbicide and type of job, but always involves knowing how much active ingredient is being applied over how many square feet (or hectares) of area. One simple exercise that all spray crews should try is the 1/128 of an acre calibration method.

The 1/128th of an Acre Calibration Method

1) Measure off a flat area 18.5 x 18.5 feet. This is 342 square feet, approximately 1/128th of an acre.
2) Pressure up your sprayer and spray it just like you would in the field. Time yourself while doing this.
3) Spray into a bucket for the same number of seconds it took you to spray the area.
4) Measure the volume of water in the bucket.

The Solution: The number of fluid ounces in the bucket is equal to what you would be spraying in gallons per acre. There are 128 fluid ounces in one gallon of water. So, whatever you spray on 1/128th of an acre in fluid ounces is equal to what you would spray in gallons per acre.

Example: If you spray 20 seconds and collect 50 oz of water, you know:
1) You spray at the rate of 50 gallons per acre.
2) If you spray 1/128th of an acre in 20 seconds, then you spray one acre in 20 x 128 = 2560 seconds, or about 43 minutes.
3) If Apocalypse herbicide is supposed to go out at 2 qts/A, you would add 2 quarts of Apocalypse to a little more than 50 gallons of water (don’t want to run short!) and spray all of it on one acre of ground.

That’s not all there is to it, but it’s a good start!
Hybridization as a Stimulus for the Evolution of New Weeds and Invasives

Norman C. Ellstrand, Professor of Genetics, Department of Botany & Plant Sciences, University of California, Riverside, CA 92521-0124, norman.ellstrand@ucr.edu

In 1949, Edgar Anderson coined the term “superweed” to describe newly invasive lineages resulting from hybridization between crops and their wild relatives. During the next half century, the role of hybridization in adaptive evolution was examined by an array of plant biologists from Stebbins to deWet and Harlan to Barrett. In 2000, Kristina Schierenbeck and I published a paper called, “Hybridization as a stimulus for the evolution of invasiveness in plants?”, listing 28 well-documented examples and considering why hybridization might lead to more aggressive lineages. Apparently, it was the right time for such a paper. At the writing of this abstract, the article has been reprinted in three times and has received well over 150 citations. In my talk I will update the 2000 study with several new examples. Also, I will examine some biological commonalities that emerge from this reexamination. The research published since the 2000 paper reveals that (1) the phenomenon is not rare for plants, (2) hybridization can stimulate the evolution of invasiveness in organisms other than plants, but (3) some “classic” examples from plants probably do not involve hybridization as previously suggested. Furthermore, (4) the evolution of invasiveness via hybridization can explain some of the paradoxes of the occurrence of invasiveness. Most importantly, (5) it is now clear and well-accepted that invasiveness can evolve. By hybridizing the fields of plant evolution, plant ecology, and applied plant science, the question “Hybridization as a stimulus for the evolution of invasiveness in plants?” has stimulated a new and growing multidisiplinary field of study.

Relevant references:


Traits of Invasive Plants: Adaptation and Dispersal

Scott Steinmaus, Biological Sciences, California Polytechnic State University, 1 Grand Avenue, San Luis Obispo, CA, 93407, ssteinma@calpoly.edu

For weed risk assessment purposes, traits of invasive plants can be divided into roughly three major components: Undesirability, biogeographical, and biological. Undesirability components usually include traits that are undesirable to humans, for example, traits that cause allergies, toxicity, or physical harm. These traits may also contribute to a species’ invasibility but the component is not usually defined in this context. The biogeographical component relates to the climatic match between the native and invaded site. This too may relate indirectly to invasibility traits but it is really the biological component that explicitly addresses the traits possessed by a species that contribute to its invasibility.

It is tempting to develop a single set of biological traits when assessing threat of invasion. To this end, lists have been devised to simplify the assessment process for governmental agencies. After considering groups of related woody species that were known to be invasive to those that were known to be non-invasive certain traits were significantly associated with the invasive group. The consensus list included small seed size, short juvenile period, low nuclear DNA content, short interval between large seed flushes, few seed dormancy breaking requirements, rapid vegetative spread and propagation. These lists were devised with a limited set of species, primarily Pinus species. Subsequently, dispersal opportunities were found to add significant discriminating power resulting in an assessment flow chart that may be used to detect invasive woody species (Table 1).

Table 1. Likelihood of an unknown woody species being invasive based on biological traits and the presence or absence of vertebrae dispersal opportunities where \( Z=23.39-0.63\sqrt{M}-3.88\sqrt{J}-1.09S \) and \( M=\) seed mass (mg), \( J=\) juvenile period (yr), and \( S=\) interval between large seed crops (yr) (after Rejmanek et al. 2005).

<table>
<thead>
<tr>
<th>Vertebrate dispersal opportunities</th>
<th>absent</th>
<th>present</th>
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<tr>
<td>( Z&gt;0 ) Dry fruits, seed &gt;3mg</td>
<td>likely</td>
<td>very likely</td>
</tr>
<tr>
<td>Dry fruits, seed &lt;3mg</td>
<td>likely (wet habitats)</td>
<td>likely (wet habitats)</td>
</tr>
<tr>
<td>Fleshy fruits</td>
<td>unlikely</td>
<td>very likely</td>
</tr>
<tr>
<td>( Z&lt;0 )</td>
<td>not, unless dispersed by water</td>
<td>possibly</td>
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Growth analysis comparing known invasive and non-invasive groups of related species revealed that size-independent growth rate (relative growth rate) may be a mechanism by which
invasive species are more competitive than their non-invasive counterparts (Table 2). Specifically, the morphological allocation of biomass to the rapid production of many thin leaves contributed most to the superior growth rate. Further, photosynthetic efficiency as assessed by net assimilation rate (NAR) was found to not be significantly different among the groups.

**TABLE 2.** Growth differences of 29 known invasive, non-invasive, and unclassified *Pinus* species where RGR is relative growth rate (mg g\(^{-1}\) d\(^{-1}\)), NAR is net assimilation rate (mg cm\(^{-2}\) d\(^{-1}\)), LAR is leaf area ratio (cm\(^{2}\) g\(^{-1}\) plant), SLA is specific leaf area (cm\(^{2}\) g\(^{-1}\) leaf) and RLPR is relative leaf production rate (leaves produced per leaf present per day) (after Grotkopp et al. 2002).

<table>
<thead>
<tr>
<th></th>
<th>Non-invasive</th>
<th>Unclassified</th>
<th>Invasive</th>
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<tr>
<td>RGR</td>
<td>23b*</td>
<td>33a</td>
<td>37a</td>
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<tr>
<td>NAR</td>
<td>0.505a</td>
<td>0.559a</td>
<td>0.572a</td>
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<tr>
<td>LAR</td>
<td>50b</td>
<td>67a</td>
<td>73a</td>
</tr>
<tr>
<td>SLA</td>
<td>79b</td>
<td>101a</td>
<td>111a</td>
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<tr>
<td>RLPR</td>
<td>0.014b</td>
<td>0.022a</td>
<td>0.024a</td>
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* Numbers in the same row sharing a letter are not significantly different at 5% level according to Scheffe’ Test.

Several of the significant biological traits associated with herbaceous invasive species were described over four decades ago in Baker’s 1965 list of ideal weedy characteristics for agroecosystems. Long-lived seed with variable dormancy prevents an entire population from committing to a single germination event. In ephemeral natural environments especially those that are water limited, germination following precipitation could be catastrophic if subsequent precipitation events were widely separated. Successful invaders have been described as generalists because 1.) a broad native range correlates with a broad invaded range, 2.) germination requirements can be easily met in a variety of environments, 3.) ability to produce seed early that is dispersed through a variety of biotic and abiotic mechanisms. Many of Baker’s ideal weedy traits match those that make alien ornamental plants invasive in natural settings. The matches illustrate the anthropocentric selection pressure that has resulted in creating our own problematic weeds following their escape into natural ecosystems.

Invasive plants in California provide many examples of exceptions to the “single set of traits” approach to predicting invasibility. There is a unique suite of ideal characteristics associated with each invaded ecosystem type in California. Finding moisture is the most significant challenge for any invasive species in California natural ecosystems. This is probably true for
invasive species in any state west of the 100th meridian. I have selected five representative ecosystems to illustrate some exceptional traits to those listed previously.

1. **AQUATIC:** Flotation devices such as the bulbous petioles of water hyacinth facilitate maximal photosynthesis in open air at the water surface where light and CO₂ levels are higher than under water. The plastic response to aerobic and anaerobic conditions exhibited by cultivated species may provide insight to how invasive species tolerate aquatic conditions. Examples include the large air-filled lacuna in the roots of submerged corn and the reduced matrix in the mitochondria of submerged rice obviate the need for the citric acid (TCA) cycle when oxygen is not present. These mechanisms of dealing with anoxic environments almost certainly exist in successful aquatic invaders. Hydrilla (*H. verticillata*) has no stomata and utilizes a C₄-like malate producing photosynthesis to concentrate CO₂ in low CO₂ environments, otherwise it utilizes the normal C₃ pathway, which does not expend the extra ATP when the advantages of C₄ photosynthesis are not necessary such as under high CO₂ conditions.

2. **OPEN CANOPY RIPARIAN:** Species that invade these habitats typically take advantage of the ecotone caused by seasonal flooding and drying which creates an opening between the aquatic and terrestrial environments. Giant reed (*Arundo donax*) is a species that can move into these ecozones and facilitate its own success due to its tolerance of a range of moisture levels. Its presence along waterways slows water flow along the water edge increasing sedimentation around shoot bases raising the water bed. This pushes water further up onto the stream bank allowing more giant reed to infest onto the bank and into the stream. As the waterway becomes shallower due to sedimentation and water is pushed up on the banks, giant reed eventually can infest from bank to bank. This species is not known to produce viable seed in California, and relies on a large rhizome that fragments and can survive submerged conditions for extended periods for dispersal.

3. **CLOSED CANOPY RIPARIAN:** Species invading these environments must be shade tolerant to be successful especially during the initial infestation stages. Tree species such as tree of heaven (*Ailanthus altissima*) spread short distances by prolific suckering and long distances by producing wind dispersed seed. The vine-like growth habit of cape ivy (*Delairea odorata*) allows this species to climb existing trees as if they were a trellis. Even though this species produces seed, it propagates primarily by fragmentation and subsequent establishment downstream.

4. **FOOTHILL GRASSLANDS:** Having a high water use efficiency (WUE, mol CO₂ fixed per mol H₂O transpired) is one way to be superior in water limited environments. Plants utilizing C₄ photosynthesis notoriously have a high WUE. Between 10-50% of summer grasses in California exhibit C₄ photosynthesis. However, annual exotic grasses that comprise much of the primary productivity in California grasslands are C₃ winter annuals that germinate,
establish and set seed quickly in response to the relatively short rainy season typical of California. Preemption of resource space seems to be the most successful strategy for these grasses. Yellow starthistle (Centaurea solstitialis), however, is adapted to efficiently extract water that becomes spatially separated from the shallower root systems of its competitors in the summer. It establishes early in the winter and remains a rosette while many of its grassy counterparts are producing seed. Starthistle develops a very deep tap root during the winter and spring months which will facilitate its success later in the summer when everything else has died and water is restricted to the deep soil layers. The success of these grass and thistle species is perpetuated by their adaptation to disturbances that characterize the foothill grassland ecosystem: fire, grazing and perhaps nutrient pulses associated with air pollution. The latter two (and perhaps the first) are associated with human.

5. COASTAL: Brooms, dune grasses, pampas/jubata grass, Eucalyptus, and iceplant illustrate unique traits of a successful invader in these ecosystems. Gorse and the brooms (primarily French, Spanish, and Scotch) are typically found just inland from and northerly along the California coast. These species possess traits that were attractive to the horticulture industry. They belong to the Fabaceae family and as such produce seeds with very hard seedcoats that contribute to their longevity and dormancy. Spatial dispersal of seed is associated with ants, birds, and rodents. The Cortaderia species, pampasgrass and jubatagrass, were propagated originally for ornamental purposes. They are prolific seed producers that establish readily in freshly disturbed soil combined with the trait of a shallow fibrous root system that perpetuates soil erosion and thus their continued success. The dune grasses, European beachgrass (Ammophila arenaria) and veldtgrass (Ehrharta calycina) were also propagated for human interests: dune stability and forage for grazing. Strong vertical and horizontal growth has resulted in the complete displacement of dune natives at some locations. Eucalyptus (E. globulus, Tasmanian bluegum) was also propagated for human associated interests but also possess characteristics that are well adapted to invade California coastal ecosystems. However, its capacity as a primary invader is questionable because it seems to require human assistance in the form of soil disturbance to displace natives. Its putative allelopathic properties may simply be due to a mulching effect from fallen leaves and bark. Its wind dispersed seed may be a more significant invasive characteristic. Highway iceplant (Carpobrotus edulis) was also planted originally for human interests, this time as a roadside soil stabilizer and ornamental. Its spread is attributed to vegetative fragmentation and to fruit-eating mammals.

SUMMARY:
The traits that have lead to the most successful invaders in representative California ecosystems originated with human activities and interests. After that, traits that confer an ability to be successful across a broad range (i.e. generalist), strong vegetative growth and temporally unpredictable reproduction seem to be ubiquitous among successful invaders. There are many
exceptions in California and they center on being able to efficiently acquire water when and
where it is available.

REFERENCES:
Grotkopp, E., M. Rejmanek, and T. Rost. 2002. Toward a causal explanation of plant
invasiveness: seedling growth and life-history strategies of 29 pine (Pinus) species. The
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Effect of Root Pruning Preemergence Herbicides on Root Morphology of Kentucky Bluegrass (Poa pratensis L.)

Sowmya Mitra¹ and Prasanta C. Bhowmik²

¹Department of Plant Science and Technology, California State Polytechnic University, Pomona, smitra@csupomona.edu, and ²Department of Plant Soil and Insect Sciences, University of Massachusetts, Amherst.

Introduction

Preemergence herbicides are used to control various annual grasses like large crabgrass [Digitaria sanguinalis (L.) Scop.], smooth crabgrass [Digitaria ischaemum (Schreb. ex Schweig.) Scerb. ex Muhl], yellow foxtail (Setaria lutescens Weigel.), green foxtail [Setaria viridis (L.) Beauv.], fall panicum (Panicum dichotomiflorum Michx.), barnyardgrass [Echinochloa crus-galli (L.) Beauv.], annual bluegrass (Poa annua L.), and goosegrass [Eleusine indica (L.) Gaertn.] in established cool-season turfgrasses like Kentucky bluegrass (Poa pratensis L.), perennial ryegrass (Lolium perenne L.) and creeping bentgrass (Agrotis palustris Huds.). The soil applied preemergence herbicides control weeds by inhibiting or pruning root meristems of germinating seedlings. Root pruning herbicides are those which inhibit root meristematic activity in susceptible plants by disrupting the cell division process. Susceptible plants include crabgrasses, foxtails and other grass species as well as several broadleaf weeds (Bhowmik 1996).

Dinitroaniline herbicides are a class of herbicides which are commonly used as preemergence herbicides in cool-season turfgrasses by binding to tubulin and inhibiting mitosis during the formation of microtubules (Bhowmik and Bingham, 1990). The effects often observed in dinitroaniline treated grass roots is abnormal swelling of root tips leading to nonemergence of germinating seedlings, stunting of plants with lack of lateral roots or severely pruned roots in the herbicide treated-zone. Emerged grass shoots are thick and stunted, often with a purple or reddish discoloration (Bhowmik, 1996).

Other classes of herbicides have similar effects on turfgrass roots. Dithiopyr, a pyridine class herbicide, inhibits mitosis by binding to another protein that may be a microtubule associated protein (MAP). Dithiopyr results in shortening of microtubule that can form spindle fiber and results in club-shaped root tips. Isoxaben, a benzamide class herbicide, affects cell division in root meristematic regions by inhibiting cell wall biosynthesis in susceptible plants. DCPA inhibits mitosis by affecting phragmoplast microtubule arrays and cell wall formation. Bensulide inhibits root elongation and cell division and may directly inhibit mitosis, resulting in binucleated cells (Bhowmik, 1996).

Prodiamine and oryzalin have been reported to reduce ‘Tifgreen’ bermudagrass root growth. These dinitroaniline herbicides decreased root weight at low concentration (4 ppb by
weight) in a fine textured soil while higher concentration (8 ppb) was required in coarser soil texture (Frederick and Coats, 1993). Long-term exposure to dinitroaniline herbicides like pendimethalin and oryzalin on bermudagrass have been reported to suppress the growth of sprigs which can last up to six to eight weeks and can potentially cause genetic change in triploid bermudagrasses (Goatley et al. 2003). Kaminski et. al. (2004) reported reduced seedling emergence and reduced cover of creeping bentgrass (*Agrostis palustris* L.) in the spring following an autumn application of prodiamine at 0.36 kg. a.i. ha\(^{-1}\). Researchers have reported the adverse effects of prodiamine on the spring recovery of Tifway bermudagrass when the herbicide was applied in the autumn of the previous year. In the same study pendimethalin had lesser and briefer suppressive effects than prodiamine on the sprig establishment of Tifway bermudagrass (Fagerness et. al., 2002).

The objective of the research project was to evaluate the effects of various preemergence herbicides on tiller production, rhizome, root growth and development of ‘Baron’ Kentucky bluegrass and to study the effect of different rates of the herbicide on the root growth and development.

**MATERIALS AND METHODS**

**Experiment 1.**

Experiments were conducted at the University of Massachusetts Turfgrass Research Center, South Deerfield, MA in 1987 and 1988. Preemergence herbicides were applied on ‘Baron’ Kentucky bluegrass to evaluate large crabgrass control and their response on Kentucky bluegrass tiller production and root morphology. Benefin (2.2 kg a.i. ha\(^{-1}\)), benefin and trifluralin pre-mix combination (2.2 kg a.i. ha\(^{-1}\)), pendimethalin (1.7 kg a.i. ha\(^{-1}\)), prodiamine (0.5 kg a.i. ha\(^{-1}\)), and flumetralin (0.8 kg a.i. ha\(^{-1}\)) were applied on 22 April 1987 and 25 April 1988 with a CO\(_2\)-backpack sprayer using Teejet XR 11004 VS nozzles at 152 kPa with a carrier volume of 450 L ha\(^{-1}\).

**Experiment 2.**

Separate experiments were conducted with benefin, pendimethalin and prodiamine applied at three different rates on ‘Baron’ Kentucky bluegrass in the field. Benefin was applied at 2.0, 3.0, and 4.0 kg a.i. ha\(^{-1}\), pendimethalin was applied at 1.5, 3.0, and 4.5 kg a.i. ha\(^{-1}\), and prodiamine was applied at 0.5, 1.0 and 2.0 kg a.i. ha\(^{-1}\) on 22 April 1987 and 25 April 1988. A 0.25 m\(^{-2}\) quadrant was randomly tossed in the plots and the number of large crabgrass was counted and recorded every other week. The numbers were converted to plants m\(^{-2}\). Percent turf injury and percent large crabgrass control were evaluated visually weekly until 8 weeks after application. The percent turf injury was based on the injury to individual plants. Tiller numbers, rhizome numbers, root dry weight and tiller dry weight was recorded at 4, 8, and 12 weeks after treatment (WAT). The data collected from the 0.25 m\(^{-2}\) quadrant was converted into g m\(^{-2}\) for the root dry weight and tiller dry weight, while the tiller numbers and rhizome numbers were reported in numbers m\(^{-2}\).
Experiment 3.

The effect of five dinitroaniline herbicides, benefin (2.2 kg a.i. ha\(^{-1}\)), benefin and trifluralin combination (2.2 kg a.i. ha\(^{-1}\)), pendimethalin (1.7 kg a.i. ha\(^{-1}\)), prodiamine (0.5 kg a.i. ha\(^{-1}\)), flumetralin (0.8 kg a.i. ha\(^{-1}\)) on Kentucky bluegrass root growth was examined 4 weeks after treatment (WAT). One hundred twenty mm diameter plugs were removed from the field and planted in 150 mm diameter plastic pots in bleached sand in the greenhouse. The plants were irrigated to avoid any moisture stress and were fertilized every month with a liquid application of 20-20-20 fertilizer. Tiller numbers, dry weight of tillers, rhizome numbers, root length and root dry weight were measured at 4, 8 and 12 WAT.

The data was analyzed with analysis of variance with the general linear model (proc glm program of SAS). Normality and significance at \(\alpha \leq 0.05\) and \(\alpha \leq 0.01\) were calculated. Means were separated using Duncan’s New Multiple Range Test (DNMRT) (\(\alpha = 0.05\)) and Fishers protected least significant difference (LSD) (\(\alpha = 0.05\)). Regression analysis was used to explain the effect of rates of herbicides on tiller numbers, rhizome numbers, dry weight of tillers, and dry weight of roots.

RESULTS AND DISCUSSION

All five dinitroaniline herbicides provided over 92% large crabgrass control. The control plots had a dense stand of large crabgrass (220 plants m\(^{-2}\)) compared to no plants in the pendimethalin and prodiamine treated plots. The effect of the dinitroaniline herbicides on root regrowth of ‘Baron’ Kentucky bluegrass was evaluated in the greenhouse. After 4 weeks of regrowth the root length for all the herbicide applications was not significantly different than the control or each other in the first year (1987). In 1988 the prodiamine application at 0.5 kg a.i. ha\(^{-1}\) resulted in the shortest root length compared to the untreated control and all the other herbicide applications. There was no difference between the other herbicide treatments. In the first year of the study (1987) highest root dry weight was observed with the pendimethalin application at 1.7 kg a.i. ha\(^{-1}\) compared to all the other herbicide treatments. There was no significant difference between the pendimethalin treatment and the untreated control. All the other herbicide treatments had lower root dry weights compared to the control but were not significantly different from each other. In the second year of study the benefin and trifluralin treatment at 2.2 kg a.i. ha\(^{-1}\) had the lowest root dry weight compared to the control but there was no significant difference between the herbicide treatments.

Turf injury on ‘Baron’ Kentucky bluegrass with benefin, benefin and trifluralin combination, pendimethalin, prodiamine, and flumetralin was evaluated at 6 and 8 WAT of the preemergence herbicides. In the first year of study the benefin and trifluralin combination applied at 4.0 kg a.i. ha\(^{-1}\) resulted in 18% and 23% injury to ‘Baron’ Kentucky bluegrass at 6 and 8 WAT, respectively. There was no significant difference in the level of injury between the benefin and trifluralin, pendimethalin at 4.5 kg a.i. ha\(^{-1}\), and prodiamine at 2.0 kg a.i. ha\(^{-1}\) applications at the 6 WAT. At 8 WAT the benefin and trifluralin treatment reported highest turf

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injury followed by the prodiamine treatment applied at 2.0 kg a.i. ha\(^{-1}\), but there was no significant difference between the two treatments. Benefin applied at 4.0 kg a.i. ha\(^{-1}\), pendimethalin at 4.5 kg a.i. ha\(^{-1}\), and flumetralin at 3.0 kg a.i. ha\(^{-1}\) had higher levels of injury compared to the control but there was no difference between the treatments.

In the second year of study the benefin and trifluralin combination applied at 4.0 kg a.i. ha\(^{-1}\) and the prodiamine treatment at 2.0 kg a.i. ha\(^{-1}\) resulted in highest injury at the 6 and 8 WAT. Turf injuries for all the other herbicide applications were not significantly different than each other but were significantly higher than the control. The difference in the level of injury to ‘Baron’ Kentucky bluegrass between the two years may be due to higher 1988 spring temperatures compared to 1987. All the herbicide treatments at the high rates of application resulted in significantly higher levels of turf injury compared to the control at the 6 and 8 WAT for both the years.

The effect of different rates of benefin, pendimethalin, and prodiamine on the tiller numbers m\(^{-2}\), rhizome numbers m\(^{-2}\), root dry weight and tiller dry weight (g m\(^{-2}\)) of ‘Baron’ Kentucky bluegrass was recorded at 4, 8, and 12 WAT. Application of the label rate of benefin (2.0 kg a.i. ha\(^{-1}\)) lead to an increase in tiller numbers at 8 and 12 WAT compared to the control. Higher rates of benefin (3.0 and 4.0 kg a.i. ha\(^{-1}\)) resulted in a decrease in tiller numbers at 8 and 12 WAT. At the 4 WAT benefin application at 3.0 kg a.i. ha\(^{-1}\) resulted in highest tiller numbers compared to the other rates of application and control. The rhizome numbers decreased with increasing rate of application of benefin at 8 and 12 WAT. The root dry weight and tiller dry weight of ‘Baron’ Kentucky bluegrass increased when benefin was applied at 2.0 kg a.i. ha\(^{-1}\) and then decreased as the rate of benefin increased to 3.0 and 4.0 kg a.i. ha\(^{-1}\) at the 4, 8 and 12 WAT (Figures 1, 2, 3).

The tiller numbers and rhizome numbers decreased as the rate of pendimethalin increased from 1.5 to 3.0 and 4.5 kg a.i. ha\(^{-1}\) at 4, and 12 WAT. The tiller numbers increased with the application of pendimethalin at 1.5 kg a.i. ha\(^{-1}\) compared to the control and then decreased as the rates increased to 3.0 and 4.0 kg a.i. ha\(^{-1}\) at 8 WAT. There was no significant difference in rhizome numbers, root dry weight and tiller dry weight between the treatments at 8 WAT (Figures 4, 5, 6).

Higher rates of prodiamine (1.0 and 2.0 kg a.i. ha\(^{-1}\)) resulted in lower tiller numbers, rhizome numbers, root dry weight and tiller dry weight compared to the control at 12 WAT. Rhizome numbers at 8 WAT, root dry weights at 4 WAT, tiller dry weights at 4 and 8 WAT were not significantly different than the control and each other. Tiller numbers increased with the application of prodiamine at 0.5 kg a.i. ha\(^{-1}\) compared to the control at 4 and 8 WAT (Figures 7, 8, 9).
Figure 1. Effect of benefin on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 4 weeks after treatment.
Figure 2. Effect of benfin on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 8 weeks after treatment.
**Figure 3.** Effect of benefin on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 12 weeks after treatment.
Figure 4. Effect of pendimethalin on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 4 weeks after treatment.
Figure 5. Effect of pendimethalin on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 8 weeks after treatment.
**Figure 6.** Effect of pendimethalin on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 12 weeks after treatment.
Figure 7. Effect of prodiamine on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 4 weeks after treatment.
Figure 8. Effect of prodiamine on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 8 weeks after treatment.
Figure 9. Effect of prodiamine on the tiller numbers, rhizome numbers, dry weight of tillers and dry weight of roots of Kentucky bluegrass as observed 12 weeks after treatment.
REFERENCES


Northern Willowherb Control in Nursery Containers

James Altland

North Willamette Research and Extension Center
Oregon State University
Aurora, OR 97002
James.Altland@oregonstate.edu

Introduction

Northern willowherb (Epilobium ciliatum Rafin, syn. E. adenocaulon Hauss.) is a perennial in the family Onagraceae and is native to North America. Northern willowherb is one of the most prevalent weed species in west coast container nurseries and is becoming increasingly problematic in cooler regions along the east coast. E. ciliatum is wrongly, but commonly, referred to as fireweed by many west coast nurserymen. Northern willowherb is also known by the common names hairy willowherb, slender willowherb, or fringed willowherb depending on the region where it is found.

A single plant can produce up to 60,000 seeds per plant per season. Seeds are attached to a tuft of hair which aid in wind dispersal allowing for widespread seed dissemination in container nurseries. Northern willowherb germinates in dry to water logged soils, and is particularly well suited for establishing in dry soils compared to other species in the same genera. Northern willowherb seeds germinate readily in full sun (100%) or darkness (84%), making them well adapted to germination in containers with little or complete cover from crop canopies. Seeds can germinate over a range of temperatures from 4 to 36°C, although germination is reduced as temperatures approach 30°C. This allows for germination to occur throughout the spring and summer growing season in northern climates, and virtually year-round in protected container crops. It also explains why its spread has been primarily limited to cooler summer climates typical of the west coast and northeast U.S. Northern willowherb seed that mature during the summer have no dormancy. Germination of seed from recently ripened seed pods occurred within four days of sowing (personal observation). Plants can flower in 5 to 6 weeks and then produce mature seed 4 weeks later. This species only requires 9 to 10 weeks for seeds to germinate, mature, and produce another generation of seeds. This allows multiple generations during a single growing season in most nursery producing regions.

This species demonstrates strong apical dominance growing rapidly up to 1.5 m tall; taller than all other common container weeds and many crops common to container production. Rapid growth allows this weed to out-compete many smaller container shrubs and herbaceous perennials for light.

While some European research has addressed control of this weed in orchard systems and other field-grown crops, none has addressed its control in nursery containers. The objective of these experiments was to identify effective preemergence herbicides currently labeled in the U.S. for control of northern willowherb in nursery containers.
Materials and Methods

Experiment 1. On May 6, 2004, #1 containers were filled with 100% Douglas fir (Pseudotsuga menziesii (Mirbel) Franco) bark amended with 9.5 kg/m$^3$ Osmocote 18-6-12 and 0.9 kg/m$^3$ Micromax micronutrients. Granular herbicides (Table 1) were applied May 17 with a handheld shaker. All herbicides were applied at the highest labeled rate. A non-treated control group was also maintained. Containers were irrigated immediately after herbicide application with 1.2 cm water and thereafter with the same volume split in two equal applications per day. Twenty northern willowherb seeds were applied to each container May 18. There were eight single pot replications per treatment arranged in a completely randomized design.

Experiment 2. On July 28, 2004, #1 containers were filled with the same substrate used in Expt. 1. Herbicides (Table 2) were applied to all containers July 30. Sprayed herbicides were applied with a CO$_2$ backpack sprayer equipped with a three-nozzle boom containing 8004 flat fan nozzles. The sprayer was set at 2.46 kg/cm$^2$ and calibrated to deliver 467 L/ha. Granular herbicides were applied with a handheld shaker. Herbicides were applied to 12 containers per treatment. Seeds were applied to six of the 12 containers immediately after herbicide application (0 WAT), then to six different containers per treatment at 4 WAT. All containers were arranged in completely randomized design.

Results and Discussion

Experiment 1. Ronstar G, OH2, and RegalStar reduced northern willowherb numbers 3 WAT the most (Table 1). Snapshot, Kansel+ and RegalKade did not reduce weed numbers compared to non-treated controls. While OH2 reduced weed numbers 3 WAT, subsequent growth of those weeds was similar to non-treated controls by 8 WAT. Ronstar G numerically reduced weed growth the most, but was similar to Rout, BroadStar, and RegalStar. Northern willowherb control seemed to be responsive to oxadiazon rate. Ronstar G, RegalStar, and Regal O-O reduced SDW by 89, 63, and 33%, respectively, compared to non-treated controls. Ronstar G contains 2% oxadiazon resulting in 4.48 kg/ha oxadiazon; RegalStar contains 1% oxadiazon resulting in 2.24 kg/ha oxadiazon; Regal O-O contains 1% oxadiazon and thus only 1.12 kg oxadiazon/ha was applied.

Experiment 2. Among containers in which seeds were applied immediately after herbicide application, Ronstar G reduced weed numbers in containers through 4 WAT more than all other herbicides (Table 2). Among granular herbicides, Ronstar G reduced weed numbers lower than Rout and RegalKade throughout the experiment, both of which did not reduce weed numbers compared to non-treated controls. This concurs with other research by the author, in which Ronstar G consistently reduced weed number and shoot dry weight compared to RegalKade and Rout, although differences weren’t always significant.

At 1 WAT and throughout the experiment, adding Gallery to Devrinol, Barricade, or Surflan did not improve control over any of those herbicides alone (Table 2). Furthermore, Gallery alone did not reduce weed numbers compared to non-treated controls. Devrinol with or without Gallery did not reduce weed numbers compared to non-treated controls; however, weed
heights in these containers were small. Surflan treatments reduced weed numbers compared to non-treated controls, although weed numbers were still relatively high. However, SDW data show that established seedlings were not able to grow far beyond the cotyledon stage. Devrinol alone and Devrinol + Gallery reduced SDW by 91% and 83%, respectively. While there were weeds in the Surflan + Gallery treated pots, these weeds were so small that average SDW rounded to 0.0 g.

Among containers in which seeds were applied 4 WAT, no sprayed herbicides reduced weed numbers throughout the experiment compared to non-treated controls. However, all sprayed treatments except for Gallery alone reduced weed SDW. Surflan provided effective preemergence northern willowherb control in terms of growth reduction. Ronstar G reduced weed number more than all other herbicide treatments and reduced SDW numerically lower than other treatments.

In summary, northern willowherb disseminates seeds via wind and thus a few local plants have the potential to infest many containers. Where appropriate, granular Ronstar G should be applied soon after potting new plants or hand-weeding existing plants. Ronstar G provided the most effective control in terms of reduction of northern willowherb seedlings and their subsequent growth. While Ronstar G provided excellent control of northern willowherb, the active ingredient oxadiazon is not effective on all weed species. It is particularly ineffective on weeds in the family Caryophyllaceae, most notable are pearlwort (Sagina procumbens) and chickweed (Stellaria media) which commonly infest nursery containers.

The authors recommend that nursery producers aggressively control northern willowherb plants growing within and around the production site using a combination of hand pulling or postemergence applications of glyphosate. Ronstar G can be used in containers to prevent establishment within the crop, particularly in mid-summer when plants in surrounding areas are mature and disseminating seeds into the production site. Ronstar G can be used in rotation with other labeled preemergence herbicides.

**Literature**


<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Common name</th>
<th>Rate (kg ai/ha)</th>
<th>Number(^\text{2})</th>
<th>SDW (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BroadStar</td>
<td>flumioxazin</td>
<td>0.42</td>
<td>2.9 cd(^\text{x})</td>
<td>10.2 bcd</td>
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<td>Kansel+</td>
<td>oxadiazon+pendimethalin</td>
<td>3.64</td>
<td>7.6 ab</td>
<td>18.4 ab</td>
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<td>OH2</td>
<td>oxyfluorfen+pendimethalin</td>
<td>3.36</td>
<td>2.0 de</td>
<td>14.5 abc</td>
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<td>Regal O-O</td>
<td>oxyfluorfen+oxadiazon</td>
<td>3.36</td>
<td>4.8 bcd</td>
<td>13.9 abc</td>
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<td>RegalStar</td>
<td>oxadiazon+prodiamine</td>
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<td>1.6 de</td>
<td>7.8 cd</td>
</tr>
<tr>
<td>RegalKade</td>
<td>prodiamine</td>
<td>1.68</td>
<td>6.3 abc</td>
<td>12.0 bc</td>
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<tr>
<td>Ronstar G</td>
<td>oxadiazon</td>
<td>4.48</td>
<td>0.1 e</td>
<td>3.0 d</td>
</tr>
<tr>
<td>Rout</td>
<td>oxyfluorfen+orzyzalin</td>
<td>3.36</td>
<td>2.4 d</td>
<td>9.6 cd</td>
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<tr>
<td>Snapshot 2.5TG</td>
<td>isoxaben+trifluralin</td>
<td>5.6</td>
<td>6.9 ab</td>
<td>12.7 abc</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>9.8 a</td>
<td>20.8 a</td>
<td></td>
</tr>
</tbody>
</table>

\(^{2}\) Number of northern willow herb germinated in containers. Data were square root transformed prior to analysis, but actual data are presented.

\(^{\text{x}}\) Weeks after treatment.

Means with the same letter within a column are not different according to Fisher's Protected LSD ($\alpha = 0.05$).
Table 2. Preemergence northern willowherb (*Epilobium ciliatum*) control with granular and sprayed preemergence herbicides.

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Common name</th>
<th>Rate (kg ai/ha)</th>
<th>Seeds applied 0 WAT</th>
<th>Seeds applied 4 W AT</th>
<th>Seeds applied 8 W AT</th>
<th>Seeds applied 12 W AT</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Rate</td>
<td>Number(^a)</td>
<td>Number(^b)</td>
<td>SDW (g)</td>
<td>Number(^c)</td>
</tr>
<tr>
<td>Granular products</td>
<td></td>
<td></td>
<td>1 WAT</td>
<td>4 W AT</td>
<td>8 W AT</td>
<td>8 W AT</td>
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<tr>
<td>RegalKade</td>
<td>prodiamine</td>
<td>1.68</td>
<td>10.3 ab(^x)</td>
<td>10.3 bcd</td>
<td>14.3 a</td>
<td>8.8 ab</td>
</tr>
<tr>
<td>Ronstar G</td>
<td>oxadiazon</td>
<td>4.48</td>
<td>1.7 d</td>
<td>2.2 e</td>
<td>3.5 cd</td>
<td>1.8 c</td>
</tr>
<tr>
<td>Rout</td>
<td>oxyfluorfen+oryzalin</td>
<td>3.36</td>
<td>7.3 bc</td>
<td>9.0 cd</td>
<td>14.2 a</td>
<td>6.5 b</td>
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<tr>
<td>Sprayed products</td>
<td></td>
<td></td>
<td>6.72 + 1.12</td>
<td>8.7 ab</td>
<td>11.5 abc</td>
<td>2.6 d</td>
</tr>
<tr>
<td>Devrinol + Gallery</td>
<td>napropamide + isoxaben</td>
<td>1.68 + 1.12</td>
<td>8.2 bc</td>
<td>8.5 cd</td>
<td>7.6 bc</td>
<td>10.0 ab</td>
</tr>
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<td>Barricade + Gallery</td>
<td>prodiamine + isoxaben</td>
<td>4.48 + 1.12</td>
<td>4.2 c</td>
<td>6.7 d</td>
<td>0.0 d</td>
<td>12.8 a</td>
</tr>
<tr>
<td>Surfian + Gallery</td>
<td>oryzalin + isoxaben</td>
<td>6.72</td>
<td>10.5 ab</td>
<td>13.3 ab</td>
<td>1.4 d</td>
<td>13.3 a</td>
</tr>
<tr>
<td>Devrinol</td>
<td>napropamide</td>
<td>1.68</td>
<td>10.0 ab</td>
<td>9.2 cd</td>
<td>11.0 ab</td>
<td>11.5 a</td>
</tr>
<tr>
<td>Barricade</td>
<td>prodiamine</td>
<td>4.48</td>
<td>6.0 bc</td>
<td>8.0 cd</td>
<td>0.4 d</td>
<td>11.5 a</td>
</tr>
<tr>
<td>Surfian</td>
<td>oryzalin</td>
<td>1.12</td>
<td>9.8 ab</td>
<td>14.2 ab</td>
<td>13.4 a</td>
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</tr>
<tr>
<td>Control</td>
<td>isoxaben</td>
<td>1.12</td>
<td>15.5 a</td>
<td>15.1 a</td>
<td>11.5 a</td>
<td>2.8 a</td>
</tr>
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</table>

Contrast analysis

| RegalKade vs. Barricade | NS | NS | NS | NS | NS |
| Gallery +/-             | NS | NS | NS | NS | NS |

\(^a\) Weeks after treatment.

\(^b\) Number of northern willowherb germinated in containers. Data were square root transformed prior to analysis, but actual

\(^c\) Means within a column with the same letter are not different, Duncan's multiple range test (\(\alpha = 0.05\)).
Pre-Plant Drip Applied Fumigation

James S. Gerik
USDA-ARS
9611 S Riverbend Ave.
Parlier, CA 93654

Abstract

Trials were conducted in the coastal areas of California to test methyl bromide alternatives, applied by drip irrigation, for the production of cut flowers and bulbs. Drip applications can be used on the small plot size normally treated with the methyl bromide hot gas method, can be grower applied, and can better distribute chemicals with relative low vapor pressure. Chemicals tested included chloropicrin, iodomethane, 1,3-dichloropropene, metham sodium, sodium azide, furfural, and dimethyl disulfide. The chemicals were tested either alone or in various combinations. Weed control was good in 2 calla lily rhizome nursery trials. All the treatments controlled weeds relative to the control, except for sodium azide which did not control nutsedge. In a snapdragon trial none of the tested chemicals controlled malva, clover or groundsel. Cudweed was controlled by the InLine (1,3-dichloropropene + chloropicrin) treatment, but the rest of the treatments were not statically better than the control. Only furfural plus metham sodium controlled sowthistle better than the control. Weed control was lacking in 2 liatris trials. None of the treatments controlled Malva, pigweed, clover, lambsquaters, groundsel, or field bindweed. Most of the treatments controlled mustard and knotweed better than the control, but control was still not good. In three freesia trials weed control was only fair. In the first trial various rates of InLine fro 20 to 56 gpa did not control chickweed, but did control mustard. In a second trial, Midas (iodomethane + chloropicrin) controlled both chickweed and bitter-cress. In a third trial various Midas formulations and rates controlled weeds better that the control, but not well. It is concluded that weed control will be the most challenging aspect of growing cut flower and other ornamental crops without methyl bromide. The best treatments will include metham sodium, either at the time of initial application, or as a sequential application.
Plastic Mulches – It’s not just Black or White

Cheryl A. Wilen, Area IPM Advisor, UC IPM and UCCE San Diego County, 5555 Overland Ave. Ste. 4101, San Diego, CA 92123 cawilen@ucdavis.edu

A mulch is a material that covers the soil surface, shades the ground, and physically hinders germinating weed seedlings. In general, it is considered a mechanical method of weed control but there are many other physical and biological plant and insect responses to plastic mulches.

- Mulches may be used to:
  - Manipulate temperature
  - Manipulate light
  - Manipulate soil moisture
  - Reduce insect feeding and disease transmission

In agricultural fields, black plastic is the most widely used because of weed control and soil warming properties but clear plastic is often used in the winter to keep and retain heat. When clear plastic is used, herbicides, preplant fumigation, or solarization must be used to reduce weed pressure.

Just as black and clear mulches can raise soil temperatures, white, white-on-black, or silver reflective mulches may slightly decrease soil temperature because they reflect back most of the incoming solar radiation.

Ranunculus are grown in coastal San Diego County. This flower crop is seeded in late fall and grown through the winter for cut flowers production and the bulbs are harvested in the summer. Unfortunately, the major weed species, various clovers, germinate in cool soil temperatures and grow highly competitively alongside the crop. Fumigation by methyl bromide or methyl bromide replacements is ineffective for preplant control of the clovers due their hard seed coat. Additionally, there are no herbicides, either PRE or POST that will control clovers without injuring the crop.

We decided to try to manipulate soil temperature by lowering it to stimulate clover germination and then use a contact herbicide to kill the emerged clover prior to planting the ranunculus. We selected white, white over black and reflective silver over black plastics. These were compared to clear and black plastic mulches and bare ground.

Plastics were put in place on raised beds with 24” bed top on August 20, 2006. Each plot was 20’ long with 4 replications. Dataloggers were placed 2” deep under the plastics. Soil
temperature data for August 21 to October 9, 2006 are shown below (Figure 1). Air temperature points are from the La Jolla CIMIS station. Data show that the reflective mulch provided the lowest soil temperature, providing a mean decrease in soil temperature of 1.76°F and a maximum of 3.86°F as compared to bare soil.

Figure 1. Soil (2” below surface) temperature as influenced by mulch type and air temperature August 21 to October 9, 2006 in San Diego, Ca.

Plastics were removed on October 9 and weed cover evaluated 17 days later. While there was insufficient amount of clover to make statistically valid comparisons, we did find that the type of plastic had a significant effect on cover from creeping spurge and mallow (Table 1). Fescue was also in the plots but data is not shown here. Creeping spurge was not controlled using black plastic and appeared to be stimulated by white and clear plastics. However, both the reflective and white on black mulches provided excellent creeping spurge control. All mulches provided good mallow control.
Table 1. Mean percentage weed cover 17 days after plastic mulch removal.

<table>
<thead>
<tr>
<th>Plastic Type</th>
<th>Total % Weed Cover</th>
<th>Creeping spurge</th>
<th>Mallow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare ground</td>
<td>58.00</td>
<td>10.63 a</td>
<td>39.5 b</td>
</tr>
<tr>
<td>Black</td>
<td>12.38</td>
<td>10.00 a</td>
<td>0.875 a</td>
</tr>
<tr>
<td>Clear</td>
<td>34.38</td>
<td>32.50 b</td>
<td>0.125 a</td>
</tr>
<tr>
<td>Reflective</td>
<td>3.25 a</td>
<td>1.25 a</td>
<td>0.875 a</td>
</tr>
<tr>
<td>White</td>
<td>79.38</td>
<td>63.13 c</td>
<td>4 a</td>
</tr>
<tr>
<td>White on black</td>
<td>7.63 a</td>
<td>0.00 a</td>
<td>5.5 a</td>
</tr>
</tbody>
</table>

Means followed by the same letter in a column are not significantly different at the P=0.05 level by Fisher’s protected t-test.

Because this trial was designed for a different purpose, we do not have data to explain the differences. However, mallow control may due to either heating or a physical obstruction to growth. The increase of creeping spurge under white plastic and the exceptional control under the reflective and white on black plastics is more difficult to explain. More studies are needed to understand these responses.
Monrovia Growers is a large, wholesale nursery company with six locations in California, Georgia, North Carolina, Ohio, and Oregon. Over 22 million containerized plants are produced annually on approximately 2,000 acres. The product line consists of over 2,200 varieties of trees, shrubs, vines, and perennials. The nursery environment presents an optimal environment for weed growth, with frequent irrigation and relatively high fertility. Consumers demand plants that are free of diseases, pests, and weeds. Therefore, weed control is an important aspect of nursery operations.

Monrovia uses an integrated approach to weed control, employing cultural and chemical controls. Cultural methods of weed control include the use of clean planting stock, use of clean planting media, hand weeding, and mulches and barriers.

Clean planting stock is the first line of defense against weed infestation. Starter plants, or liners, are grown at high density and are difficult to weed by hand. Most plants are propagated from cuttings in coarse rooting media, and therefore root-inhibiting herbicides are generally not used in the propagation stage. These clean liners must be planted into clean potting media. Media can become contaminated with seed from contaminated ingredients or from weeds growing on or near stored soil piles. Green waste, including weeds, is recycled at the nursery and used in the potting media. Weeds in this green waste are a potential source of seed. Therefore the green waste is composted, with the heat of composting providing the heat necessary to kill seed. We have conducted numerous trials to ensure that weed seeds are effectively killed during composting.

Monrovia makes extensive use of hand weeding. Each block of plants is weeded approximately once a month. Weeding teams track their progress through the nursery to ensure that all areas are routinely covered. Pulled weeds are bagged and removed from the area to eliminate sources of weed seed.

Mulches and barriers are widely used in landscapes for weed control, and in recent years we have used them at the nursery as well. Plastic and weed barrier cloth is used to cover the growing grounds and prevent weed growth underneath and between the containers. However, mulches are also applied directly to the containers. Mulches may consist of bulk products such as bark or nut shells that are spread on the surface of the container. Weed control disks are also available which are specifically designed for placement on nursery containers. These products
may be manufactured from natural or man-made materials. These disks are effective, but are labor-intensive to apply and can blow-off the container in windy conditions. Furthermore, they often have to be removed before plants are shipped to the customer.

Despite the use of cultural weed control methods, chemical control is a necessity. A combination of cultural and chemical control results in the lowest overall cost. Monrovia Growers uses most of the preemergent herbicide active ingredients currently labeled for nursery use. Sprayable formulations are used when practical, as this is the least expensive method of application in terms of the cost of product and labor. Large 50 ft. boom sprayers are used to apply these sprayable formulations in most cases. This is a very efficient application method when there are large blocks of plants that receive the same herbicide. However, in many cases there are small blocks of plants that require herbicide treatment. The large boom sprayer is not well suited for these situations, and therefore the nursery also uses granular herbicides. Granulars are also used under shade houses, as the support poles prevent the use of large booms. Granular herbicides are applied with hand-crank broadcast spreaders.

Many plant species grown at the nursery are not listed on product labels. It is even more unlikely that the specific cultivars produced would be listed. Therefore, Monrovia has had a phytotoxicity testing program in place for many years to test herbicide safety. To date, we have tested about 14,000 plant/herbicide combinations. Herbicides are typically tested at elevated rates, with multiple applications over one growing season.

Monrovia Growers recycles irrigation water at most of its nurseries. Herbicides may be recycled with the water and subsequently applied to sensitive crops. We have experienced plant damage from trace levels of herbicides in irrigation water on several occasions in the past. Therefore, care must be taken to avoid extensive use of herbicides with high water solubility, and to limit the use of certain active ingredients that have potential for damage.

Postemergent herbicides are also used at the nursery. The primary use is for spot-spraying weeds on gravel bed surfaces and in non-crop areas. Preemergent is usually tank mixed with postemergent herbicide. We have determined that weed seeds can splash from bed surfaces into the containers, and therefore weed control on the bed surface is an important part of the overall control strategy. Applicators track their progress through the nursery to make certain that all areas are spot-sprayed about once a month.

Control methods must be coordinated for most effective results. For example, plants should be hand-weeded and weeds on the ground should be sprayed before preemergent herbicide is applied. Weed infestations at the nursery can be kept to a minimum with the disciplined use of cultural and chemical control methods.
Herbicide Registration of Vegetables

Cindy L. Baker
Gowan Company
370 South Main Street
Yuma, AZ 85364
Email address: cbaker@gowanco.com

Background: Herbicides are a critical piece of any integrated pest management program. Having as many effective tools as possible is good for weed control and resistance management. For many different reasons discussed in this paper and described in the presentation, there are challenges that must be addressed by registrants in bringing effective and affordable herbicides to the market for the vegetable industry. The presentation will focus on the costs and regulatory hurdles that must be successfully navigated to register and bring to market a herbicidal product. It will also address the specific challenges related to adding vegetable crops for a herbicide.

Registering a new Active Ingredient. Most R&D companies screen many molecules before deciding to develop and register one for sale. A tremendous amount of work and money goes into research. It is estimated that R&D companies spend over 7% of their sales just on R&D and certainly very few actually make it as candidates for products and even fewer through the regulatory and development process to become registered. A new product takes 8-9 years to bring to market and can cost close to $200 million dollars. The presentation will describe and illustrate the typical flow of activities a basic manufacturer must go through to bring a product successfully to the market.

Registration in California. Once you successfully navigate and generate all the data necessary to obtain a registration from the U.S. Environmental Protection Agency (EPA), you must still obtain registration from the California Department of Pesticide Regulation (CDPR). There are some California specific data requirements that are necessary before a CA registration can be obtained. While most of these data may be generated through the standard development and registration process, some are unique to California and can add to the typical cost of registering a product. In recent years, CDPR has been working with US EPA to do concurrent reviews or even do some reviews for EPA to allow for products to receive simultaneous approval or at least receive CA approval pretty quickly after US EPA approval so that California growers don’t have the long delays they have had in the past in gaining access to new tools. There is still progress that can be made on this front but things have improved.
Registering Vegetable Uses. Most R&D companies when considering to develop and register a new herbicide look to large acre crops first to see if they can recover their investment—soybeans or corn for example. It usually isn’t until later in the marketing and development plan that they consider expansion into vegetable crops. There are many factors that must be considered when adding a new use to any label but vegetable crops bring some unique considerations especially for herbicides. A company must consider the technical fit—will the product control the weed spectrum in the vegetable crop. Are their unique features of the soil type of vegetable growing practices the influence the effectiveness of the herbicide for example? Can the company recover an acceptable return on its investment? What about crop safety? What about plant back issues since vegetable crops often have shorter growing seasons the grower is likely to rapidly plant back to another crop. Will the herbicide affect the follow on crop? Often smaller companies, organizations like IR-4 or commodity groups can assist with the generation of data necessary to register on vegetable crops—many times considered minor crops.

Other Issues to Consider. In addition to deciding about whether to register a product for use on vegetables, companies must consider the stewardship and development that is unique to a herbicide used on high value specialty vegetables. Things like weed spectrum, crop safety, residual in soil with respect to plant back, crop groupings versus individual crops, the rapid development of cultural varieties, all the possible tank mixes, etc. Additionally, companies must consider their ability to protect their investment through data protection.
Solarization for Vegetable Weed Control

James J. Stapleton
Statewide Integrated Pest Management Program
Kearney Agricultural Center, University of California
Parlier, CA 93648
Email: jim@uckac.edu

How does soil solarization work?

Solarization is a non-chemical, hydrothermal method of soil disinfestation accomplished by passive solar heating of plastic film-covered soil. For best results, soil is moist during the heating process. The three main modes of action of solarization are physical, chemical, and biological processes. Physical inactivation of soil pests is usually the primary mechanism of action. As the soil is heated, pest organisms are damaged or killed by direct heating. However, in addition to the physical activity of solarization, chemical methods are also involved. As moist soil is heated, the organic fraction begins to break down and soluble compounds are released into the soil solution. Some of these organic compounds are biotoxic, and may cause further damage to surviving pest organisms and add to the pest control effect of direct heating. Furthermore, biological activity plays a part in the mode of action of solarization. Many of the pest organisms which are targeted by soil disinfestation (fungi, bacteria, and nematodes more so than weed propagules) tend to be somewhat physiologically specialized with regard to their preferences and tolerances for conditions in the open soil. They are more adapted for conditions present within, or in close proximity to roots of their plant hosts, rather than for competition in open soil. On the other hand, numerous other soil organisms are highly adapted to the competition of the soil environment. As the pest organisms become weakened by the effects of the physical and chemical modes of action, they are susceptible to opportunistic predation and parasitism by surviving organisms in the soil. The solarization process relies upon these mechanisms of activity, alone and in combination, to provide control of a broad spectrum of soil pest organisms.

Why use solarization?

As with any pest management approach, solarization has both benefits and limitations. Solarization can be successfully used in a variety of agricultural and horticultural situations. The primary benefits of solarization are that it is a non-chemical method of disinfesting soil, and that it costs less than many chemical treatments. Therefore, it can be used in situations where chemical soil disinfestation is not desired, not permitted, or not economically feasible. As with chemical fumigation, solarization often provides an “increased plant growth response” in subsequently planted crops. Solarization is very useful for vegetable growers in hot climatic areas, such as in the desert southwest of the U.S.A., and also in conjunction with organic farming.
and home gardening. It can offer broad spectrum pest control similar to the effects of chemical soil disinfestation without the risks and costs involved with chemical use. However, in cool climatic areas and during cool weather even in warmer climates, solarization may not be of significant value. Under such conditions, solarization may be combined with soil pesticides or organic amendments for increased efficacy. When practiced correctly by organic growers in warm climatic areas, solarization can be the difference between farming profit or loss, since it reduces or eliminates the need for hand-weeding. Solarization costs only a fraction of a tarped, chemical soil fumigant application, or in the case of organic farming, of hand weeding labor. Current costs range from ca. $250 (user-applied row treatment) to $800+ per acre (broadcast, glued panel treatment by custom applicator), depending on the current cost of plastic (which is based on the price of oil). In addition to organic production and gardening procedures where chemical products are not desired, solarization can be especially useful in farm production at the urban-ag interface where chemical applications are highly regulated or prohibited.

**How can solarization be used?**

Solarization can be applied to open fields in the same ways that tarped chemical applications are made. Most users apply solarization as a row or bed treatment, in which individual beds are covered with the clear plastic film, irrigated by drip, and solarized, while the furrows between the beds remain untreated. As in chemical soil disinfestation, this method is cheaper but does not control pests in the untreated furrow areas. On the other hand, solarization can also be applied as a broadcast treatment in which the entire field is covered with film, with the field either pre-irrigated or water run under the plastic. This is most often done by a custom applicator, since gluing of the individual plastic sheets together is the best way to accomplish the broadcast treatment.

Another specialized method of solarization is the use of a double-tent technique in conjunction with container nursery production. The California Department of Food and Agriculture has approved such a double-tent method as an alternative to soil fumigation for eradication of phytoparasitic nematodes from container nursery stock destined for field planting. The method also works well for eradicating weed propagules. The double-tent method is done by applying a layer of clear plastic film over containers of soil or planting media. This layer of film is covered by a second layer, supported by hoops or frames, to provide a still-air chamber between them. The soil in the containers is raised off the ground during treatment by placing the containers on pallets or frames to provide a layer of heated air beneath, as well as above, the containers. By using the double-tent method, temperatures in treated soil become significantly higher than those achieved during field solarization. These temperatures can rise to greater than 170 °F, which is essentially the same as achieved during soil disinfestation using aerated steam.
What are the limitations of solarization?

Since solarization is achieved via passive solar heating, there are a number of limitations that accompany its use. The primary limitation is that, for optimal benefit, the treatment must be done during the hottest part of the year. This requires that land be out of production for 2-6 weeks during the summer production season. In the deserts of the southwestern U.S.A., this is not a problem, as most vegetable ground is fallowed during the peak summer months. However, plastic film must be well-anchored to prevent wind damage in many desert areas. In other regions, growers who have adopted solarization successfully often time the soil treatment for the mid-summer period between the harvest of a spring crop and the planting of a fall crop. This works very well, but a strict schedule of cultural operations must be adhered to for best results. Since solarization provides “top-down” heating, lethal temperatures drop off deeper in the soil, and treatment during sub-optimal weather conditions or periods may not provide satisfactory results. For example, clear plastic applied to soil that does not reach temperatures sufficient to inactivate weed propagules may act as a “greenhouse” to allow luxuriant weed growth. Another limitation is the existence of heat resistant weed seeds and other pest organisms. Some organisms are able to survive at quite high temperatures, and are more difficult to control by solarization. The same weed species which are resistant to the effects of solarization [e.g. the nutsedges (Cyperus spp.)] tend also to be difficult to control by herbicides or other soil chemical treatments. For this type of heat-resistant organism (or for use during suboptimal weather conditions), combination of solarization with other control methods, such as low dosages of chemical disinfection products, herbicides, or biofumigants often gives improved control. Finally, solarization is primarily a knowledge-based, rather than product-based, method of soil disinfection. Unlike chemical treatments, there are a limited number of trained consultants available to help users with technology. Most of the successful users of solarization have developed their own methodologies by trial and error, or have relied upon plastic film distributors or other growers who have mastered the technique. For that reason, we recommend that potential users of solarization start off by testing the treatment on a relatively small scale to develop their knowledge base. Since solarization is safe and relatively inexpensive to conduct, developing technical knowledge is not difficult, risky, or costly.

What new information is being developed?

Improved plastic formulations are constantly being developed. Most distributors of agricultural plastics offer products that are specifically designed for solarization. Some of the newer plastics have shown improved heating properties which may be especially useful in marginal or cooler areas. On the other hand, in very warm climates such as the Central and Desert Valleys of California, the increases in heating characteristics provided by these new generation materials usually have not resulted in significantly improved pest control. Another aid to growers which is under development is predictive maps for growers. New geographical information systems (GIS) technology has been employed to pinpoint locations of individual
fields and provide historical air temperature data for these areas. Growers can access maps of their fields and get some determination of what kind of temperatures they might expect. A preliminary overview is available on the UC Kearney Agricultural Center website (http://www.solar.uckac.edu). The use of temperature maps can be coupled with information on the time-temperature dosages needed to kill specific pest organisms. A description of lethal dosages for six weed species important in California [annual sowthistle (Sonchus oleraceus), barnyardgrass (Echinochloa crus-galli), black nightshade (Solanum nigrum), common purslane (Portulaca oleracea), London rocket (Sisymbrium irio), and tumble pigweed (Amaranthus alba)] also is available on the abovementioned website.

Additional Information and References

For more information on solarization in California, including how to locate the listed references, contact your local UCCE farm advisor. These publications may provide useful information on the topics covered above:

Stapleton, J.J., 2007. Soil Solarization Informational Website. http://solar.uckac.edu/ (This website provides comprehensive information and references on soil solarization)


Elmore, C.L., Stapleton, J.J., Bell, C.E., and DeVay, J.E. 1997. Soil solarization: A nonpesticidal method for controlling diseases, nematodes, and weeds. University of California, Division of Agriculture & Natural Resources Publication 21377, Oakland, CA. http://vric.ucdavis.edu/veginfo/topics/soils/soilsolarization.pdf (This leaflet provides a “how-to” overview of solarization, including photographs, and includes lists of susceptible and resistant pest organisms)

biofumigation in relation to soil heating)


Stapleton, J.J. 2000. Soil solarization in various agricultural production systems. Crop Protection 19:837-841. (This paper gives a more technical discussion of solarization and lists numerous other references)

Herbicide Control of Nightshade and Nutsedge in Processing and Fresh Market Tomatoes

C. Scott Stoddard, UC Cooperative Extension Merced & Madera Counties
2145 Wardrobe Ave.
Merced, CA 95340
csstoddard@ucdavis.edu

Introduction

Yellow nutsedge (Cyperus esculentus) and nightshade (both black and hairy, Solanum nigrum and S. sarrachoides) are two dominant weed problems for tomato growers in Merced and Madera Counties. One of the available herbicides for both of these weeds is metalochlor (Dual Magnum), which received late registration in 2003. While there are a few other herbicides registered to control these weeds, two relatively new chemicals that target these species specifically are rimsulfuron (formerly Shadeout, now marketed under the trade name Matrix) and halosulfuron-methyl (trade name Sandea). Post emergent sprays of Matrix target nightshades, whereas Sandea is almost exclusively a nutsedge herbicide. Efficacy for both is improved through the use of a non-ionic surfactant or crop oil concentrate. Furthermore, tank-mixes of Sandea + Matrix have given exceptionally good weed control of both nutsedge and nightshades.

One disadvantage with Sandea is potential crop phytotoxicity, especially with certain varieties. This sensitivity is exacerbated with the addition of Matrix. In trials on processing tomatoes in 2004, certain varieties showed up to 80% phytotoxicity symptoms with a Sandea + Matrix combination. Yields were not significantly affected, but fruit quality was not evaluated.

In 2005, eight fresh market tomato varieties were screened for sensitivity to various post-application herbicides. In processing tomatoes, nightshade and nutsedge control were evaluated with several different pre and post application materials. In both locations, the standard herbicide was Dual Magnum. The objective of these trials was to compare efficacy and crop sensitivity to various herbicides that suppress nutsedge and nightshade in tomatoes.

Procedure

The trials were located in commercial production fields near Gustine (fresh market) and Firebaugh (processing). Plots were furrow irrigated and managed similarly as the rest of the field with the exception that mechanical cultivation and hand weeding were not performed. At the Firebaugh location, the pre-plant herbicides were incorporated with sprinklers, whereas at the Gustine site Dual Magnum was incorporated with a disc. Post emergent herbicides were applied over-the-top when the crop was near first bloom. Following herbicide application, plots were evaluated for weed control on a 0 to 10 scale, where 0 = no weed growth and 10 would indicate complete weed coverage.
Results

At the Gustine location, Dual Magnum, Sandea, and a tank-mix of Sandea + Matrix did the best job controlling nutsedge, especially by the latest evaluation date on July 18 (Figure 1). In Figure 1, herbicide pressure is shown as percentage, though the statistical analysis was performed on the transformed data (0 to 10 scale). At this time, all herbicide treatments provided significantly better control of both nutsedge and broadleaf weeds than the untreated check plots. Sencor did not perform as well as the other herbicides on controlling nutsedge, but did significantly reduce broadleaf weeds as compared to the untreated control.

The main weeds in this trial were purslane (*Portulaca oleracea*) and yellow nutsedge, and as a result Matrix alone had significant less nutseed control than Sandea, Dual, or Sandea + Matrix (Matrix post emergent is predominantly a nightshade control material). Matrix did significantly reduce purslane as compared to the untreated control. Dual Magnum, however, did not suppress purslane as well as the other weeds, especially later in the season. There were few grass weeds in this location, though there was a trend for more grassy weeds in the untreated plots.

No herbicide treatment was found to cause phytotoxicity problems with any of the varieties used in this test. Furthermore, there was no impact on yield or fruit maturity.

Early season weed growth at the processing tomato trial was dominated by nutsedge. Prior to transplanting at the Firebaugh location, all pre-plant herbicides significantly reduced nutseed growth as compared to the untreated control treatment, though Dual Magnum did better than Matrix. As a post emergence herbicide, Matrix is mainly effective on nightshades, but as a pre-emergent offers some suppression of nutseed as well. At the July 19 rating, all herbicide treatments significantly reduced nutseed growth as compared to the untreated control, though there was no significant difference between pre-plant or post-emergence (Figure 2). There was a trend for reduced broadleaf weeds (mainly nightshade and purslane) as compared to the check plots, but this was not significant. Overall best weed control was observed with V-10142 at 0.5 lbs ai (unregistered herbicide from Valent), Dual Magnum, and the Sandea + Matrix (post) tank mix.

Like the fresh market trial, no crop phytotoxicity was observed (field variety was H9665). Yield was not measured at this location.

Summary

In the trials conducted in 2005 in commercial tomato fields, yellow nutseed was a greater problem than nightshade. At both locations, Dual Magnum pre-plant incorporated significantly reduced nutseed as compared to not applying any herbicide. In plots without pre-plant herbicides, best weed control was seen with the Sandea + Matrix tank mix. In three years of trials in various tomato production fields, a tank-mix of Sandea + Matrix has consistently provided excellent weed control as a post-emergent herbicide treatment. A few processing
varieties have been found to be sensitive to this mix, but in general most tomato varieties tolerate this tank-mix well and yield nor fruit development are significantly impacted.

**Weed Ratings, July 18, 2005**
**Fresh Market Tomato Weed Trial, Gustine CA**

![Chart showing weed pressure and herbicide treatment effects]

Figure 1. Weed pressure in fresh market tomatoes as affected by herbicide treatment. All herbicides except for Dual Magnum were applied post emergent to the weeds when the crop was near first bloom. UTC = untreated control. Weed categories (broadleaf, grass, and nutsedge) with the same letter are not significantly different at the 95% confidence level. Main broadleaf weed was purslane.
Figure 2. Yellow nutsedge control on various dates as affected by herbicide treatment in processing tomatoes. All herbicide treatments significantly reduced nutsedge growth as compared to the untreated control (UTC). V-10142 is an unregistered herbicide from Valent Corp. Post-emergent treatments were evaluated only after June 30.
New Uses for Mature Herbicides

Jesse M. Richardson, Dow AgroSciences, Hesperia, CA, jmrichardson@dow.com

In recent years, fewer new herbicide active ingredients have been registered for use in vegetables. Consequently, there is increasing dependence on older herbicides. Herbicide manufacturers have been successful in obtaining exciting new registrations for many of these older active ingredients utilizing new methods of application, new formulations, and registrations on new vegetables. Kerb® 50-WSP herbicide applied through overhead sprinklers has become popular during the past few seasons in the low desert lettuce production regions of Arizona and southern California, and more recently in Fresno County, as a result of section 24(c) registrations. Studies in Yuma, AZ from 2002 to 2004 demonstrated that chemigating Kerb provides better weed control than aerial applications. In Fresno County field research in 2004, chemigating Kerb resulted in substantial hand thinning and weeding cost savings, compared to ground application. Dual Magnum is a product that traditionally had its strongest fit in Midwest corn. But in recent years, Syngenta has secured SLN registrations in spinach, celery, tomatoes and peppers where it has been used largely for control of nutsedge. Field research in Ventura County celery has shown that its activity on nutsedge compares very favorably to other registered products. GoalTender®, a new flowable formulation of oxyfluorfen, has recently been registered for post-emergence use in broccoli and cauliflower. This new formulation shows superior crop safety to Goal® 2XL. Recent research in Yuma, the central valley, and coastal valleys demonstrates the utility of GoalTender for controlling tough weeds when they are young. Similar studies have also shown that GoalTender can be used at the first true leaf stage of onions with less crop damage than Goal 2XL, while controlling target weeds. This use has not yet been registered. The active ingredient in Sandea has its roots in Midwest crops. But since it has been under the umbrella of Gowan Company, several vegetable registrations have issued. Asparagus, tomatoes, snap beans, cucurbits and peppers are now listed on the label and it has developed a strong reputation for post-emergence nutsedge control. Research in the central valley has shown its utility in these crops. Prowl is a pre-emergence product that has been registered in a number of crops for many years. But a recent formulation change has allowed the use of Prowl H2O at the loop stage of onions. By applying earlier, weed control is improved and crop safety is maintained. The SLN allows sequential applications. Stinger® has activity on weeds in the sunflower, nightshade, buckwheat and legume families. Its lack of activity on plants in the mustard family has facilitated its registration as a post-emergence product in cole crops. Its activity on volunteer alfalfa, clovers, and various weeds in the asteraceae family has made it popular under many weed scenarios. It was recently granted a supplemental label in California.
Early Season Onion Weed Control through Chemigation

Harry L. Carlson¹, Grant J. Poole², Rick M. Bottoms³ and Don Kirby¹
University of California, Intermountain Research & Extension Center, Tulelake, California¹
University of California Cooperative Extension Los Angeles County, Lancaster, California²
University of California, Desert Research & Extension Center, El Centro, California³

Weed control can be problematic being a major yield limiting factor in onions (Allium cepa) as they are poor competitors for sunlight, water, and nutrients. Weeds can germinate unnoticed until the first true leaf resulting in competitive environments that severely reduced onion yields; so, early season weed control is critical. Crop injury is also more likely when these herbicides are applied to very small onions. Recent registrations of selective herbicides for use on onions prior to the first true leaf have become available. This paper summarizes a series of onion weed control studies in southern and northern California desert environments where 33 different herbicide treatments were evaluated for efficacy over a 3-year period. The use of traditional herbicide programs like, Dacthal 75W (DCPA) applied at planting controls a wide range of weed species. Prefar 4E (Bensulide) is registered for use on onions prior to the second true leaf; however in sandy soils it can cause significant vigor loss and weed control is sporadic. Prowl H2O (Pendimethalin) is registered at two true leaves. In other states the traditional Prowl 3.3 EC was registered for use at the onion loop stage. (Prowl H2O just received a California SNL registration for application at the loop stage)

In sandy desert soils environments with little organic matter (OM) and heavier desert soils, particularly with higher OM levels selecting the correct herbicide product, application method, timing and rate to provide effective weed control without crop injury is challenging at best.

In Lancaster Prowl H2O was applied at planting at rates ranging from 2 oz. to 2 pts per acre. Spotty vigor loss was noted at rates of 8 oz. in 2005 in very sandy with and low OM. However, the effect on yield was not documented and may have been minimal. However, for three years Prowl H2O was applied at rates of 1 pt to 2 pts at the onion loop stage without noticeable vigor loss. In 2006 this treatment was made through chemigation and controlled mustards (Brassica spp.) and foxtail (Setaria spp.) by 88% in weed counts compared to the untreated check (Table 1).

The Prowl H2O treatment applied at 1.5 pts at the onion loop stage yielded the greatest overall weed control. The GoalTender 4F (Oxyfluorfen) application of 4 oz. following the Prowl application helped to suppress the weeds. It should be pointed out that GoalTender applied by itself is very weak on weeds and needs to applied at the earliest stage as possible, at the first true leaf, to enhance weed control. The Goal 2XL (Oxyfluorfen) applied at 8 oz. at the first true leaf caused significant onion damage initially, but the onions seemed to recover over time. This
application seemed to suppress weeds. The 6 oz. rate of GoalTender without the Prowl H2O onion loop treatment did not control weeds at all. Weed populations suppressed by the Prowl H2O onion loop treatment included foxtail, mustard, lambsquarters (Chenopodium album) and redroot pigweed (Amaranthus retroflexus). The Prowl H2O loop treatment will be registered in the 2007 season under a 24c exemption label.

Another trial was conducted with a CO2 backpack sprayer within the untreated check of the chemigation trial to determine the effect of GoalTender on common weed species. Field results (Table 2) with GoalTender have shown a lack of control of lambsquarter at 3 to 4 oz. per acre. This trial was applied at the first true leaf to evaluate the effectiveness of early applications of GoalTender on lambsquarters, mallow, shepherds purse, tumble mustard, and redroot pigweed. Mallow (Malva parviflora) and redroot pigweed were effectively controlled by these early applications of GoalTender. Although there was initial injury of all the weeds, by the end of the trial there was less than 25% control of shepherds purse (Capsella bursa-pastoris), tumble mustard, and lambsquarters. From these results GoalTender should be used with caution and supplemented with Goal 2XL. It may be best to apply Prowl H2O as a standard treatment in every field at the loop stage, as it is a cheap and effective treatment.

| Location: Lancaster | Plot Size: 24 ft wide by 120 ft long (2 to 4 replications) |
| Injection time: 25 minutes per treatment. | Soil Type: Sand with loam |
| Soil Type: Sand with loam | Number of Sprinklers per treatment: 4 |

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rates/Acre</th>
<th>Onion Growth Stage</th>
<th>lbs. a.i. per acre</th>
<th>Onion Phyto</th>
<th>Onion Phyto</th>
<th>Onion Phyto</th>
<th>Foxtail Populations1</th>
<th>Weed Count1</th>
<th>Percent Weed Control1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prowl H2O (loop) + Goal 2XL (1st leaf)</td>
<td>1.5 pts.</td>
<td>Onion loop 1st true leaf</td>
<td>1.2</td>
<td>6.0</td>
<td>5.5</td>
<td>2.8</td>
<td>36</td>
<td>492</td>
<td>87%</td>
</tr>
<tr>
<td>2. Prowl H2O (loop) + GoalTender (1st leaf)</td>
<td>1.5 pts.</td>
<td>Onion loop 1st true leaf</td>
<td>1.2</td>
<td>3.3</td>
<td>1.9</td>
<td>1.7</td>
<td>959</td>
<td>1,268</td>
<td>67%</td>
</tr>
<tr>
<td>3. GoalTender (1st leaf)</td>
<td>6 oz.</td>
<td>1st true leaf</td>
<td>0.19</td>
<td>4.8</td>
<td>4.3</td>
<td>3.0</td>
<td>2,061</td>
<td>5,484</td>
<td>0%</td>
</tr>
<tr>
<td>4. Prowl H2O (loop)</td>
<td>1.5 pts.</td>
<td>Onion loop</td>
<td>1.20</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>221</td>
<td>485</td>
<td>88%</td>
</tr>
<tr>
<td>5. Untreated check</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,474</td>
<td>3,894</td>
<td>0%</td>
</tr>
<tr>
<td>LSD (p = 0.05)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rating:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Onion phytotoxicity rating</td>
<td>Ratings taken on a scale of 0 to 10: 0 = No evidence of onion injury; 5 = deformity and some stunted growth; 6-8 = Not acceptable for production; 10 = dead plants.</td>
</tr>
<tr>
<td>2. Foxtail populations</td>
<td>Numbers represent the number of green foxtail (Setaria) per acre calculated from weed counts per 30 foot plot.</td>
</tr>
<tr>
<td>3. Weed count per acre</td>
<td>Numbers represent the number of weeds per acre calculated from weed counts per 30 foot plot. Weed population made up of foxtail (Setaria), mustard, lambsquarters, and redroot pigweed.</td>
</tr>
<tr>
<td>4. Percent Weed Control</td>
<td>Numbers represent the percent control compared to weed populations of the untreated check.</td>
</tr>
</tbody>
</table>
TABLE 2. Effect of GoalTender on common weed species

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate/Acre</th>
<th>Timing</th>
<th>lbs. a.i. / acre</th>
<th>Onion Phyto' 5/23/06</th>
<th>Weed Species Controlled</th>
<th>% Weed Control 5/18/06</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. GoalTender</td>
<td>4 oz</td>
<td>1st true leaf</td>
<td>0.12</td>
<td>1</td>
<td>Malva (Mallow)</td>
<td>85</td>
</tr>
<tr>
<td>2. GoalTender</td>
<td>4 oz</td>
<td>1st true leaf</td>
<td>0.12</td>
<td>1</td>
<td>Shepherds purse</td>
<td>25</td>
</tr>
<tr>
<td>3. GoalTender</td>
<td>6 oz</td>
<td>1st true leaf</td>
<td>0.19</td>
<td>2</td>
<td>Redroot pigweed</td>
<td>90</td>
</tr>
<tr>
<td>4. GoalTender</td>
<td>6 oz</td>
<td>1st true leaf</td>
<td>0.19</td>
<td>2</td>
<td>Tumble mustard</td>
<td>20</td>
</tr>
<tr>
<td>5. GoalTender</td>
<td>6 oz</td>
<td>1st true leaf</td>
<td>0.19</td>
<td>2</td>
<td>Lambsquarters</td>
<td>17</td>
</tr>
<tr>
<td>LSD (p = 0.05)</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>0.9</td>
<td>----</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Rating:
1. Onion phytotoxicity rating
   Ratings taken on a scale of 0 to 10: 0 = No evidence of onion injury; 5 = slight deformity and some stunted growth; 7-8 = Not acceptable for production; 10 = Dead plants.

2. % Weed Control Rating
   Ratings taken on a scale of 0 to 100: 0 = no control; 100 = Complete control

A trial was conducted to compare Dacthal 75W and Prowl H2O applied at planting and the loop stage. The full rate of Dacthal (10 lbs) controlled weeds (Figure 1) by 100%, whereas the half rate application (5 lbs) controlled weeds by 90%. Prowl H2O applied at the loop stage controlled weeds by 96%, whereas when it was applied at planting at 8 oz. /ac. it controlled weeds by 91%. All of these treatments were favorable, but Prowl H2O at 1.5 pts at the loop is probably the cheapest and most logical application to consider.
Weeds per acre of Dacthal 75W applied at two rates (5 and 10 lbs) at planting and Prowl H2O applied at planting (8oz.) and the loop stage (1.5 pts).

Some of most difficult weeds to control in onions hare yellow nutsedge (*Cyperus esculentus*) and volunteer potatoes (*Solanum tuberosum*). Outlook (Dimethenamid) has proven to suppress yellow nutsedge in the field. Nortron (Ethofumesate) is another herbicide in a similar chemical family as Outlook and has shown some effectiveness in controlling yellow nutsedge. A trial was conducted in sandy soils to compare Nortron and Outlook for onion tolerance and yellow nutsedge control.

Outlook should not be applied to onions prior to the second true leaf. These treatments were made at the second true leaf into an emerging patch of yellow nutsedge. Although the onion phytotoxicity ratings (Table 3) for the Nortron treatments were low, later in the season these treatments showed significant stunting that was not acceptable for production. It is not recommended that Nortron be registered for onions in sandy soils.

It was discovered as the season progressed that onions showed ‘looping’ symptoms in the Outlook treatment. Symptoms of ‘looping’ were that the third leaf actually grew through the 4th and 5th leaves, of which both were on the same side of the plant (onion leaves should be alternating from opposite sides). This was confirmed by others as being phytotoxicity from herbicides and is common among herbicides similar to Outlook. In earlier carrot (*Daucus carota*) trials Outlook has shown nutsedge suppression at 7 oz./ac. This rate should be used in sandy soils in onions. Outlook registration is currently pending, but is scheduled to be registered in California for use in 2007.
### TABLE 3. Onion tolerance of Nortron and Outlook for yellow nutsedge control.

<table>
<thead>
<tr>
<th>Location: Lancaster</th>
<th>Plot Size: 36” bed x 30’ long (3 replications)</th>
<th>Soil Type: Sandy</th>
<th>Nozzle: 8004 EVS @ 25 psi</th>
<th>GPA: 52.4</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate/Acre</th>
<th>Timing</th>
<th>lbs. a.i.</th>
<th>Onion Phyto(^1) 6/7/06</th>
<th>Onion Looping(^2) (per acre) 6/7/06</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nortron SC</td>
<td>1 pt</td>
<td>2 true leaves</td>
<td>0.50</td>
<td>3.7</td>
<td>0.0</td>
</tr>
<tr>
<td>2. Nortron SC</td>
<td>2 pts.</td>
<td>2 true leaves</td>
<td>1.00</td>
<td>4.0</td>
<td>1,618 (1% population)</td>
</tr>
<tr>
<td>3. Outlook</td>
<td>14 oz</td>
<td>2 true leaves</td>
<td>0.66</td>
<td>5.7</td>
<td>4,530 (3% population)</td>
</tr>
<tr>
<td>4. Untreated Check</td>
<td>0.6 pts.</td>
<td>2 true leaves</td>
<td>0.12</td>
<td>0.0</td>
<td>----</td>
</tr>
</tbody>
</table>

LSD (p = 0.05) ---- ---- ---- 1.2 1,067

Rating: Description:
1. Onion phytotoxicity rating
   - Ratings taken on a scale of 0 to 10: 0 = No evidence of onion injury; 5 = deformity and some stunted growth; 7-8 = Not acceptable for production; 10 = dead plants

2. Onion looping per Acre
   - The number of onion plants with looping symptoms from herbicide toxicity on a per acre basis. Estimations were made from individual plant counts per plot.

Onion Nutsedge Control
   - Nutsedge control ratings were not taken in this trial as the plot was hand weeded before ratings could be made. However, in other trials, nutsedge control for one application of Outlook at 14 oz per acre has been around 60% at the end of the season.

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A post-emergence herbicide weed control experiment was conducted at the Intermountain Research and Extension Center (IREC) in an attempt to identify treatments that produce satisfactory weed control with little or no crop injury. The primary herbicides evaluated were Goal and Buctril, applied post-emergence, at various rates, alone and in combination. Sequential applications of low rates were also applied in a strategy that has been successfully tried in onions and other crops. This strategy is designed to slow early weed growth, making weeds susceptible to control with repeat applications later in the season. The strategy is designed to avoid serious crop loss to early weed competition or herbicide injury.

In the post emergence studies broadleaf weeds; mostly redroot pigweed, hairy nightshade (Solanum sarrachoides) and lambsquarters began germinating shortly after planting. The experimental treatments evaluated on Table 4 indicate treatments produced acceptable commercial control (>70%). Split applications of Goal XL provided excellent control without apparent yield loss. Perfect weed control was archived with the early combination treatment of Prowl H20, a half rate of Outlook and split Goal applications. Applications with the full rate of Outlook at the 1 to 1.5 leaf stage appeared to reduce onion yields.
<table>
<thead>
<tr>
<th>Herbicides</th>
<th>Application Date</th>
<th>Onion Yield (cwt/A)</th>
<th>Weed Control Rating (10=complete control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal XL</td>
<td>6/6/06</td>
<td>Goal XL @ 2oz/A</td>
<td>Goal @ 4 oz</td>
</tr>
<tr>
<td>Goal XL</td>
<td>6/9/06</td>
<td>Goal XL @ 4oz/A</td>
<td>Goal @ 6 oz</td>
</tr>
<tr>
<td>Goal + Buctril</td>
<td>6/13/06</td>
<td>Goal XL @ 4oz/A + Buctril @ 4 oz/A</td>
<td>Goal @ 6 oz</td>
</tr>
<tr>
<td>Outlook + Goal</td>
<td>6/26/06</td>
<td>Outlook @ 21 oz/A + Goal XL @ 2oz/A</td>
<td>Goal @ 4 oz</td>
</tr>
<tr>
<td>Outlook + Goal</td>
<td></td>
<td>Goal XL @ 4oz/A + Outlook @ 21 oz/A</td>
<td>Goal @ 6 oz</td>
</tr>
<tr>
<td>Outlook + Goal + Buctril</td>
<td>6/13/06</td>
<td>Goal XL @ 4oz/A + Buctril @ 4 oz/A + Outlook @ 21 oz/A</td>
<td>Goal @ 6 oz</td>
</tr>
<tr>
<td>Prowl + Goal</td>
<td>6/9/06</td>
<td>Prowl @ 4 pts/A + Goal XL @ 2oz/A</td>
<td>Goal @ 4 oz</td>
</tr>
<tr>
<td>Prowl + Goal + Outlook</td>
<td>6/13/06</td>
<td>Prowl @ 4 pts/A + Goal XL @ 2oz/A + Outlook @ 10.5 oz/A</td>
<td>Goal @ 4 oz + Outlook @ 10.5 oz/A</td>
</tr>
<tr>
<td>UTC (hand weeded weekly)</td>
<td>6/26/06</td>
<td>UTC (hand weeded weekly)</td>
<td>10.0</td>
</tr>
<tr>
<td>UTC</td>
<td></td>
<td>UTC</td>
<td>1.0</td>
</tr>
</tbody>
</table>
New Weed Management Options in Alfalfa 
and for Ground Water Protection Areas

Mick Canevari¹

Abstract

Alfalfa is the largest crop produced in California exceeding one million acres. It is estimated that 75% of acreage is treated for weeds on an annual basis. The hay market financially rewards weed free high quality hay with high prices. In 2006, the price for number 1 weed free hay exceeded $160 per ton to the grower, as compared to weedy hay which sold for $80 per ton. Managing weeds in a timely manner is necessary to provide maximum production of high quality alfalfa hay. Poor weed management can lead to premature stand loss, poor quality hay, unacceptable weed control, alfalfa injury and a loss of money. Therefore the importance of maintaining an appropriate amount of weed control tools, primarily herbicides is critical to the alfalfa industry.

Increased regulations to insure water and air quality for future generations are impacting many of the agricultural herbicides which fail to meet new standard under our farming practices. California ground water protection regulations and air quality standards begin affecting pesticide usage in 2004. Many of the herbicides targeted for mitigation are the mainstays to annual weed control in alfalfa and other crops. Searching for new farming methods that allow critical herbicide usage and development of new herbicides has a high priority to secure crop production and a high quality product.

Keywords: alfalfa, ground water protection areas, diuron, norflurazon, pendimethalin, halosulfuron, flumioxazin, Roundup Ready alfalfa.

Introduction

Groundwater protection areas GWPA are geographically defined areas that are vulnerable pesticide contamination, either by leaching or runoff. GWPA include all areas previously designated as PMZs, plus new ones based on soil types and depth to ground water of 70 feet or less. Seven herbicides, two of which are used in alfalfa, Karmex® and Zorial® (diuron and norflurazon) have been placed on the ground water protection (6800) (a) list and are limited for use in leaching and runoff areas unless certain irrigation management practices are used. California groundwater area maps and mitigation alternatives can be found at http://www.cdpr.ca.gov/docs/empm/gwp_prog/gwpamaps.htm

Management alternatives for use of herbicides proposed by regulatory agencies may not be accepted under current alfalfa management practices and therefore not satisfactory solutions.

M. Canevari, UCCE County Director Farm Advisor, San Joaquin County, 420 South Wilson Way Stockton, CA 95205
One of the following management practices must be employed for use of herbicides in leaching GWPA.

1. Shall not apply any irrigation water for six months following application.
2. Shall apply the pesticide to the planted bed or berm above the level of irrigation water for six months following application.
3. Irrigation shall be managed to apply a net irrigation requirement of 1.33 or less for six months after application.

Management practices required in runoff protection areas.

1. Within 7 days before the pesticide is applied, the soil to be treated shall be disturbed by using a disc, harrow, rotary tiller.
2. Within 48 hours of application the pesticide shall be incorporated on 90% of the area treated by mechanical tillage or irrigation.
3. The pesticide shall be applied between April 1 and July 31
4. Retain all runoff in the field for 6 months or,
5. Retain all runoff in a holding area off the field.

Farming practices used in alfalfa make it extremely difficult if not impossible to follow these management guidelines. Retention and recycling ponds are one avenue that provide acceptable alternatives in certain areas where soil type, size of operations make it economically feasible. In the northern SJ valley existing drainage ponds and recirculation back onto irrigated crops is being done successfully.

Air quality standards are also making an impact on pesticides in alfalfa. The Central Valley region produces 60% of the state’s alfalfa hay crop, and the desert region produces 20% of the state’s alfalfa hay crop. The remaining 20% of the acreage is in the coastal and mountain areas. California Department of Pesticide Regulation has identified a number of pesticides (insecticides and herbicides) used on alfalfa as contributing volatile organic compounds (VOC) to air quality problems in California. A pesticide with an evaporate potential (EP) of greater than 20% is defined as a VOC. Alfalfa hay is the fourth largest VOC contributor of all agricultural commodities from emulsifiable concentration formulations of pesticides and contributed over 189,000 lbs of VOCs in 2005. The top eight alfalfa VOC producing pesticides are; Chlorpyrifos, dimetholate, hexazinone, trifluralin, sethoxydim, clethodim, permethrin and methomyl.

Four of the eight VOC pesticides are herbicides that are important to the Alfalfa industry, hexazinone, trifluralin, sethoxydim, clethodim. If these herbicides were eliminated from use, it would have significant economic impacts to the industry. Research is currently underway to study the true economic impacts if these herbicides were removed from the market. In addition, new herbicides are being evaluated as acceptable replacements when needed.
New Herbicides Options.
Chemical weed control is the most effective and cost efficient method of weed control and is used on an estimated 75% of the alfalfa acres on an annual basis in California. Herbicides are an integral component of the weed management system and when coupled with cultural practices can result in excellent quality hay. Researching the application of new herbicides is critical to obtaining environmentally friendly and safe chemicals. The development of transgenic alfalfa is creating a completely new approach to weed management.

Roundup *glyphosate* tolerant Alfalfa
Roundup Ready alfalfa for annual and perennial weed control has great potential showing promising results. Having the flexibility of applying an herbicide without limitations to alfalfa size and having a wide range of rate options allows for a timely and more effective weed control program, especially in the case with larger weeds or perennial weeds that more difficult to control. It is also possible to combine other alfalfa herbicides with Roundup without crop injury problems or compatibility issues, so implementing weed management systems that produce weed-free hay seems achievable. Tank mixing or rotating herbicides will also be important in managing weed shifts and protecting against the development of glyphosate resistant weeds. It will take time to fine-tune the weed control system but unquestionably the tools are now available to take alfalfa weed control to the next level.

Without question, the RR alfalfa system has heightened interest and is gaining popularity. The low cost and flexibility of glyphosate with little threat of crop injury, plant back issues or listed as a problem in groundwater; will attribute to a rapid adoption. However, one of the greatest concerns facing rapid adoption of this new technology is the potential overuse leading to weed resistance and weed shifts. In the case where three years of Roundup only was applied, a shift of burning nettle was documented. Figure 1.

Sandia *halosulfuron*
Sandia herbicide is well noted for nutsedge control in field and row crops. Nutsedge has been a serious problem in alfalfa with few management options that are effective. Sandia was granted a section 18 in established alfalfa for the lower desert areas of California in 200X. In 2006 it was granted a full registration throughout California for alfalfa. Highly effective for control of nutsedge, Sandia can cause temporary stunting and yellowing when applied during the growing season in the Sacramento and San Joaquin Valley. Less injury and yield loss occurs in the desert region.

Prowl H20 *pendimethalin*
Prowl herbicide has an anticipated registration for California alfalfa in spring 2007. Prowl controls annual grasses and certain broadleaf weeds before they germinate. It will be especially important in alfalfa for summer grass control, dodder control and used as a
tank mix partner for winter dormant weed control. It is safe on established alfalfa once a harvest has been made. Prowl is in the dinitroaniline family of herbicides with little known weed resistance issues. This will be particularly helpful in managing against the development of glyphosate weed resistant in Roundup Ready alfalfa. Initially, it will have a 50 day pre harvest interval which is restrictive to its most effective use in alfalfa which is spring and summer applications. That is expected to change to a shorter PHI by the 2008 season.

Chateau \textit{flumioxazin}

Chateau has been undergoing alfalfa research for several years in California and Arizona for winter weed control in semi dormant alfalfa. Chateau was granted a section 18 registration in Arizona for groundsel control. It was scheduled for California alfalfa registration in 2007 but that date has been extended until 2008/09 until ongoing research is completed. It has contact postemergence action so it will control small annual weeds. The postemergence action may not be sufficient in most field situations containing emerged weeds, especially large annuals so a postemergence herbicide should be added. Tank mixing with paraquat, glyphosate, imazamox and hexazinone have demonstrated excellent results. Chateau by itself at the low rate of 0.094 lb ai/A gives very good control of common chickweed and common groundsel with 80% control of annual bluegrass and annual sowthistle. The higher rate of 0.125 lb ai provided excellent control ranging from 92 to 100%. 

Chateau 12 days after treatment and depending upon the rate shows alfalfa burn from 15-27%. Alfalfa stunting at 36 DAT ranged from 13-28%. Prior to harvest alfalfa had completely recovered with normal yields. Chateau would be an excellent addition for alfalfa especially in winter applications for preemergence weed control. It has no restrictions in GWPA or worker safety issues and has been granted fast track registration in California for trees and vine crop use. See Figure 2.

**Summary**

Alfalfa acreage in California continues to increase and prices are escalating as the demand for high protein weed free hay remains strong in the dairy and horse industry. As the mature herbicides are faced with new regulatory restrictions and possible elimination, it becomes critically important to find alternative solutions through alternative farming systems and development of new herbicides. The use of glyphosate tolerant alfalfa will be rapidly adopted and create higher expectations of weed control leading to potential for over use. Across the country in other RR crops, weed shifts and possible herbicide resistant’s may emerge. The importance of developing new herbicides in alfalfa becomes even more important for rotation and adds balance to an integrated system. The new herbicides entering the alfalfa market are not only timely from a weed management standpoint but extremely important as new regulations reduce the weed management options available.
**Glyphosate Tank Mixtures for Weed Control in Established Roundup Ready Alfalfa**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>lb ai/acre</th>
<th>% Crop Injury &amp; Weed Control</th>
<th>% Biomass @ Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Burning Chickweed Annual Sowthistle</td>
<td>Harvest</td>
</tr>
<tr>
<td>Roundup Ultra Max 4SL</td>
<td>2.0</td>
<td>73 95 93 48</td>
<td>53 47</td>
</tr>
<tr>
<td>Roundup Ultra Max 4SL</td>
<td>1.0</td>
<td>30 7 90 52</td>
<td>23 77</td>
</tr>
<tr>
<td>Roundup Ultra Max 4SL</td>
<td>0.5</td>
<td>0 72 85 43</td>
<td>18 82</td>
</tr>
<tr>
<td>Velpar 2EC + Gramoxone Max 3EC</td>
<td>0.5 + 0.375</td>
<td>95 95 93 60</td>
<td>74 26</td>
</tr>
<tr>
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Evaluations 62 days after application.

**Alfalfa & Weed Yield in Dormant Alfalfa**

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<th>Treatment</th>
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Yield 1st cutting: 4/24/06. Hay = 90% D.M.
New Weed Control Approaches in Small Grains
and Off-Target Movement Challenges
Steve Wright¹, Mick Canevari², Lalo Banuelos¹, Matt Mills¹, Anna Brown¹

¹University of California Cooperative Extension, Tulare & Kings Counties
4437B S Laspina St, Tulare, CA 93274, sdwright@ucdavis.edu
420 South Wilson Way, Stockton CA 95205 wmcanevari@ucdavis.edu

There are approximately 700,000 acres of small grains planted in California. This represents wheat, triticale, barley, oats, and small grain forage mixes. Some of the major broadleaf weeds infesting small grains include mustards, fiddleneck, chickweed, malva, and burning nettle. Some of the important broadleaf herbicides used include 2,4-D, MCPA, Dicamba, and Carfentrazone (Shark).

These herbicides are most effective when applied to small and actively growing weeds. Small grains vary in their sensitivity to these herbicides; for example, oat is more tolerant to MCPA than to 2,4-D. MCPA is often easier to tank mix with foliar nitrogen than some formulations of 2,4-D.

Bromoxynil (Buctril), a contact herbicide, is effective on young seedling weeds. It is less effective on older weeds and must be tank-mixed with other herbicides when larger mustards are present. Therefore, higher volume application and thorough coverage is more important with bromoxynil than with phenoxy herbicides. An advantage of bromoxynil is that it controls fiddleneck. Bromoxynil also is recommended in areas with phenoxy-sensitive crops. The use of Bromoxynil has declined since the introduction of Shark herbicide.

Weeds such as burning nettle, malva, and chickweed are increasing as more uncomposted manures are being applied to fields. In addition the lack of cotton rotations is also increasing the weed pressure. Carfentrazone (Shark) is a contact herbicide that is effective at very low use rates on fiddleneck, malva sp., burning nettle, chickweed and other weeds that are difficult to control with other herbicides. Adding surfactants to carfentrazone often causes temporary crop burn. Tank mixing with UN-32 may enhance weed control. Tank mixing with dicamba provides good control of chickweed. Combining carfentrazone with phenoxy herbicides broadens the weed spectrum controlled, lowers herbicide application rates, and can reduce the risk of weeds building up herbicide resistance.

Dicamba (Banvel, Clarity) controls many broadleaves and gives partial control of chickweed, fiddleneck, pineappleweed, mayweed, malva, and knotweed. It is safer when applied at early growth stages 4 to 5-leaf stage. Later applications such as late tillering through early jointing often cause a flattening effect. The addition of foliar fertilizer often reduces this effect. Dicamba usually is combined with Shark or MCPA to increase the weed spectrum controlled compared to either of the herbicides used alone.
Work conducted by Ron Vargas, Mick Canaveri, and Jack Orr demonstrated it is safest to apply phenoxy herbicides after the small grains are well tillered in order to avoid yield reductions caused by phytotoxicity. Best control is obtained when weeds are small and before the crop has reached the jointing stage (Fig. 1.).

**Fig. 1. Effect of Broadleaf Herbicides on Yecora Rojo Wheat**

Ron Vargas, Madera Co. 1991

![Graph showing the effect of different herbicides on Yecora Rojo Wheat]

In 2005 there was considerable off target herbicide damage to tree crops and vegetables in the southern San Joaquin Valley. The small grain and cotton fallow ground burndown herbicide carfentrazone (Shark) and another cotton fallow ground burndown glyphosate was implicated in several instances. The outcome of this was that several postemergent herbicides ended up with greater restrictions depending on the county. Some of these included the following: 2,4-D, 2,4-DB, 2,4-DP, bromoxynil, Carfentrazone (Shark), Dicamba, Flumioxazin (Chateau), Glyphosate, MCPA, Oxyflouren, (Goal), Paraquat, Propanil, and Pyraflufen (ET). There was also a change in application dates not allowing air applications after February 1 depending on the county for some of these herbicides and additional requirements for aircraft applications.

**Grass Control-Wheat, Barley**

Grass weeds are increasing due to lack of crop rotations and more use of dairy manures. Fenoxaprop (Puma) controls wild oat canarygrass and several *Setaria* spp.. It also suppresses mustards. It has a wide window of application, providing effective control when applied between the 1-leaf and 6th leaf grass stage. For best control of wild oat, delay application until most wild oat plants have emerged. A tank mixture with bromoxynil allows for a wide range of weed control at an early timing. Fenoxaprop cannot be tank-mixed with phenoxy herbicides because it may reduce grass control when
tank mixed. Most growers are applying a carfentrazone application and then coming back 7-10 days with Puma to keep up with early weed competition.

Mesosulfuron (Osprey) is especially effective on Italian ryegrass, wild oat, little seed and hood canarygrass, and annual bluegrass. It controls ripgut brome and other brome species depending on weed size at application. It also controls many broadleaf weeds such as mustard, w.radish, and chickweed in wheat. Most California wheat cultivars have good tolerance to the herbicide. However, wheat often turns a lighter green color for a couple weeks following application.

It also provides partial control of many other broadleaf weeds including common groundsel, common malva, fiddleneck, yellowstar thistle and milk thistle. Mesosulfuron can be tank mixed with bromoxynil and MCPA and may be applied from the 1-leaf to 1-tiller wheat stage and up to the 2-tiller stage of grass weed development. A methylated seed oil or a non-ionic surfactant is required; ammonium sulfate or low rates of UN-32 added will enhance weed control on difficult to control weeds. Restrictions on crop rotations are greater than with Fenoxaprop.

During 2004-2006, several herbicides were evaluated for chickweed and wild oat control. In addition non label combinations of UN-32 were included. Treatments giving the highest control of chickweed were Osprey, Shark + Clarity, Shark + Clarity + UN-32, and Shark + 2,4-D (Fig. 1.2). ET combinations gave good control of chickweed. Puma and secondly Osprey gave excellent control of wild oat (Fig.5,7). Additions of 5 gal. of UN-32 or Shark to Puma or Osprey did not reduce weed control. Additions of 5 gal. of UN-32 or Shark to Puma caused only a temporary stunting which quickly grew out of it (Fig.8). Additions of 5 gal. of UN-32 or Shark to Osprey caused severe stunting but eventually grew out of it by harvest time (Fig 6.).

**References:**


**Broadleaf Control in Wheat**
Tulare Co. – Visalia – 2005
Chickweed % Control

![Bar chart showing percent control of chickweed in wheat (27 DAT and 68 DAT)]

Figure 1. Percent control of chickweed in wheat

**Broadleaf Control in Wheat 2005**
Wheat Injury, Visalia

![Bar chart showing percent injury in wheat (13 DAT, 21 DAT, 27 DAT)]

Figure 2. Percent of injury in wheat

**Chickweed Control in Wheat**
Tulare Co. – Visalia – 2006

![Bar chart showing percent control of chickweed in wheat (44 DAT and 92 DAT)]

**Broadleaf Control in Wheat**
Tulare Co. – Visalia – 2006
Chickweed % Control

![Bar chart showing percent control of chickweed in wheat (44 DAT and 92 DAT)]

Figure 1. Percent control of chickweed in wheat

Figure 2. Percent of injury in wheat
Figure 3. Control of chickweed in wheat
Wild Oat Control in Wheat 2005

Figure 4. Broadleaf control in wheat
Wild Oat Control in Wheat 2005

Figure 5. Percent control of wild oat in wheat
Wild Oat Control in Wheat 2005

Figure 6. Injury in wheat
Wild Oat Control in Wheat 2005
Wheat Injury, Visalia

Figure 7. Percent control of wild oat in wheat

Figure 8. Percent control of injury in wheat
Wild Oat Control in Wheat 2005
Wild Oat Control in Wheat 2005

WEED RESISTANCE MANAGEMENT AND CHALLENGES WITH ROUNDUP RESISTANT ALFALFA

Steve Orloff, Mick Canevari and Tom Lanini

Summary

Weeds are a challenge to profitable alfalfa production. The Roundup Ready alfalfa production system, has potential to simplify weed management, and improve control of both annual and perennial weeds. Roundup has proven to be a reliable herbicide treatment in other transgenic crops and has improved weed management in the short term. However, weed species shifts and the selection for Roundup-resistant weeds have resulted from the increased use of this technology. Alfalfa is especially vulnerable for several reasons: tillage is not practical, alfalfa is produced in large fields with a great diversity of weeds, and there is significant potential for long-term repeated use of a single herbicide because it is a perennial crop. Alfalfa growers can learn from the experience gained with other Roundup Ready crops to minimize weed shifts and the evolution of resistant weeds. Weed control systems that integrate tillage between plantings, crop rotations, rotations with herbicides of different modes of action (preferably soil residual herbicides), and tank mixtures are important. The long-term effectiveness and sustainability of the Roundup Ready system in alfalfa depends upon how well growers adopt the concept of herbicide rotation into their production systems. Use a preemptive approach—one should not wait until weed shifts and resistance occur before utilizing herbicide rotation strategies.

DEVELOPMENT OF ROUNDUP READY ALFALFA

Alfalfa, is an important crop throughout the Western US. Because nearly all weeds reduce the palatability and nutritional value of alfalfa, livestock industries—especially the dairy and horse industry—expect nearly weed-free hay. This can be difficult to achieve using conventional alfalfa herbicides. Typically, no single herbicide controls all weeds present in a field and some weeds, especially perennial weeds, are not adequately controlled with any of the current conventional herbicides. In addition to being difficult to achieve, complete weed control in alfalfa is costly. Growers continually seek ways to enhance the level of weed control while minimizing costs.

Glyphosate (Roundup)-resistant or Roundup Ready alfalfa (RR alfalfa), developed in late 1997 and made commercially available in the fall of 2005, makes broadcast applications of Roundup to alfalfa possible. The biotechnology-derived plants have an altered enzyme that allows them to tolerate a Roundup application while susceptible weeds are killed. This technology allows growers to deal with some of the most difficult-to-control weed species. Beginning in 2001, trials conducted by UC Farm Advisors throughout California demonstrated the effectiveness of this technology. Roundup was especially effective for seeding alfalfa, as less alfalfa injury resulted and superior weed control was realized compared to standard herbicides. One of the

1 S. Orloff, UCCE Farm Advisor, Siskiyou County, 1655 S. Main St., Yreka, CA 96097; M. Canevari, UCCE Farm Advisor, San Joaquin County, 420 South Wilson Way, Stockton, CA 95205 and T. Lanini, Weed Science Specialist, Plant Sciences Department, University of California, Davis, CA 95616; CA; Email: sborloff@ucdavis.edu; wmcanevari@ucdavis.edu; wtlanini@ucdavis.edu;
greatest advantages of this technology is that it suppresses perennial weeds such as dandelion, nutsedge, Bermudagrass, and quackgrass that have not been adequately controlled with conventional practices. Initial experience in commercial fields has confirmed these research findings and has further demonstrated the benefits of this technology—increased ease of use and superior weed control.

WEED SHIFTS AND RESISTANCE WITH RR ALFALFA

The greatest concern with this new weed-management system is the potential for weed shifts and weed resistance. A weed shift occurs when weeds easily controlled by Roundup, such as chickweed decline, and difficult-to-control weeds such as burning nettle increase. Weed resistance is different from a weed shift. An example of weed resistance is ryegrass which is normally controlled by Roundup. If ryegrass develops resistance for Roundup then it can no longer be controlled with this herbicide. It is important to understand the distinction between a weed shift and weed resistance because the significance, as well as the management approaches for dealing with each, is different.

The possibility of weed shifts and weed resistance is particularly a concern with RR alfalfa, the first perennial crop with this transgenic trait, due to a long alfalfa stand life and the potential for repeated use of a single herbicide over several years. For some growers alfalfa is the primary crop, and they want to minimize the amount of time the field is planted to low-profit rotation crops. Therefore, in areas like the Intermountain area of northern California there may be continuous alfalfa in a field for 12 or more years with only one year of a small grain rotation crop between alfalfa plantings. Stand life is shorter in warmer production areas like the Central Valley of California (3-4 year stand life is typical), and there are more rotation crops. However, cotton and corn are commonly rotated with alfalfa, and if transgenic RR varieties are produced, this again could result in a prolonged time period where a single herbicide is used repeatedly.

There are aspects of the alfalfa production system that both favor and discourage the development of weed shifts and resistant weeds. First, rotation opportunities in a perennial crop like alfalfa are less compared with annual cropping systems. Resistance and weed shifts are believed to evolve more rapidly in crops like alfalfa that are solid seeded, relatively low value, and grown on large acreages. Mechanical cultivation and hand weeding are not practical in a solid-seeded lower-value crop like alfalfa. On the other hand, alfalfa is an aggressive competitor with most weeds, and many weed species do not tolerate frequent cutting.

Weed shifts or resistant weeds are unavoidable and will eventually occur with any herbicide after repeated use. Fortunately, resistance to Roundup is not as common as resistance to many other herbicides. Two weed species have documented resistance to Roundup in California—rigid ryegrass and marestail. Roundup-resistant ryegrass was first found in California orchards where there was a long history of continual Roundup use. Roundup resistant marestail originated in the southern San Joaquin Valley of California in orchards, vineyards, and ditch banks where tillage was no longer used and Roundup was used continuously for several years, oftentimes with multiple applications per season.
Roundup is the most effective broad-spectrum post-emergence herbicide available, and it would be a shame to lose its effectiveness as a result of mismanagement. Weed shifts and/or weed resistance have occurred with the other transgenic RR crops released before RR alfalfa. This has typically occurred after approximately 6 years of continual use. Alfalfa growers can learn lessons gained from experience with these other crops as a preemptive measure to avoid, or at least minimize problems with weed shifts and weed resistance. The obvious questions are, “What management practices can be utilized to avoid weed shifts and weed resistance, and how do we effectively utilize this new technology?”

**RECOMMENDED WEED MANAGEMENT PROGRAM FOR RR ALFALFA**

Roundup Ready alfalfa is still a relatively new technology, so we have limited field experience to date. The following are some suggestions to consider based upon proven resistance management strategies, our understanding of alfalfa production practices, and our initial experience with RR alfalfa. Ultimately, growers and pest control advisors hold the key to avoiding weed shifts and resistance by reducing selection pressure.

Controlling weeds when alfalfa is in the seedling stage is the most challenging as alfalfa is most vulnerable to weed competition when it is in this stage. Additionally, complete weed control in seedling alfalfa is often difficult to achieve and frequently requires tank mixes of different herbicides to control the broad spectrum of weeds found in an individual field. Crop injury and yield loss are also usually far greater in seedling than in established alfalfa. Numerous field trials throughout the country have proven the effectiveness of Roundup in herbicide-resistant transgenic alfalfa. Therefore, it is only logical to use Roundup for weed control in transgenic seedling alfalfa for the cost savings, improved weed control, reduced crop injury, and to eliminate the alfalfa seedlings that do not carry the Roundup resistance gene. Ordinarily, the 1.0 pound active ingredient rate (22 oz of Roundup UltraMax) is sufficient. However, a higher rate may be needed if the field contains tolerant weeds such as malva or filaree. A tank mix may be advised if especially tolerant weeds such as burning nettle are present. For example, a tank mix with Raptor or Pursuit may be advised if burning nettle is present, or a tank mix with Prism may be necessary if the field contains ryegrass.

Alfalfa stand life varies considerably throughout the West depending on the production area, grower practice, and the existence of profitable rotation crops. However, a stand life of 3 to 4 years is common in the Central Valley of California. For the principles outlined above, it is unwise to rely solely on Roundup applications for weed control throughout the life of a transgenic alfalfa field. This practice would encourage weed shifts and resistance, and over time weed control would diminish in most cases. Once a resistant weed population has gained a foothold, it is practically impossible to eliminate and the usefulness of an herbicide is greatly diminished.

Most alfalfa producers treat alfalfa during the dormant season for winter annual weeds that infest the first cutting. It is strongly recommended that growers not rely solely on Roundup for their winter weed control program for the duration of the stand. They should rotate to another herbicide or tank mix at least once in the middle of the life of a stand, and perhaps twice if the stand life is over 5 years.
Fortunately, there are several herbicides to choose from that have a different target site of action than Roundup. The soil-residual herbicides applied during the dormant season to established alfalfa [such as hexazinone (Velpar), diuron (Karmex) and metribuzin (Sencor)] would be appropriate herbicides for a rotation or tank-mix partner. The rotation herbicide or tank-mix partner of choice depends on the weeds present in the field and their relative susceptibility to the herbicides. Paraquat (Gramoxone) is another candidate for rotation or tank mixing, but Gramoxone, like Roundup, is applied late in the dormant season. By rotating Gramoxone with Roundup, growers could potentially be selecting for early-emerging weeds that may be too large to control at the typical timing for Roundup or Gramoxone. Or, they could be selecting for late emerging weeds that germinate after the application.

Weed control in the last year of an alfalfa stand is often challenging because the stand is typically less dense and competitive, and there are also fewer herbicide options to choose from due to the plant-back restrictions associated with many of the soil-residual herbicides. Therefore, Roundup is a good choice for controlling weeds in the final year of an herbicide-resistant alfalfa field. This underscores the importance of having rotated herbicides before the final year so that Roundup will remain effective and control the majority of the weeds in a last-year alfalfa stand.

Summer annual grasses, such as yellow and green foxtail, barnyardgrass, cupgrass and jungle rice, and sometimes pigweed, can be problematic in established alfalfa. These weeds emerge over an extended time period whenever soil temperatures and moisture are adequate, typically from late winter or early spring—as early as February in the Central Valley—throughout the summer. They may emerge between alfalfa cuttings, so several applications may be necessary for a foliar herbicide like Roundup to provide season-long control. Multiple applications of a single herbicide during a season is cited as promoting weed resistance. Therefore, growers should not rely solely on Roundup for summer grass control for multiple seasons. It still remains to be seen how many applications of Roundup will be required for season-long summer grass control. In long growing-season areas, as many as two to three applications per season may be needed. Rather than making multiple applications of Roundup, a better approach may be to apply the pre-emergence herbicide trifluralin (Treflan), and follow-up with Roundup as needed for escapes. This approach helps avoid weed shifts and resistance, and may be more economical compared with multiple applications of Roundup.

Herbicides rotation and use of tank mixtures should be done for both dormant applications to control winter annual weeds and for spring/summer applications intended to control summer annual weeds. For example, rotating to Velpar for winter annual weed control for a year does nothing to prevent weed species shifts or the development of resistance in the summer annual weed spectrum. Herbicides for summer annual weed control should be rotated as well.

There is no definitive rule on how often herbicides should be rotated. The suggestion to rotate or tank mix at least once in the middle years of the life of a stand (or more often for long-lived alfalfa stands) is only a suggestion. The key point, which cannot be overemphasized, is the importance of diligent monitoring for weed escapes. Producers should stay alert to the development of weed species shifts and resistant weeds. If the relative frequency of occurrence
of a weed species increases dramatically, chances are that it is tolerant to Roundup and immediately rotating herbicides or tank mixing is advised. If a few weeds survive among a weed species that is normally controlled easily with Roundup, it could be an indication of possible weed resistance, assuming misapplication and other factors can be eliminated as possible causes. In these situations, it is imperative to prevent reproduction of a potential resistant biotype. Treat weed escapes with an alternative herbicide or use another effective control measure.

CONCLUSIONS

The Roundup Ready production system has potential to simplify weed management, while also improving the spectrum of weed control. However, growers should learn from the experience gained in other crops and stay alert to the development of weed shifts and resistant weeds. The key is for growers to reduce selection pressure—not to rely on repeated applications of Roundup year-after-year, application-after-application. Rotate crops, rotate herbicides and utilize tank mixes as needed, depending on the weed species and weed escapes present. A grower should not wait for there to be a problem before he employs these practices; a preemptive approach is strongly encouraged.
Wild Oats Control in Bermuda Grass
Production in the Imperial Valley

Rick M. Bottoms *, Ron Cardoza, Francisco Maciel and Jose Quiroz
University of California, Desert Research & Extension Center, El Centro, California

Wild oat (*Avena fetua*) infestations in Bermuda grass (*Cynodon dactylon*) can increase harvest cost and down time and reduce yield potential. Typically wild oat control has been achieved by good fertility programs with non granular type herbicides, i.e. Diuron, 2, 4-D, Atrazine and others. This paper summarizes the findings of a study undertaken to determine the effectiveness of Triallate granules (Far-GO) in controlling wild oat in Bermuda grass. This paper also presents our findings regarding the best time of herbicide application and both seed yield and seed quality of Bermuda grass following herbicide treatments. Finally, this paper outlines our results regarding the rate of Triallate best suited to the desert environment.

Four research sites were selected through the Imperial Valley each having demonstrated a history of wild oat infestations that typically compromised Bermuda grass harvest efficiency and yield potential. A series of randomized plots 41.8 sq. m large in four commercial fields replicated 3 times provided the research sites for determining the effectiveness of Triallate, rate variations, timing and the form of Triallate.

The first site was used to determine if there was a difference in weed control performance with Triallate applied at 6.8 and 13.6 kg/ha 7 and 3 days prior to incorporation from precipitation. The second through forth sites were used to determine the efficacy of Triallate applied at 6.8 and 13.6 kg/ha, Trifluralin + Triallate (Buckle) applied at 6.8 kg/ha, Trifluralin 10G applied at 9.07 kg/ha and Aatrex 4FL applied at .946 L/ha compared to untreated checks.

Comparisons of Triallate applied at 6.8 and 13.6 kg/ha 7 and 3 days prior to incorporation from precipitation (Figure 1) show no significant difference in weed control performance between applied product rates and timing of application prior to incorporation as compare to the untreated check. All treatments provided acceptable levels of performance of 85% or better.

Figure 1. Weed control of 2 rates of Triallate (FarGO) applied at different timings on Bermuda grass for wild oats infestation.
As illustrated in Figure 2, when compared to the “Untreated” area, all treatments control at least 50% of the Wild Oat population. As shown in the figure, Triallate at 13.6 kg/ha worked significantly better than any of the other treatment. The effectiveness of Trifluralin + Triallate (Buckle) applied at 6.8 kg/ha was found to be 15 percent lower than that of Triallate at 13.6 kg/ha. Triallate at 6.8 kg/ha performed 14% lower than Trifluralin + Triallate applied at 6.8 kg/ha. Trifluralin 10G applied at 9.07 kg/ha and Aatrex 4FL applied at .946 L/ha performance is comparable.

Figure 2. Wild oat control comparing 5 treatments applied 2 days before incorporation.

One of the major reasons to grow Bermuda grass in Imperial Valley is the production of seed. Findings using the treatments described above are reported in Figure 3. As shown in the figure, when compared to untreated areas, no significant yield reduction was found. This demonstrates that the application of any of these treatment, while significantly controlling Wild Oat do not impact seed yield.

Figure 3. Bermuda grass seed yield following 5 treatments applied 2 days prior to irrigation.
Germination tests were performed on seed harvested in each of the three treated sites to determine if the application of herbicide has an impact on seed quality. Results are encouraging, demonstrating that herbicides are management tools that do not negatively impact the quality of seed production.

Figure 4. Bermuda grass seed germination following 5 treatments applied 2 days prior to irrigation.

Results from this study show that Triallate (Far-Go) is effective against Wild Oats in Bermuda grass. Results also show that Triallate does not reduce the seed yield nor does it diminish seed quality. Future studies will investigate the timing of the herbicide application and the compare the use of Triallate formulations.
Control of Nutsedge (*Carex sp.*) in Highbush Blueberries (*Vaccinium corymbosum*)

Debra A. Boelk (daboelk@ucdavis.edu) and Benny Fouche (bfouche@ucdavis.edu) University of California - Cooperative Extension, San Joaquin County

**Introduction**

Highbush blueberries are a relatively new crop in San Joaquin County. They are grown in raised beds covered with a thick layer of organic mulch or, more recently, with synthetic cloths. Mulch helps retain moisture and moderate soil temperatures. The mulch is necessary as blueberries are shallow-rooted and, therefore, sensitive to fluctuating moisture and temperature. Unfortunately, the shallow-rooted nature of the plant makes it difficult to control perennial weeds such as nutsedge. In established plantings, cultivation needs to be restricted to the upper 2 – 4 inches of soil between beds. In any age planting, the mulch on the berms is not cultivated. These practices may not provide deep enough cultivation to impact the perennial root system of nutsedge. Although mulch is necessary for the reasons stated above, we thought that the high organic content of the mulch might be problematic with the use of pre-emergent herbicides. Herbicides that readily bind to organic matter would be rendered useless for weed control in an organic mulch environment. A limited pre-emergent trial and a more extensive post-emergent trial were executed in 2006 to explore nutsedge control in blueberries.

**Materials and Methods**

Pre-emergent: Two chemicals, Dual II Magnum 7.64 EC (S-metolachlor 82.4% at 1.4# ai/acre) and Outlook EC (dimethenamid 63.9% at 1# ai/acre), were applied in March of 2006 on Star, Santa Fe and Blue Crisp varieties of highbush blueberries.

Post-emergent: Five compounds, two registered materials, Roundup Weathermax 6SL (glyphosate at 2.75# ai/acre), and Shark 40 EW (carfentrazone at 0.03# ai/acre); and three unregistered materials, Permit 75% DF (halosulfuron at 0.062# ai/acre), Rely (glufosinate at 1.0# ai/acre), and V10142 75 WDG (imazsulfuron at 0.5# ai/acre) were applied in May of 2006 on Star, Santa Fe and Blue Crisp varieties of highbush blueberries. Carrier rate was 25 gpa and 0.2% NIS was added to all tank mixes. One application of all chemicals was made at the 3 – 4 leaf stage. Data was taken at 14, 21, 32 and 60 DAT. Ratings were made on a percent control basis. Percent control was based on partial and total necrosis.
Results and Discussion

Pre-emergent: Poor weed establishment prevented us from being able to perform an analytical analysis of the weed control provided by these chemicals, but no phytotoxicity was noted in any variety of blueberry.

Post-emergent: The results of the efficacy tests showed Permit to be a consistently better performer at both sites than any of the other materials tested (figures 1 and 2). Control remained around 50% out to 60 DAT. There were marked differences in the performance of the other herbicides at each site. Rely controlled nutsedge well, out to 32 days, at site two, but not at site one. This may have been due to differing watering regimes. Site 1 was drip irrigated and had a heavy layer of fine wood mulch. Site 2 utilized overhead sprinklers, and the mulch was coarser and not as thick. Since nutsedge is a perennial plant the method of estimating percent control was chosen to reflect that the infestation was not eliminated, but curtailed for a period of time. All nutsedge populations eventually recovered to the level of the untreated controls. Multiple applications or combinations of herbicides may be needed to obtain more permanent control.

Figure 1. Post-emergent control of nutsedge in blueberries – Site 1

Figure 2. Post-emergent control of nutsedge in blueberries – Site 2
Shifts in Weed Community Composition in Response to Organic and Conventional Weed Control Practices in a California Vineyard

Kendra Baumgartner1†, Kerri L. Steenwerth1*, Lisa Veilleux1
1USDA - Agricultural Research Service, Crops Pathology and Genetics Research Unit Davis, CA 95616, †baumgartner@ucdavis.edu, *ksteenwerth@ucdavis.edu

Organic wine grapes are becoming increasingly more popular among consumers and winemakers, as evidenced by the fact that grapes represented 10% of 2002 organic commodity sales in California (Klonsky 2004). The rise in organic wine grapes may be driven partly by the increasing proximity between urban areas and vineyards as well as more stringent controls over water quality (Anonymous 2006). These water quality regulations encourage growers to reduce pesticide applications, shift their selection of pesticide, or adopt organic practices.

Integrated weed management (IWM) employs multiple tactics to control weed infestations, and can be useful in reducing problematic weeds. IWM in California vineyards typically involves the integration of post-emergence herbicides and pre-emergence herbicides (Agamalian 1992), with less emphasis on incorporation of non-chemical methods. Therefore, the aim of this research was to compare the organic weed control practice, soil cultivation, to the conventional practice, applications of the herbicide, glyphosate, in terms of their effects on weed community dynamics in a vineyard system. Objectives were to: 1) evaluate the efficacy of the practices in reducing weed biomass, 2) characterize the weed community, 3) monitor vine yield, growth, and nutrition under the influence of the practices, and 4) determine the effects of the practices on soil biological activity. An understanding of all aspects is important to growers who desire sustainable weed management practices that do not threaten production goals.

The experiment was conducted in a commercial winegrape vineyard in the Napa Valley of northern California from 2003 to 2005. The vineyard was established in 1996 with Merlot (clone 314) on 110R rootstock (V. berlandieri Planch. X V. rupestris Scheele). Vine spacing was 1.8 x 1.8 m, with east-west row orientation. Vines were trained as unilateral cordons to a vertical shoot positioning trellis system. The vineyard was drip-irrigated (40-80 kL ha⁻¹ week⁻¹, May-October). The 0.84-m-wide section of soil in the vineyard row, where treatments were carried out, was level with the soil in vineyard the middles; vines were not elevated on berms. The vineyard was on Bale soil (fine-loamy, mixed, thermic Cumulic Ultic Haploxeroll).

The annual treatments were winter-spring glyphosate, spring cultivation, fall-spring cultivation, and fall cultivation-spring glyphosate, and were applied to the berm. Glyphosate¹ [N-(phosphono-methyl-glycine), Roundup UltraMAX] was applied at label rates with a tractor-mounted, 1.2-m-wide, boom sprayer with two fan-type nozzles directed beneath the vines on both sides of the tractor. Cultivations were done with a Radius Weeder² (Clemens cultivator). At peak plant biomass in the spring, the weed response to each treatment was measured using four randomly placed, 0.6-m² quadrats per row (two at the base of vine trunks, two between adjacent vines). In 2005, effects of weed management treatments on soil biology were also
assessed. To determine cumulative effects of treatments on soil biological activity, we measured net nitrification and nitrogen (N) mineralization, potential N mineralization, and potential microbial respiration in 2005 only. Potential N mineralization provides information about the availability of N in the soil organic matter while potential microbial respiration indicates the lability of soil carbon (C). Soils with more labile C tend to support higher microbial activity. Vine nutrition was described annually by measuring boron, potassium, and phosphorus in grapevine petioles at bloom.

The weed control practices employed in this study did not affect soil microbial activity, but the soil ammonium pool in the spring was greater in the spring cultivation treatment than in other treatments. This was attributed decomposition of the weeds that had been recently incorporated into the soil by the Clemens. No effect of weed treatment was observed on vine nutrition, except potassium was lower in the fall-spring cultivation treatment than in the winter-spring glyphosate treatment. However, lower petiole K in cultivated rows was within adequate levels (>15 mg g\(^{-1}\) at bloom).

In general, cultivation alone was not as effective as glyphosate, but the overall effectiveness of each treatment in reducing weed biomass was not consistent among all years. For example, lower weed biomass occurred in the glyphosate-only treatment in two of three years. However, given that two passes with the Clemens cultivator (i.e., fall-spring cultivation) decreased weed biomass relative to one pass, it is possible that additional passes could bring about further reductions. Pairing fall cultivation with glyphosate was as effective at reducing weed biomass as two glyphosate applications in two of three years, suggesting that substituting a glyphosate application with cultivation may be an effective method of reducing herbicide use in vineyards. Treatment effects on weed community structure were evident. Persistent infestations of unique problematic species associated with glyphosate (curly dock), cultivation (annual sowthistle, field bindweed, spiny sowthistle), and a combination of both practices (panicle willowherb) suggest that alternating control practices among years may be important for preventing such weed shifts in California vineyards.
Herbicide Screening in Fruit and Nut Tree Nurseries

Bradley D. Hanson
USDA-ARS, SJVASC, 9611 S. Riverbend Ave, Parlier, CA 93648
bhanson@fresno.ars.usda.gov

The nursery industry is very important to the agricultural economy of California. Nurseries in the state produce over 60% of the fruit and nut trees for replanting each year. In 2003, 133 California operations combined had $138 million in wholesale sales of fruit and nut tree planting stock – a value that is multiplied in the state by retailers and exporters. Fruit and nut tree nursery production practices vary among growers, regions, and tree species; however, production cycles usually follow a similar schedule. Generally, a rootstock is fall planted in the field as seed or cuttings and scion is grafted or budded onto the rootstock in the next spring or fall. After one to three years in the field, trees are harvested from the field and sold as bareroot planting stock in California, across the U.S., and around the world.

Producers of field grown tree nursery stock currently rely on soil fumigation for broad spectrum control of a variety of soil borne pests including parasitic nematodes, disease pathogens, and weeds. For more than 50 years, methyl bromide has been widely used for soil fumigation in high value vegetable and nursery crops but is currently being phased out because of adverse environmental impacts. Intensive research efforts have identified several fumigant treatments that effectively control nematodes and pathogens. However, none of the currently registered and available chemical alternatives has the same spectrum of activity and efficacy as methyl bromide.

Weed control in fruit and nut tree nurseries continues to be a major problem for producers in the Central Valley. Competition from weeds can decrease crop productivity and interfere with field operations (i.e. budding, grafting and pruning) and harvest operations. Soil fumigation alone (even with methyl bromide), often does not provide and maintain a consistently high level of weed control over a multi-year crop cycle. Some weed species are not well controlled by fumigants due to their biological (impermeable seed coat, dormancy) and ecological (airborne invasion, large seed bank) characteristics, or due to environmental conditions (dry soil). This problem likely will be compounded by use of alternative fumigants (e.g. 1,3-dichloropropene) that may provide good control of nematode and pathogens but do not always provide acceptable weed control. Most tree nursery production systems currently rely on a combination of preplant soil fumigation, preemergence herbicides, and extensive tillage and hand labor during the growing season for acceptable weed control.

Broad spectrum herbicides (i.e. glyphosate) and tillage are used to control germinated weeds prior to crop planting. Many growers also use broadcast or band applications of a residual herbicide applied after planting but before the crop emerges to extend effective weed control into
the growing season. Currently, preemergence herbicide choices are limited by number of registered materials and by crop safety concerns. Commonly used products include: oryzalin, trifluralin, pendimethalin, and isoxaben. Relatively few herbicides are available for application during the growing season or as directed or dormant applications between growing seasons of a two- or three-year crop cycle. Some herbicides can harm young trees by reducing emergence or by injuring the root growth (stunting or malformations) or the above-ground growth (meristem damage, stem malformations, stunting, chlorosis, or death). Because nursery-grown trees are sold as bareroot stock, any root or stem damage is unacceptable to the buyers and those plants are not marketable.

Tillage can provide effective weed control between rows of nursery crops but fail to control weeds close to or within the crop rows. Efforts to till close to the crop row can lead to an increase in mechanical damage to the crop resulting in more unmarketable plants. Frequent tillage during the growing season is expensive in terms of fuel usage and is associated with negative environmental impacts from airborne dust and decrease in soil tilth. Hand labor can provide weed control within the crop row but can result in mechanical crop damage, requires access to a large labor force, and is becoming more expensive and subject to greater worker safety regulations.

Herbicides are likely to become a more important part of weed management in tree nurseries as labor and fuel costs rise. Application of a foundation herbicide at planting followed by a spring application of another PRE or POST herbicide may extend residual weed control further into the summer and provide control of difficult weeds in tree nurseries. Identification of herbicides and herbicide application techniques that provide effective, non-phytotoxic weed control in field nurseries will provide growers with additional options to effectively and economically produce planting materials using an integrated pest management strategy.
Overview of the Positive Points System (PPS) for Citrus: For the past 6 years, a group of University of California Extension Specialists, Farm Advisors, and citrus growers have been working together to develop a “Positive Points System for Citrus”. The PPS for citrus is a set of 220 questions that cover topics in seven categories of citrus production (Table 1). These topics include horticulture, soils, water, pest management, post harvest issues, food safety and continuing education. The purpose of the PPS is to help growers determine their strengths and weakness in citrus production, to quantify the adoption of reduced risk practices used in California citrus and to document good agricultural practices. The citrus assessment was modeled after the PPS for Vineyards developed by the Central Coast Vineyard Team.
### Table 1. Positive Points for Citrus Assessment Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Total Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. Horticultural Management</strong></td>
<td></td>
</tr>
<tr>
<td>A. Site Development</td>
<td>200</td>
</tr>
<tr>
<td>B. Rootstock/Scion</td>
<td></td>
</tr>
<tr>
<td>C. Canopy Management</td>
<td></td>
</tr>
<tr>
<td>D. Plant Growth Regulators</td>
<td></td>
</tr>
<tr>
<td>E. Frost Control</td>
<td></td>
</tr>
<tr>
<td><strong>II. Soil Management</strong></td>
<td>140</td>
</tr>
<tr>
<td>A. Preplant Soil Structure Modif</td>
<td></td>
</tr>
<tr>
<td>B. Post Plant Soil Structure Mod</td>
<td></td>
</tr>
<tr>
<td>C. Erosion Control</td>
<td></td>
</tr>
<tr>
<td>D. Soil Monitoring/Leaf Analysis</td>
<td></td>
</tr>
<tr>
<td>E. Amendments</td>
<td></td>
</tr>
<tr>
<td><strong>III. Water and Nutrient Manage</strong></td>
<td>195</td>
</tr>
<tr>
<td>A. Water Quality</td>
<td></td>
</tr>
<tr>
<td>B. Off-site Water Movement</td>
<td></td>
</tr>
<tr>
<td>C. Irrigation System Efficiency</td>
<td></td>
</tr>
<tr>
<td>D. Irrigation Scheduling and Amount</td>
<td></td>
</tr>
<tr>
<td>E. Fertilization/Fertigation/Plant Analysis</td>
<td></td>
</tr>
<tr>
<td><strong>IV. Pest Management</strong></td>
<td>255</td>
</tr>
<tr>
<td>A. Insect/Mite/Snail/Nematode/Vertebrate Pest Control</td>
<td></td>
</tr>
<tr>
<td>B. Natural Enemies</td>
<td></td>
</tr>
<tr>
<td>C. Disease Control</td>
<td></td>
</tr>
<tr>
<td>D. Weed Management</td>
<td></td>
</tr>
<tr>
<td>E. Spray Efficiency and Efficacy</td>
<td></td>
</tr>
<tr>
<td><strong>V. Post Harvest</strong></td>
<td>155</td>
</tr>
<tr>
<td>A. Harvesting</td>
<td></td>
</tr>
<tr>
<td>B. Packinghouse</td>
<td></td>
</tr>
<tr>
<td>C. Fruit for Export</td>
<td></td>
</tr>
<tr>
<td><strong>VI. Food Safety</strong></td>
<td>65</td>
</tr>
<tr>
<td>A. Sanitary Standards</td>
<td></td>
</tr>
<tr>
<td>B. Chemical Residues</td>
<td></td>
</tr>
<tr>
<td><strong>VII. Continuing Education</strong></td>
<td>90</td>
</tr>
<tr>
<td>A. Grower</td>
<td></td>
</tr>
<tr>
<td>B. Employee</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1100</strong></td>
</tr>
</tbody>
</table>

**Sample PPS questions:** The questions in the PPS (see the sample set of questions in Table 2) ask the grower about his/her use of various horticultural practices or knowledge of citriculture in his/her orchard. For example, in Table 2, question 1 asks if the trees were propagated with registered budwood (a grower practice). Question 7 asks if the grower is aware that some rootstock and scion combinations are incompatible (grower knowledge). If the grower says confidently that he uses a practice, or has knowledge of an aspect of citriculture, he gives himself 5 points. If he does not use that practice, or is not aware of the information described, then no points are assigned. The assessment is weighted towards practices that promote long-term health of the tree and marketability of the crop, reducing dependence on broad spectrum...
pesticides and protecting the environment and human health. The total number of points in each category reflects the level of adoption of these types of practices by the grower.

Table 2. Sample set of questions on horticultural management

I. HORTICULTURAL MANAGEMENT: B. ROOTSTOCK/SCION section

Goal: To select a rootstock and scion combination that maximizes tree vigor and fruit quality and reduces the need for chemicals to control pests and diseases.

<table>
<thead>
<tr>
<th>5 pts</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Are trees planted propagated with registered budwood?</td>
</tr>
<tr>
<td>2.</td>
<td>Are disease and/or pest resistant rootstocks utilized?</td>
</tr>
<tr>
<td>3.</td>
<td>Are you aware that resistant rootstocks provide long-term benefits in controlling citrus nematodes or Phytophthora even if the orchard was fumigated before planting?</td>
</tr>
<tr>
<td>4.</td>
<td>Were the soil characteristics and prior planting history considered when rootstock(s) were chosen?</td>
</tr>
<tr>
<td>5.</td>
<td>Did you consider matching the scion to your growing conditions?</td>
</tr>
<tr>
<td>6.</td>
<td>Do you have a rootstock or scion trial on your site, or have you used information obtained from a similar site (other grower or U.C. trials) when making your rootstock choices?</td>
</tr>
<tr>
<td>7.</td>
<td>Are you aware of the incompatibility of certain rootstock and scion combinations?</td>
</tr>
<tr>
<td>8.</td>
<td>Are you aware that fruit quality is affected by certain rootstock and scion combinations?</td>
</tr>
</tbody>
</table>

The sample questions in Table 3 show that PPS questions address not only citrus management practices but also stewardship of a product that is safe for consumers.

Table 3. PPS questions relating to food safety

VI. FOOD SAFETY: A. CHEMICAL RESIDUES section

Goal: To ensure that chemical residues (pesticides, fertilizers) do not contaminate fruit.

<table>
<thead>
<tr>
<th>5 pts</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Do you know your reentry intervals (REI) and post harvest intervals (PHI) for pesticides to avoid pesticide residues and worker safety problems?</td>
</tr>
<tr>
<td>2.</td>
<td>Does your packinghouse test the fruit from your orchard for pesticide residues after packing?</td>
</tr>
<tr>
<td>3.</td>
<td>Do you know the limits on use of organic fertilizers?</td>
</tr>
<tr>
<td>4.</td>
<td>Do you have an internal trace back system to match potential residue problems with specific orchards?</td>
</tr>
<tr>
<td>5.</td>
<td>Are you aware that when there is a chemical residue problem, the contaminated fruit can be traced to you, and you are responsible?</td>
</tr>
</tbody>
</table>

Table 4 shows that the questions about weed management are fairly general, but give an indication as to whether the growers is simply treating weeds as he sees them, or is considering the species of weed, the stage of plant, the type of herbicide, the weather and the alternatives to persistent herbicides.
Table 4. PPS questions relating to weed management

IV. PEST MANAGEMENT: D. WEED MANAGEMENT

Goal: To use methods that minimize weeds that compete with citrus trees or that harbors pests and to minimize contamination of groundwater.

<table>
<thead>
<tr>
<th>5 pts</th>
<th>Questions</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Are you familiar with the weed species that grow in your orchard?</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Are weeds treated at a stage when they are most susceptible to the herbicide?</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Is spot spraying part of your weed control program?</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Are contact herbicides used instead of pre-emergent herbicides?</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Where soil leaching is a problem, have you discontinued the use of triazines or other problematic herbicides that may leach into the groundwater (i.e. simazine)?</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Do you vary your herbicide application rate according to climatic conditions?</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Do you position your microsprinklers to take advantage of tree shading and reduce weed growth between trees?</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Do you grow a cover crop for weed suppression?</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Are you aware the summer weeds can increase your orchard water usage.</td>
<td></td>
</tr>
</tbody>
</table>

Benefits of completing a PPS for the Grower:

- The grower identifies areas of citrus management that need more attention. For example, a low point accumulation in the area of soil management, indicates this is an area that he should learn more about. The grower can take classes, or read books, or discuss the subject with experts.
- Growers learn about practices that they are unfamiliar with that can be used in their orchard. Growers who helped us develop the PPS frequently discovered a citrus production practice in the list of questions that they had never heard of before. During that meeting, they were able to ask their Farm Advisor more details about that practice, chat with other growers, and consider adopting the practice in their orchard.
- Participation in the assessment provides documentation for various regulatory agencies that the grower is protecting ground water, air, and the environment. For example, the PPS questions that address irrigation management, sediments, nutrients and pesticides may be accepted by the Regional Water Quality Control Board as documentation of a farm plan.
- Participation in the assessment provides documentation for consumers and regulatory agencies that the grower is producing food that is safe from disease or chemical contamination. The PPS questions that address water quality, use of manures, pesticide use, post harvest handling of fruit, and employee training may be accepted as documentation of ‘Good Agricultural Practices’ (GAP).

Benefits for the Citrus Industry

- Growers can demonstrate to the community and regulatory agencies that they are committed to sustainable, integrated citrus pest management practices. The Pest Management Section of the PPS evaluates grower utilization of soft pesticides, natural enemies, and cultural control practices for management of pests.
Participation shows other growers that implementation of sustainable practices can be commercially successful. Some growers are hesitant to adopt new practices till they “see it work”. If the results of the PPS show that a practice is widely used in a region, then a grower is more likely to adopt that practice. When groups of growers over a wide area adopt softer pesticide practices, natural enemies and other nonchemical methods of pest control are more to succeed.

Benefits for University of California Cooperative Extension

- Participating University of California Cooperative Extension Personnel will be provided the results of the assessments for their region. Low scores in a category will alert educators to subject areas that need attention. The results of the assessment could be used by UCCE personnel to request grant funds for developing a class, field day, video, web site, or publication for a particular subject.
- If the grower completes an assessment each year for a particular orchard then the PPS can document change in practices over time. These data can be used by Extension and research personnel to demonstrate that learning and change are taking place.
- Analysis of the PPS completed in different regions of the state (coastal, central, desert, southern) will reveal regional differences in pest management practices.

What does it cost to complete a PPS for Citrus Assessment?

There is no cost, other than time, for being a “Participating Grower” who completes a PPS for Citrus assessment. It will take 1.5-2 hours to complete each assessment and this should be done once a year. Growers may want to complete more than one assessment if they have different management practices in different orchards. While the score is used to analyze trends, the grower name will never be published. Growers don’t compare their scores to other growers, but compare practices between their own orchards or look at practices in the same orchard through time.

How does a grower complete the PPS for Citrus Assessment?

UCCE Citrus Farm Advisors (Tulare, Kern, Fresno, Riverside, Ventura, San Diego, San Luis Obispo) will be hosting grower meetings throughout the state of California during Jan-Feb of 2007. During these meetings, growers will fill out a PPS assessment for one of their orchards. Extension personnel will be there to assist and 2 hours of continuing education credits can be earned by participating in the meeting. The information will be collected and tabulated and the individual results reported back to the grower.

Acknowledgements

I thank UCCE personnel and citrus growers for development of the PPS. This project was funded by the University of California ANR Citrus Workgroup and the ANR Core Grant program.
Control of Glyphosate-Resistant Marestail in Orchards and Vineyards

*Kurt Hembree*

*Farm Advisor, UCCE, Fresno County*

Horseweed or marestail (*Conyza canadensis*) is a major weed pest in California. It is an annual weed commonly found infesting perennial orchard and vineyard crops, right-of ways, irrigation ditch banks, and other non-crop areas in the southern San Joaquin Valley. Historically, marestail has been managed in orchards and vineyards with combinations of preemergent and postemergent herbicides. However, with adoption of regulated groundwater protection areas (GWPA), declining crop prices (particularly raisins) since about 2000, and the potential for crop injury when some of these preemergent herbicides are used on lighter soil types, many people began relying more on repeated sprays of postemergent herbicides for weed control. Since generic glyphosate brand products could be bought for less than $20/gal, it became the herbicide of choice for many growers during this time (figure 1).

By 2004, large populations of marestail were readily observed in the region which had not been previously seen. In 2005, a glyphosate-resistant horseweed biotype was documented in California along an irrigation canal system that ran through Fresno and Tulare counties. Including California, there are now 12 states that have horseweed populations resistant to glyphosate in the USA. Preliminary studies in 2006 estimate 85% of the marestail populations tested in the area have some degree of glyphosate resistance (figure 2). The primary reason for marestail evolving resistance to glyphosate is this area is thought to be due to repeated applications of glyphosate to the same areas over a number of years.
Managing populations of glyphosate-resistant marestail requires changing the current control strategy. To be successful, growers should use diverse control tactics and not rely on a single herbicide approach for control. An integrated approach to weed control will undoubtedly eliminate, or at least delay the risk of weed resistance. Three important steps for managing resistant (or non-resistant) marestail populations include: 1) diversify control with the use of both pre- and postemergent herbicides and timely cultivation, 2) apply timely postemergent applications, and 3) use appropriate nozzle or pre- and postemergent herbicides.

Preemergent herbicides registered in orchards and vineyards in California are seen in table 1. When using these herbicides, treatment should begin before marestail seeds germinate. In the southern San Joaquin Valley, marestail emerges in fall following rainfall or post-harvest irrigation water and in late-winter/early-spring (February-April). Products containing bromacil, diuron, norflurazon, and simazine require a permit from the county agricultural commissioner if they are being used in a state GWPA (refer to www.cdpr.ca.gov at the California Department of Pesticide Regulation for additional information). Additionally, to reduce the risk of marestail or other weeds becoming resistant to these herbicides, rotate herbicides with different mode of actions (MOA) and/or use tank-mix combinations.
Table 1. Preemergent herbicides registered in California in orchards and vineyards for marestail control.

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Lb ai/acre</th>
<th>Control</th>
<th>MOA Group</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>bromacil (Hyvar X®)</td>
<td>3.2</td>
<td>Excellent</td>
<td>C1</td>
<td>GWPA permit required</td>
</tr>
<tr>
<td>diuron (Direx®, etc)</td>
<td>2.5</td>
<td>Good</td>
<td>C2</td>
<td>GWPA permit required</td>
</tr>
<tr>
<td>bromacil + diuron (Krovar®)</td>
<td>3.2</td>
<td>Excellent</td>
<td>C1 + C2</td>
<td>GWPA permit required</td>
</tr>
<tr>
<td>eptc (Eptam®)</td>
<td>3.0</td>
<td>Excellent</td>
<td>N</td>
<td>Short residual, primarily nut crops</td>
</tr>
<tr>
<td>fluomioxazin (Chateau SW®)</td>
<td>0.375</td>
<td>Excellent</td>
<td>E</td>
<td>Good coverage of soil surface</td>
</tr>
<tr>
<td>isoxaben (Gallery T&amp;V®)</td>
<td>1.0</td>
<td>Excellent</td>
<td>L</td>
<td>Non-bearing only</td>
</tr>
<tr>
<td>norflurazon (Solicam®)</td>
<td>2.0</td>
<td>Fair</td>
<td>F1</td>
<td>GWPA permit required</td>
</tr>
<tr>
<td>oxyfluorfen (Goal 2XL®)</td>
<td>2.0</td>
<td>Fair</td>
<td>E</td>
<td>Good coverage of soil surface</td>
</tr>
<tr>
<td>Simazine (Princep®)</td>
<td>2.5</td>
<td>Good</td>
<td>C1</td>
<td>GWPA permit required</td>
</tr>
<tr>
<td>Simazine + diuron</td>
<td>1.5 + 1.5</td>
<td>Excellent</td>
<td>C1 + C2</td>
<td>GWPA permit required</td>
</tr>
<tr>
<td>Thiazopyr (Visor®)</td>
<td>1.0</td>
<td>Fair</td>
<td>K1</td>
<td>Split the rate in fall and winter</td>
</tr>
</tbody>
</table>

Refer to the pesticide label for crops labeled and follow all label recommendations. Other effective products may be available but not listed here.

Postermergent herbicides registered in orchards and vineyards in California are shown in table 2. Rotating to alternative herbicides like glufosinate, paraquat, and 2,4-D can provide effective control of marestail resistant to glyphosate. When several species of weeds are present and are not controlled by these other products alone, tank mixing with glyphosate can work as long as the alternate product is effective on marestail and is allowed on the pesticide labels. Effective control can be achieved as long as treatments are made when the weeds are small and not stressed for moisture. Like with the preemergents, rotate postemergent herbicides with a different MOA. Do not continue to use the same product year-after-year, or resistance could evolve.

Table 2. Postemergent herbicides registered in California in orchards and vineyards for marestail control.

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Lb ai/acre</th>
<th>Control</th>
<th>MOA Group</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>carfentrazone (Shark EW)</td>
<td>0.031</td>
<td>Good</td>
<td>E</td>
<td>Marestail &lt;21 leaves</td>
</tr>
<tr>
<td>glufosinate (Rely®)</td>
<td>1.0-1.5</td>
<td>Excellent</td>
<td>H</td>
<td>Marestail &lt;4” tall</td>
</tr>
<tr>
<td>glyphosate (Roundup Weathermax®, etc.)</td>
<td>2.0</td>
<td>Good</td>
<td>G</td>
<td>Marestail &lt;21 leaves</td>
</tr>
<tr>
<td>paraquat (Gramoxone Inteon®, etc.)</td>
<td>2.0</td>
<td>Excellent</td>
<td>D</td>
<td>Marestail &lt;4” tall</td>
</tr>
<tr>
<td>2,4-D (Dri-Clean®, etc.)</td>
<td>1.4</td>
<td>Excellent</td>
<td>O</td>
<td>Marestail &lt;4” tall</td>
</tr>
</tbody>
</table>

Refer to the pesticide label for crops labeled and follow all label recommendations. Other effective products may be available but not listed here.

Cultivation is also an effective option for managing resistant marestail populations. Marestail plants less than 4” tall are very sensitive to tillage. Numerous types of equipment are available that can be used for cultivating both in- and between-row in orchard and vineyard systems. Shallow disking of row middles two to three times a year can effectively remove weeds between the trees. In grapes, specialized in-row cultivators can be used as long as irrigation tubing is suspended high off the soil surface. Specialized in-row cultivation equipment includes the French plow, Clemens, Weed Badger, Bezzerides, and others. When the soil is slightly moist, young weeds can be easily killed, while protecting the grape vines. Most of the other tree and vine crops are only cultivated during the establishment years. As tree nut and fruit trees mature,
cultivation is usually limited to the middles. In this case, combinations of middle cultivation and pre- and postemergent herbicide strip-sprays can be effective for eradicating marestail. In addition to cultivating emerged weeds, lightly disturbing the soil surface before marestail seed germinates may inhibit weed emergence. Most marestail seed does not emerge from depths of 2 mm or more, so burying seed may be an option (lighty disking or scraping the soil surface in October – December). Mowing is not an effective tool for marestail management. The use of propane flamers can work, but the marestail needs to be in the seedling stage and multiple applications may be needed. A permit may be required for such a technique.

Postemergent herbicide efficacy on marestail seems to be influenced by the stage of marestail growth at time of treatment. Figure 3 shows a comparison of glyphosate and glufosinate on marestail (not resistant to glyphosate) control, when treated at three different stages of growth in a trial conducted in a grape vineyard in Fresno County in 2006 (unpublished results). What is apparent from this, and other work is that marestail needs to be relatively small (rosette stage or less) to be effectively controlled with most of the postemergent products. Therefore, treat marestail plants before they become too large and escape treatment. Since “contact-type” herbicides (like paraquat, carfentrazone, and glufosinate) require thorough wetting of the weed foliage to be effective, early timing of treatment is especially critical. If weeds become large, the spray nozzles may be set to low to cover the entire weed and regrowth can occur. To improve wetting of the weed foliage, consider using twinjet or similar nozzles, rather than “standard” flat-fan spray nozzles, which are better suited for preemergence herbicides. Increasing weed cover will improve wetting of the weed foliage, including the entire stems, and will require additional water to be carried in the spray tank.

Figure 3. Efficacy of glyphosate and glufosinate at different stages of marestail growth in Fresno County 2006.
Since a single marestail plant can produce more than 200,000 seeds per plant, which can be dispersed in air currents ¼ mile or more, it is imperative that growers, pest control consultants, and others be diligent in their efforts to prevent the escape of this weed, particularly glyphosate-resistant biotypes. To help resolve this problem, diversify the approach to weed control by incorporating preemergent herbicides (like simazine, bromacil, flumioxazin, or others where appropriate) into the program at least every 2nd or 3rd year. If you farm in a GWPA and want to use some of the products currently regulated in California, obtain a permit from the agricultural commissioner. Also, time preemergent treatments in the fall and the late-winter where multiple periods of emergence may occur. When using postemergence herbicides, treat when marestail plants are at the rosette stage or sooner. Alternative herbicides that can control glyphosate-resistant marestail include glufosinate, paraquat, 2,4-D, and carfentrazone. If you must use glyphosate, tank-mix one of these other effective postemergence products and remove those plants escaping treatment. Thorough coverage of the foliage is important for marestail control. Additionally, implementing similar control practices along field margins, fence lines, road sides, and canal banks are essential components for eradication. Practicing good integrated approaches to control and routinely monitoring fields for escapes will help to resolve the situation and help maintain glyphosate as an important tool for weed control in California.

**Suggested references**

Weeds of California and Other Western States. 2006. ANR Pub. 3488.
Herbicide Handbook. 1994. 7th ed. WSSA.
UC IPM Web Site at [www.ucipm.ucdavis.edu](http://www.ucipm.ucdavis.edu)
International Survey of Herbicide Resistant Weeds at [www.weedscience.org](http://www.weedscience.org)
Managing Hard to Control Weeds
Lessons from the field

Dave Cheetham, Helena Research and Development
3155 Southgate Lane, Chico, CA 95928, dcheetham@helenaresearch.com

A host of weeds are fast becoming problematic for tree and vine growers to control in California. Many of these are exhibiting tolerance and or resistance to glyphosate. Some of the resistant weeds listed include ryegrass (*Lolium* spp.), Horseweed, and Hairy Fleabane (*Conyza canadensis* and *bonariensis*) (Hembree and Shrestha. 2004), (Simarmata et al. 2003). An increase in the diversity in weed management strategies are needed to deter the evolution of glyphosate tolerant and or resistant weeds. The use of alternative modes of action in tank mix with glyphosate and or rotation from it every few years can be crucial to maintaining its effectiveness (Rousch, RT. 2006).

Glyphosate has been claimed as the most important herbicide in agriculture. The first cases of resistance to glyphosate were detected in 1996 in ryegrass in Australia (Powel, et al. 1998). Since then, documentation of resistance to the herbicide has been noted in goose grass (*Eleusine indica*), ryegrass (*Lolium spp.*) in California, Brazil, and Chile, buckhorn plantain (*Plantago lanceolata*), and Conyza species (Rousch, RT. 2006). The mechanism for resistance in ryegrass is due to a single gene which results in the reduction of translocation of the herbicide to roots and meristematic tissues in leaves (Lorraine-Colwill et al. 2003). According to presentations by Hembree and Shrestha, resistance by Conyza species appears to be similar to ryegrass.

Control Strategies

The critical first step in managing glyphosate resistant/tolerant weeds is to recognize that they occur in your field, than limit their spread. Control options should be implemented with the understanding that limiting the weeds production of new seed is the top priority. This will likely be attained by managing the weeds both mechanically/physically and through well timed herbicide applications with multiple modes of action that work on the target weeds.

**Mechanical** – Numerous in-row equipment are available that can be used to control weeds in orchards and vineyards if timed properly. Time the operation when weeds are small and when soil is slightly moist. The best control is achieved when allowing for the top 2-3 inches of soil to be disturbed and the weeds dried out (Hembree and Shrestha. 2004).

**Herbicides** - Several pre and post emergent herbicides are available and up and coming for tree and vine growers (see table 1). It is important that applications be made according to directions on the herbicide label. Pre-emergent herbicides are most effective when applied prior to the weed germinating. Post emergent herbicides always work better on juvenile weeds than
large wolfy weeds. However, in some cases an increase in herbicidal activity has been noted in the field when tank mixing post and pre-emergent herbicides (see figures 1 and 2).

Table 1. Helpful modes of action for the control of glyphosate resistant/tolerant weeds in orchards and vineyards.

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Common Name</th>
<th>MOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unison*</td>
<td>2,4-D</td>
<td>Auxin Growth Regulator</td>
</tr>
<tr>
<td>Poast</td>
<td>sethoxydim</td>
<td>ACCase</td>
</tr>
<tr>
<td>Matrix*</td>
<td>rimsulfuron</td>
<td>ALS</td>
</tr>
<tr>
<td>Gramoxone Inteon</td>
<td>paraquat</td>
<td>Cell Membrane Disruptor</td>
</tr>
<tr>
<td>Rely</td>
<td>glufosinate</td>
<td>Cell Membrane Disruptor</td>
</tr>
<tr>
<td>Surflan</td>
<td>oryzalin</td>
<td>DNA</td>
</tr>
<tr>
<td>Prowl H2O</td>
<td>pendimethalin</td>
<td>DNA</td>
</tr>
<tr>
<td>Round-up</td>
<td>glyphosate</td>
<td>EPSPS</td>
</tr>
<tr>
<td>Rage*</td>
<td>glyphosate + carfentrazone</td>
<td>PPO + EPSPS</td>
</tr>
<tr>
<td>Shark</td>
<td>carfentrazone</td>
<td>PPO</td>
</tr>
<tr>
<td>GoalTender</td>
<td>oxyflurofen</td>
<td>PPO</td>
</tr>
<tr>
<td>Goal</td>
<td>oxyflurofen</td>
<td>PPO</td>
</tr>
<tr>
<td>Chateau</td>
<td>flumioxazin</td>
<td>PPO</td>
</tr>
<tr>
<td>Spartan*</td>
<td>sulfentrazone</td>
<td>PPO</td>
</tr>
</tbody>
</table>

* Registration pending.
Figure 1. Tank mix options for controlling glyphosate resistant ryegrass (*Lolium* spp.).

Figure 2. Tank mix options for controlling glyphosate tolerant Hairy Fleabane (*Conyza bonariensis*).
References Cited


New Problematic and Unusual Weed Introductions Affecting Southern California

Joseph M. DiTomaso. University of California, Davis, California, 95616, jmditomaso@ucdavis.edu

There are a number of important invasive species that severely impact wildlands, rangelands, coast dunes and prairies, and riparian areas of Southern California. Among these include poison-hemlock (*Conium maculatum*), fennel (*Foeniculum vulgare*), Malta starthistle or tocalote (*Centaurea melitensis*), artichoke thistle (*Cynara cardunculus*), shortpod mustard (*Hirschfeldia incana*), saltcedar (*Tamarix ramosissima*), and perennial grasses such as giant reed (*Arundo donax*), pampasgrass (*Cortaderia selloana*), and crimson fountaingrass (*Pennisetum setaceum*). These species, for the most part, are very common and easily recognizable. However, there are many other species that are either locally problematic or have the potential to greatly expand their ranges in the southern regions of the state. Some of these are listed in Table 1. For more information on each of these plants, see DiTomaso and Healy (2007).

Table 1. More obscure invasive species or problematic roadside species in southern California and their ranking on the statewide California Invasive Plant Council’s (Cal-IPC) inventory.

<table>
<thead>
<tr>
<th>Species</th>
<th>Common name</th>
<th>Family</th>
<th>Cal-IPC (2006) list</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dicots</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Mesembryanthemum crystallinum</em></td>
<td>Crystalline iceplant</td>
<td>Aizoaceae</td>
<td>Moderate Alert</td>
</tr>
<tr>
<td><em>Brassica tournefortii</em></td>
<td>Saharan or African mustard</td>
<td>Brassicaceae</td>
<td>High</td>
</tr>
<tr>
<td><em>Euphorbia terracina</em></td>
<td>Carnation spurge</td>
<td>Euphorbiaceae</td>
<td>Moderate Alert</td>
</tr>
<tr>
<td><em>Ricinus communis</em></td>
<td>Castor bean</td>
<td>Euphorbiaceae</td>
<td>Limited</td>
</tr>
<tr>
<td><strong>Monocots</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Phoenix canariensis</em></td>
<td>Canary Island date palm</td>
<td>Arecaee</td>
<td>Limited</td>
</tr>
<tr>
<td><em>Washingtonia robusta</em></td>
<td>Mexican fan palm</td>
<td>Arecaee</td>
<td>Moderate Alert</td>
</tr>
<tr>
<td><em>Asphodelus fistulosus</em></td>
<td>Onionweed</td>
<td>Liliaceae</td>
<td>Moderate Alert</td>
</tr>
<tr>
<td><em>Phragmites australis</em></td>
<td>Common reed</td>
<td>Poaceae</td>
<td>Unable to score because of native congenerics</td>
</tr>
</tbody>
</table>
Crystalline iceplant

South African native that is a trailing annual, biennial or even sometimes a short-lived perennial. The plant has two distinctly different leaf types. The young leaves are heart-shaped and much larger than the ovate or spatula-shaped mature leaves. Crystalline iceplant foliage is covered with glistening water-filled papillae. The flowers are white but turn pink with age. The capsules open when moistened. This species is common on coastal bluffs and other disturbed sites in coastal California, Catalina and the Channel Islands. It appears to be expanding its range and can form dense spreading mats in coastal dunes. When it ages and senescs the increased organic matter can lead to the establishment of other non-native weeds that typically are not adapted to native undisturbed dunes and bluffs.

Saharan or African mustard

Saharan mustard is a winter annual. Despite the common name, it is considered native to the Mediterranean region. In recent years, it has spread rapidly in the Sonoran Desert, including the Imperial Valley. This was very evident in the wet spring of 2006 when Saharan mustard became a dominant species in many communities. It can spread from roadsides into washes, drainages, desert shrubland, and sensitive dune areas. In desert communities it forms a continuous fuel source that can increase the fire frequency, cause large scale conflagrations and lead to type conversion of desert scrub to grassland. In some areas, it threatens to aggressively out compete rare desert plant species. Seeds of the plant can disperse much like tumbleweeds, when dried plant stems break at ground level and tumble under windy conditions. The plant is well adapted to desert climates and its seeds can become sticky with mucilage when moistened with water. This allows the seed to hold water longer and to survive following germination. Control of Saharan mustard is similar to many other mustards. The ALS (acetolactate synthase) inhibiting herbicides such as chlorsulfuron, metsulfuron, sulfometuron and imazapic can effectively control the plant.

Carnation spurge

A relatively uncommon perennial weed in southern California. Carnation spurge is native to southern Europe and the Mediterranean and was introduced to the state in the mid-1980s. Because of its recent introduction, it is not included in the most current California floras. It appears to be spreading rapidly and can form dense patches that increase after fire. The species is very common on the coastal bluffs near Malibu, but can also be found in grasslands, dunes, salt marshes, riparian areas, and oak woodlands in other regions of Los Angeles County. Although it prefers disturbed sites, carnation spurge can also invade relatively undisturbed habitat. The sap has been reported to be toxic, and may cause dermatitis. Control of the weed can be achieved with treatments of triclopyr, chlorsulfuron or glyphosate.

Castor bean

Castor bean has a long history as both a medicinal and toxic plant. It is native to tropical Africa and Eurasia and can be a herbaceous perennial or even a small tree to 10 feet tall. Although some varieties are cultivated as ornamentals or even for their seed oil, the species has
escaped cultivation in many locations in the central and south coast of California and has become a common roadside, railway and wildland invasive. The plant is well adapted to dry areas. The seed caruncle absorbs water which enhances germination under conditions that would otherwise be too dry for most competing vegetation. The toxicity of the plant is well recognized and can kill both animals and humans. The toxic, a proteolytic enzyme known as ricin, is primarily concentrated in the seeds, although the foliage can also contain the poison. Ingestion of about 4-8 seeds by an adult can be lethal and even fewer can kill a child. Castor oil, which is also derived from seeds, does not contain the water-soluble toxin. Ricin is considered one of the most toxic substances produced by plants and can kill a human when injected into the blood system at 0.0001 mg/kg of body weight (Kingsbury 1964). The compound has been used by the former Russian KGB to commit murder by injecting ricin into victims using an umbrella with a hypodermis needle attached at the tip. Handling castor bean foliage can also cause a severe contact dermatitis and the disagreeable odor of the plant accounts for its avoidance by foraging animals. Livestock poisonings can occur when feed is contaminated with castor bean seeds. Control of castor bean has been reported with glyphosate or growth regulator herbicides.

**Canary Island date palm and Mexican fan palm**

Both these palms are commonly cultivated as landscape ornamentals. However, they have regularly escaped into urban areas, orchards, and natural riparian stream and river corridors where they are typically found as young plants. Although they occur many regions of the state, they are much more common in southern California. They have particularly become a problem in natural riparian stream and river corridors near residential areas, orchard crops, and as seedlings that volunteer in landscaped areas. As is indicated by the common name, Canary Island date palm is native to the Canary Islands and Mexican fan palm is native to central Mexico, but not the northern mountain deserts. Birds routinely feed on the fruit and can disperse the seed with their droppings. For this reason, infestations are common under taller vegetation or telephone wires and other tall structures. In addition, the seeds are large and readily carried by winter rains from landscaped areas down storm drains into nearby creeks and rivers. Control is difficult because of the thick waxy cuticle on the leaves. This prevents herbicide absorption. However, imazapyr has been shown to be an effective management option for smaller plants.

**Onionweed**

Onionweed is an annual to short-lived perennial with thick tuber-like stem bases. It is native to southern Europe and was introduced to the United States as a garden ornamental. Although the common name contains the word onion, it does not have the characteristic odor or taste of onion or garlic when crushed. It can also be found in pastures and rangelands in Australia, where it is avoided by livestock. In Australia, onionweed is a government-listed noxious weed. In California, it is rapidly spreading along southern and central coast where it can form dense populations that exclude grasses and other desirable forage species. Control of the species is considered very difficult. Australian have reported 2,4-D to be somewhat effective, but in California a 5% solution of glyphosate has been used in control efforts.
Common reed
Common reed is more often referred to as *Phragmites*. Although its current scientific name is *Phragmites australis*, it is commonly listed in the literature as *Phragmites communis*. The species is a widespread native perennial grass of the United States, including California, where it is a desirable component of natural aquatic ecosystems such as marshes, and borders of lakes, ponds, and rivers. An invasive ecotype from Europe was first introduced to the eastern United States about 150 years ago and has spread rapidly throughout the country, but particularly in the eastern states. Genetic studies show it to be more aggressive than the native biotypes and is capable of spreading into new areas and plant communities. It is considerably more salt tolerance than the native ecotype and, as a result, has invaded more saline areas of the coast. In the eastern United States, it is replacing the native *Spartina* communities and it may do the same in the west coast. It is very difficult to distinguish the European from the native North American biotypes. The main distinguishing characteristic is the length of the ligule, which is very small in both biotypes. For some people, it is even difficult to distinguish common reed from giant reed (*Arundo donax*). Unlike giant reed, common reed produces viable seed.

Literature Cited
Introduction

Thousands of non-crop acres in California are infested with invasive weeds. The weeds destroy wildlife habitat, alter soil and water resources, invade cropland, decrease grazing productivity, and decrease recreation value. Weeds also commonly spread into suburban areas costing landowners thousands of dollars in management and land value loss. California land managers spend millions of dollars on non-crop weed control each year, but unfortunately, most weed control efforts do not produce long-term weed suppression or increases in land productivity.

Range and wildland ecology experts suggest artificial re-vegetation is critical to restoring vegetation health and land-use productivity on weedy sites. Research has also demonstrated re-vegetation of disturbed land can greatly improve long-term weed suppression. This research project addressed the importance of vegetation restoration in an integrated weed management program and developed successful re-seeding strategies for non-crop areas and pastures within Northeast California. The re-vegetation treatments were designed to maximized establishment success, minimized noxious weeds, and restored productivity of weedy sites to meet the needs of wildlife, recreation, and agriculture.

Specific objectives included:

• Evaluating different native and introduced perennial species on the basis of establishment success, vigor, and ability to prevent weed invasion
• Determining perennial species' tolerance to pre and post-emergent herbicides commonly used for range and wildland establishment
• Assessing different herbicide + seeded species combinations on their ability to suppress weeds during and after grass establishment

Materials and Methods

The experiment was conducted at six sites. Sites in Doyle, CA and Tulelake, CA (IREC) were established in fall 2003. Four additional sites were established in fall 2004 at the Tulelake National Wildlife Refuge, Yreka, CA, Likely, CA, and Susanville, CA. The experiment at all sites was arranged in a split block with three replications. Whole block treatments consisted of five or six different herbicide treatments (chosen based on weed species present on-site) applied to control weeds during establishment. The goal of herbicide treatment was to limit weed competition and prevent weed seed production and vegetative spread of creeping-root perennial weeds. Sub-block treatments consisted of seeding 15 to 17 native and introduced perennial species.
Field sites were disked and packed to control existing weeds and prepare a seedbed. Grass species were seeded around March 1st using a drill. Herbicides were applied with a CO₂ backpack sprayer at 20 GPA when grasses reached the three to five leaf stage the year of establishment and one to two months after grass green-up the year following establishment. Grass species establishment and vigor was evaluated in June and/or August each year. The percentage of drill row occupied by the seeded species, seeded grass cover, and weed species cover was measured in each plot. Data was collected using point-intercept counts and visual estimation of percent cover in 1 m² quadrats.

**Results**

Several native and introduced plant species successfully established under dryland conditions on weedy sites in Northern California. Cover measurements showed dense, perennial grass stands in combination with herbicides provided superior weed suppression compared to using herbicides alone the year after grass establishment. At locations with heavy weed competition, herbicide treatment the year of seeding and year after seeding was critical for successful establishment. Without herbicide treatment, weed cover was greater than 70% and seeded grass cover was less than 5% at weedy sites one year after planting. In herbicide-treated plots with effective weed control, seeded species cover was 10 to 20 fold greater than untreated plots. Telar, 2,4-D ester, Transline + 2,4-D ester, Banvel + 2,4-D ester, and Pursuit caused minimal injury to perennial grasses when applied at the 3 to 5 leaf stage during establishment. Pursuit was safe on seedling alfalfa.

Seeded grass cover differed between sites and was correlated to soil moisture. Sites with the highest soil moisture the year of seeding had the highest average grass cover. Although soil moisture increased grass cover, weed control remained the most important factor affecting species establishment success. At the site with the highest soil moisture (Tulelake Wildlife Refuge), average seeded grass cover was 5% in untreated plots whereas it was >50% in herbicide treated plots one year after seeding.

When comparing individual species, their establishment and persistence differed between sites. The differences were related to soil type and soil moisture trends the year of establishment. Averaged across sites, crested wheatgrass, tall wheatgrass, western wheatgrass (native), and bluebunch wheatgrass (native) had the highest cover 1 year after seeding. Squirreltail and orchardgrass had the lowest cover 1 year after seeding. Results collected over the next few years will provide an indication of species’ long-term establishment success and potential for long-term weed suppression.
An Overview of The Biological Control of Saltcedar

Raymond I. Carruthers\textsuperscript{a}, John C. Herr\textsuperscript{a} and C. Jack DeLoach\textsuperscript{b},
\textsuperscript{a} USDA-ARS, 800 Buchanan St., Albany, CA 94710, ric@pw.usda.gov
\textsuperscript{b} USDA-ARS, 808 E. Blackland Road, Temple, TX 76502

Introduction

Saltcedar (\textit{Tamarix} spp. (Tamaricaceae: Tamaricales)) is an exotic weed that has invaded many riparian areas across western North America. In the absence of natural enemies and disease causing organisms, saltcedar grows very aggressively and is highly competitive with native vegetation, especially in areas where the natural hydrology has been altered limiting stream flow during spring months when native cottonwoods and willows are seeding. Therefore, many of the nation’s most productive and diverse ecological regions are being negatively affected by the invasion of this exotic invasive plant. Common methods used to control saltcedar include herbicide application, burning and bulldozing, all of which are expensive and highly detrimental to non-target flora and fauna. Although these approaches may be successful in the short run, they do not provide permanent control of the problem as the saltcedar often grows back or reinvades from surrounding areas.

Over the past decade, biological control of saltcedar has been a major research effort within the USDA-ARS. In cooperation with ARS, a consortium of scientists and land managers has field tested the use of this technology in several western states. A leaf beetle from Eurasia, \textit{Diorhabda elongata} (Chrysomelidae: Coleoptera), has now been successfully used at several locations, where it has established reproductive populations, increased dramatically in numbers and spread extensively across saltcedar infested areas where it has caused extensive defoliation of saltcedar for multiple seasons. In many of these test locations, the leaf beetles significantly impacted saltcedar growth and development, while no non-target plants have been negatively affected. In this paper, we will primarily provide a summary of these results.

Methods And Materials

The Study Areas. Saltcedar biological control release sites have been established in at least nine different western states comprising California, Colorado, Montana, New Mexico, Nevada, Oregon, Texas, Utah and Wyoming. Some states such as California, Nevada and Texas included three or more different release sites while the other states only had a single test site. In California, initial release sites included Inyo (Owens River Valley), Monterey (along San Antonio Creek on Fort Hunter Liggett), and Yolo (Cache Creek) Counties. In Nevada release sites were established in Pershing (along the Humboldt River near Lovelock), Churchill (along
the Carson River near Stillwater) and Mineral (along the Walker River near Schurz) Counties, and in Utah in Millard County along the Severe River near Delta.

Biology And Ecology Of The Saltcedar Leaf Beetle. Both adults and larvae of the saltcedar leaf beetle, *D. elongata* (Fig. 1A-D), feed on the foliage of saltcedar and the large larvae also debark small twigs causing the distal foliage to die. The adults overwinter and the larvae pupate under litter beneath the trees. Laboratory tests of reproductive capacity showed that beetle populations can double each 6.2 days and field cage studies showed a range of population increases but a 30-fold increase per generation was not uncommon. In Nevada and Utah, overwintered adults become active in early-May and produce two generations before they begin overwintering in September. In the more southern areas, the saltcedar growing season appears to be long enough to allow completion of 3 or possibly even 4 generations each season.

![Figure 1. *Diorhabda elongata* beetles and damage to *Tamarix*: A) top to bottom adult female, 1st instar, 3rd instar, adult male all on a single stem; B) adult male; C) 1st and 2nd instars; D) 3rd instar; E) egg mass; F) moderate larval defoliation of saltcedar in a field test site.](image)

Experimental Releases And Results In Field Cages July 1999 To May 2001. After receiving US Fish and Wildlife Service concurrence and USDA-APHIS permits, beetles from China and Kazakhstan were released into field cages during the summers of 1999 and 2000 at 10 sites in 6 states. These beetles successfully overwintered in the cages at the eight most northern sites, all north of the 38th parallel. They failed to overwinter at the two most southern sites, at Seymour, TX and Hunter-Liggett, CA both south of the 38th parallel. Here, they ceased feeding and egg-laying, and began overwintering diapause in early July but did not survive the winter. During the summer of 2000, we learned that the most probable cause of the failure to overwinter at more southern locations was the short summer daylengths, which caused premature diapause that limited egg production to early in the season and decreased overwintering survival. Laboratory studies showed these beetles required at least 14 h 45 min daylength to avoid entering...
overwintering diapause. Subsequently, beetles were collected from more southern locations in Eurasia and then introduced successfully into California and Texas where they are now operating effectively. Beetles from Crete, Greece were selected, as they were determined to be the most likely to succeed in areas with shorter daylengths and thus were released into southern Texas and Central California where they have established and are continuing to be monitored. Ground sampling of beetle populations and their impact on target saltcedar and adjacent beneficial species was conducted at all of the release sites for several years, however the scale of impact quickly made ground-based field sampling both difficult and expensive. Previous studies documented the effective use of remote sensing for the assessment of saltcedar infestations. In support of the overall project monitoring and assessment efforts, further remote sensing was conducted to characterize saltcedar infestations, to follow beetle establishment, impact and spread, and eventually to document the return of beneficial vegetation into areas where saltcedar has been controlled. Here we will discuss the establishment and spread of these beetles at several sites but will concentrate on local release areas in California, Nevada, Texas and Utah where our team has been conducting detailed assessments of this biological control program.

Results And Discussion

Releases And Results In The Open Field In Northern Areas (May 2001 To Late Summer 2005). The results of the field cage studies allowed open field releases to be conducted in multiple states during the 2001 field season. A variable number of beetles were released at the 13 different field test sites, however, in an example area near Lovelock, NV approximately 1300 beetles were released into the open field to initiate establishment and spread of these biological control agents across a wide area. At most sites, a few to moderate numbers of eggs, larvae and adults were found throughout the remainder of the summer of 2001, until late August or early September, when we assumed they had entered overwintering diapause. The most damage was at Pueblo, CO where the beetles defoliated ca. two-thirds of a rather large tree. Similar low densities of beetles were found during the spring and early summer of 2002, although they had dispersed over a wider area of ca. 50 to 100 m in radius from the release point at most study areas. Then, when large larvae of the second generation developed in mid-August, extensive damage was observed at some sites. The most spectacular damage was at the Lovelock, NV release site (Fig. 2A).

Figure 2. Saltcedar leaf beetle defoliation during midsummer 2002, one year following beetle release at Lovelock, NV. Canopy area masked with white is the highly impacted area.

This site is located in a very large area of dense saltcedar in the floodplain of the Humboldt Sink. Essentially the only other vegetation present was a moderate stand of saltgrass growing between the saltcedar trees. Large populations of larvae (Fig 1F) were found during mid-August that rapidly defoliated the saltcedar within an area 100 m in diameter (2 acres, Fig 1B), centred at
the release cage. Heavy feeding but not total defoliation had occurred in an additional concentric ring 50 m wide outside the defoliated area.

By the end of the third growing season in late August 2003, *D. elongata* had begun a rapid and dramatic defoliation of saltcedar (Fig 3A) at five of the seven release sites north of the 38th parallel. At Lovelock, NV, the beetles increased to 8 acres in early July 2003 (Fig 3B), and to ca. 500 acres by early September 2003 (Fig. 3C). By September 2003, several plants had resprouted but enough beetles had remained to defoliate this regrowth. At Delta, Utah the beetles defoliated approximately 100 acres by September 2003. At Schurz, NV the beetles dispersed beyond the monitoring area in 2002, but in 2003 they had defoliated ca. 30 acres along the Walker River. No beetle establishment was ever documented at the Stillwater release site even though it is between two other very successful release areas, however, after the first few years, no additional attempts were made. By the end of 3½ growing seasons after release (late June 2004), defoliation increased 3 to 5 fold over the amount in August 2003, to an estimated 1500A at Lovelock, 500A at Delta, 300A at Schurz. In 2005 this defoliation continued heavily in each of our test sites spreading to literally 1000s of acres in each of our Nevada and Utah test sites. By the fall of 2005 in the Lovelock, NV test area, nearly every saltcedar tree within a 65,000 acre area (not continuous saltcedar) was heavily impacted by the beetles and the spread was found to be over 100 miles along the Humboldt River and Humboldt Sink.

By early spring of 2006, many trees have been completely killed in the center of the release areas and we expect to see increasing tree death during the 2006 growing season. Although it takes substantial time for the trees to die, the defoliation has been 95 to 100% over very large areas, which has greatly reduced water usage and plant reproduction in many of the release sites. This defoliation has further opened the plant canopy and allowed other plants to begin increasing in number and size. Some of those are beneficial species, such as saltgrass, willows and seedling cottonwoods, however, other weeds such as Russian Knapweed (*Acroptilon repens*) and Tall whitetop (*Lepidium latifolium*) are increasing in number. Therefore, USDA-ARS has expanded research into revegetation and restoration research to augment previous investigations of this type conducted by the USDI Bureau of Reclamation. Currently, *Diorhabda* beetles are very widely distributed at most of our release sites in both Nevada and Utah where the local Departments of Agriculture in cooperation with USDA-APHIS have begun an area-wide redistribution effort.

*Short-Daylength Beetles Discovered And Released In Southern Areas.* In California, Chinese *Diorhabda* were originally released at three different locations (Owens Valley, Cache Creek and Ft. Hunter Liggett) in 2001, however, none of these releases ended in establishment due to a variety of factors including poorly adapted diapause characteristics, heavy predation by ants and other generalist predators and other factors. Once initial releases failed, the team delayed further introductions until the diapause situation was better understood and new potential germplasm
was available and tested. As part of a follow up study, new beetles were collected at lower latitudes in Crete and mainland Greece, and through a latitudinal gradient from Tunisia, north and east into China via our co-operators at other locations in Asia. It was felt that some of these beetles had the potential to establish south of the 38th parallel and perhaps throughout the range of saltcedar in the southwestern U.S. and northern Mexico. The Crete beetles, were the first to be placed in a large outdoor cage at Temple during August 2002 and were allowed free range inside cages where they overwintered with little mortality, and began feeding and reproducing vigorously on the plants by early April. Additional host specificity testing of the Crete *D. elongata* allowed them to be permitted and released into restricted areas in Texas and California during the summers of 2003 and 2004, respectively. In California these beetles were only placed in the open field along Cache Creek where we conducted additional host specificity tests in field cages with potentially vulnerable *F. salina*. At this site, the beetles establish after the first year but did not significantly increase their populations until the summer of 2006. Currently, a significant population of Crete beetles has established and spread approximately 5 miles along Cache Creek where it has caused nearly total defoliation of saltcedar (*Tamarix parviflora*) over nearly 3.5 acres, with high numbers of adults now overwintering in the area. In Texas, the Crete beetles have followed a similar pattern where they were field released in a wide area and have become well established and are heavily defoliating saltcedar over the release area. In 2005, 2-3 acres of saltcedar were heavily defoliated with substantial populations of overwintering beetles.

**Figure 3 A.** Saltcedar defoliation caused by *Diorhabda elongata* (Lovelock, NV fall 2003).
**Figure 3 B.** Areas appearing black are the saltcedar plants defoliated by the biological control agents in July 2003. The grey areas are the healthy non-defoliated plants. The approximate area defoliated was 8 acres.
**Figure 3 C.** After the 2nd generation of beetles in 2003, (10 September 2003) approximately 500 acres of saltcedar had been defoliated (black area of canopy).
now expanding to nearly 10 times that level of impact. We hope and anticipate that the Crete beetles will follow the same course as the Chinese beetles have done in more northern areas.

To further assess the safety of the Crete beetles to *Frankenia salina*, replicated tests were conducted in field cages in Cache Creek, CA in 2003-05 and throughout the summer of 2005 in the open field in Big Springs, TX. Under heavy defoliation pressure, planted saltcedar, athel and *Frankenia salina* were challenged with high densities of Crete beetles. In the field cages, some eggs were laid on *Frankenia*, however, under more realistic open field conditions no eggs were laid on the *Frankenia* while large numbers of eggs were laid directly on adjacent saltcedar and athel. In the case of the Texas open field studies, these plants were maintained for several weeks in areas of high beetle densities where both adult counts and levels of egg deposition were recorded on several different sampling periods in areas where background saltcedar defoliation was nearly 100%. Based on these and other supporting data, USDA-ARS has requested a more extensive field release and evaluation permit for Crete *Diorhabda* beetles to be field tested into Southern California. Since these sites are in areas near potentially susceptible *Frankenia salina* populations, we acknowledge that these beetles hold some potential risk to native *Frankenia salina*. We therefore plan to work forward in the design, testing and release of these agents with appropriate cooperators from both federal and state land management/wildlife agencies and other potentially concerned groups to ensure that a full benefit/risk policy discussion and consensus has been reached regarding the next steps in this biological control program. The California Department of Food and Agriculture plans to work in parallel with USDA-ARS and distribute Crete *Diorhabda* beetles within the state of California during the spring and summer of 2007. Initial release efforts will begin in Central and Northern California *Frankenia* testing and monitoring will be conducted to assess environmental safety.

**Summary**

The biological control of saltcedar has been an outstanding example of a successful biological control project. A wide number of groups have all worked cooperatively to develop, implement and assess the effectiveness of this program. The leaf beetles from China and Kazakhstan have worked extremely well across the northern tier of the U.S. and we hope that similar beetles from Crete, Greece or other more southern locations will work equally well in the southwest. The project has worked hard to clearly identify and characterize potential non-target risks to agricultural crops and native species, and is working forward in a way to document safety as we proceed. By working in a diligent and defined manner, USDA-ARS hopes that this program will be effectively operating in more southern areas of California, in the near future. Further research and monitoring is still required both to ensure safety of this and other related agents prior to final wide-spread field release and redistribution. This will be done in conjunction with plans that are now being made by CDFA teams to implement this program state-wide in a step-like fashion. Additionally, USDA-ARS and cooperators are investigating other potential natural enemies for saltcedar to use in place of the leaf beetle if the risk of release is too high, or in combination with it at other locations where additional stress on the saltcedar is needed for economic control.
Relevant References


The Advantages and Disadvantages of Being Introduced: European Grasses on Bodega Head

Peter Alpert, Biology Department, University of Massachusetts, Amherst, MA 01003; palpert@bio.umass.edu

Introduced species are those that have been transported into a new region by people. Invasive species are those that enter a habitat and harm species already there. Does being introduced predispose species to be invasive? Advantages of having been introduced include lack of specialized predators and pathogens. Disadvantages include lack of adaptation to local conditions. For example, competition from locally adapted natives may prevent or slow invasion by introduced species, especially in plants. This leads to the ominous prediction that all human-caused alterations to natural habitats will increase invasion, since such changes should decrease the local adaptedness of natives and any competitive advantage over introduced species this may confer. This also leads to the hopeful prediction that reversing past, human-caused alterations will decrease invasion and favor the re-establishment of natives. We tested the first prediction by raising and lowering nutrient availability and disturbance, in the form of grazing by native mammals, in a remnant of native grassland on the coast of northern California. We expected that raising or lowering either factor would promote invasion. To lower nutrient availability, we added sugar to the soil, which increases microbial immobilization of nitrogen. We lowered grazing by fencing out mammals and raised it by clipping plants. After three years, the relative cover and biomass of native plants increased from about 20% to about 60% in plots that were fenced and sugared. This did not fulfill the prediction, and suggested instead simply that lower nutrient availability and lower disturbance favored natives more. We tested the second prediction in highly invaded grassland at the same site, where nitrogen availability was elevated. Here we attempted to restore the lower nutrient availability seen in the native grassland with sugar, and again raised and lowered disturbance by mammals. We also planted young adults of four common native grasses into plots, since there were almost no existing natives. After 18 months, planted natives had attained 15% cover in unmanipulated plots and 25% cover in sugared, fenced plots, again suggesting that lower nutrient availability and disturbance favored natives. We are now setting up larger scale plots on nearby national and state parks lands, and using sawdust as a carbon source in place of sugar, to try to translate these results into prescriptions for the conservation and restoration of native grassland.
Conyza species (horseweed or marestail and flaxleaf fleabane) are rapidly infesting orchards, vineyards, roadsides and canal banks throughout the San Joaquin Valley. Glyphosate resistant horseweed has shown up throughout the United States particularly in the cotton regions of the United States. Table 1 shows the distribution. Glyphosate resistance was demonstrated in 2005 in California. Research by University of California Farm Advisors Kurt Hembree and Anil Shrestha demonstrated that it took up to a 4X rate of glyphosate for some measure of control along some ditch banks where continuous low application rates of glyphosate had been used.

**Glyphosate resistant horseweed in the US.**

- KY (2001)
- TN (2001)
- IN (2002)
- MD (2002)
- NJ (2002)
- OH (2002)
- AK (2003)
- DE (2000)
- MS (2003)
- NC (2003)
- CA (2005)
- NE (2006)

Source:
www.weedscience.org
Global Occurrence of glyphosate resistant *Conyza sp.* Source: www.weedscience.org

*Conyza bonariensis*  
Hairy Fleabane  
2003 – South Africa  
2004 – Spain  
2005 – Brazil  
2005 – Brazil

*Conyza Canadensis*  
Horseweed  
2000 – USA (Delaware)  
2001 – USA (Kentucky)  
2001 – USA (Tennessee)  
2002 – USA (Indiana)  
2002 – USA (Maryland)  
2002 – USA (Missouri)  
2002 – USA (New Jersey)  
2002 – USA (Ohio)  
2003 – USA (Arkansas)  
2003 – USA (Mississippi)  
2003 – USA (North Carolina)  
2003 – USA (Ohio) Multiple – 2 MOA’s  
2003 – USA (Pennsylvania)  
2005 – Brazil  
2005 – USA (California)  
2006 – China

Across the Cotton Belt glyphosate resistance showed up in areas that were on the average 92% Roundup Ready, 2.40% Strip till, 3. 88% not cultivated and 4. There was a trend away from using residual herbicides. California weed shifts in permanent crops and non cropland occurred where there was a combination of reliance on postemergent herbicides, reduced residual herbicides and reduced tillage. There were several years with one or more glyphosate application each year. Reduced rates of glyphosate were used; discontinued use of other herbicides; Reduced
or eliminated tillage; allowed the escapes to reproduce; finally weeds were spread by wind and equipment.

Several studies were conducted last season in Tulare County to evaluate herbicides and combinations for control of horseweed. A few of the research study location results are presented. Tables 1, 2 and figures 1, 2, 3 show the results of these studies. Milestone, Transline at 10.6 oz., Krovar + Accord, Karmex + Accord, and Oust + Accord gave up to 100 percent control of horseweed. The higher rates of Milestone at 7 oz./A was needed to give the most consistent control. Treatment combinations of Glyphosate at 2 lbs. ai. + Indicate, Citric Acid, ET, Shark, or Chateau gave improved control compared to Glyphosate + AMS. In all treatments glyphosate was an important addition for control of grasses that were present.

Control of Glyphosate Resistant Horseweed with Milestone. Fig. 1.

![Control of Glyphosate Resistant Horseweed with Milestone](image)

LSD (P=.05)

138
Table 1. Horseweed control location 1. Dinuba

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Rate/A</th>
<th>11 DAT</th>
<th>34 DAT</th>
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Table 2. Horseweed control location 5. Dinuba

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Fig. 2 Horseweed Control in Ditch banks in Dinuba, Trial location 2.

**Horseweed Study on Ditch Banks**

UCCE - Tulare/Kings Co. - Alta Irrigation - Dinuba - 2006 - Trial #2

![Graph showing horseweed control](image)

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Fig. 3 Horseweed Control in Ditch banks in Dinuba, Trial location 4.

**Horseweed Study on Ditch Banks**

UCCE - Tulare/Kings Co. - Alta Irrigation - Dinuba - 2006

![Graph showing horseweed control](image)
In summary, the non-crop weed management approach must incorporate resistance management strategies: (1) Use minimum number of applications of any one herbicide per season; (2) Rotate herbicides and use tank mixes with different chemistry; (3) Control weed escapes by tillage or hand when appropriate; (4) Monitor and map locations for patterns of weed escapes consistent with developing resistance.

References:


Aquatic Plant Community Evaluations Following Three Years of Management Using Triclopyr (Renovate Aquatic Herbicide®)

Shuler, S. SePRO Corporation, 1780 Creekside Drive, #922, Folsom, CA, 95630, USA, 916-718-2596, Fax: 317-388-3316, scotts@sepro.com

Renovate is a selective broadleaf herbicide that can be used to systemically control a variety of nuisance and exotic aquatic plant species. In addition to controlling unwanted exotics, Renovate allows many native monocots and less susceptible dicots to thrive following treatment. Therefore, this product can be used as an ecosystem restoration tool in lakes, ponds, reservoirs and wetlands. Field development work conducted by the Army Corps of Engineers in the 1990’s, SePRO’s Experimental Use Permit evaluations from 1997 to 2000 and aquatic applicator evaluations during the 2003 -2005 management seasons have documented control of many nuisance and exotic broadleaf species while having minimal impact on many desirable monocots. This unique selective herbicide activity continues to be developed on a variety of emergent, floating and submersed aquatic weed species. A review of this new herbicide technology will be provided with results and discussion of the data from recent trials and field development work.
Managing Herbaceous Perennials in the Tahoe Basin

Jennifer Erskine-Ogden, University of California, Davis, Section of Evolution and Ecology, Davis, CA, 95616, jaerskine@ucdavis.edu, Mark J. Renz, University of Wisconsin, Madison, Justin Norsworthy, New Mexico State University, and Sue Donaldson, University of Nevada Cooperative Extension

Several weedy herbaceous perennial species have recently established within the Tahoe Basin and surrounding areas. While control methods exist for these species, they cannot be implemented in sensitive areas within the Tahoe Basin. We compared a new herbicide delivery method that deposits herbicide on the lower side of a stem’s cut surface with cutting only and spot spraying in both greenhouse and field trials on specific herbaceous perennials. In greenhouse studies we evaluated the effectiveness of several herbicides applied in two different growth stages of perennial pepperweed (PPW) (*Lepidium latifolium*), at the flowerbud and flowering stages. Results showed that applications made to PPW reduced pepperweed belowground biomass by 79, 82 or 42 % if plants were treated with glyphosate (25 % solution of Rodeo\(^1\)), chlorsulfuron (0.14 oz Telar\(^1\)/gallon water) or cut only respectively 45 days after treatment compared to untreated controls. No differences were found between herbicides used, method of application, or phenology of plants. Field studies were also initiated to evaluate the effectiveness of this method under field conditions on PPW, diffuse knapweed (DKW) (*Centaurea diffusa*) and dalmation toadflax (DT) (*Linaria genistifolia ssp. dalmatica*). Excessive rainfall occurred in the winter/spring of 2005 reducing densities 29, 37 and 27 % in untreated treatments for PPW, DKW and DT respectively compared to the previous year. Cover of plants treated with this new method was reduced 76-81, 90-99, and 63-81 % for PPW, DKW and DT respectively. In all cases, adding glyphosate at 10 % (25 % solution of Rodeo\(^1\)), chlorsulfuron (0.11 oz Telar\(^1\)/gallon water), or clopyralid (0.25 fl oz of transline\(^1\)/gallon water) (for DKW & DT only) in a cut stem method improved control compared to cutting stems exclusively (reduced cover 24, 53, and 56% for PPW, DKW and DT respectively). We are currently analyzing species changes as a result of this method and if any differences exist compared to a spot spray application. This new method provides land managers with an effective management option for the eradication of establishing infestations of herbaceous perennial weeds in/near sensitive areas.

For more information on this method, please see our University of Nevada Cooperative Extension Special Publication 06-09 at:
http://www.unce.unr.edu/publications/SP06/SP0609.pdf

\(^1\)Brand names are provided for example purposes only. Other brands may also be licensed for use in your area. Information herein is offered with no discrimination. Rodeo was used in this experiment because of close vicinity to water. Labels should be adhered to for all herbicides for appropriate use.
**Ludwigia Control in the Laguna de Santa Rosa, California** with glyphosate and triclopyr.

Thomas J. McNabb (1)*, Julian Meisler (2) Clean Lakes, Inc. (1) & Laguna de Santa Rosa Foundation (2)

ABSTRACT: The Laguna de Santa Rosa Foundation (Foundation) spearheaded a three-year control effort aimed at reducing the area and density of the aquatic weed *Ludwigia* sp. within selected areas of the Laguna de Santa Rosa (Laguna) watershed in 2005. The infestation hampers efforts to control mosquito vectors of West Nile Virus (WNV) that pose a health threat to humans and wildlife; out-competes native wetland species; and is believed to impair both the water quality and the flood-control functions of the Laguna.

First year control efforts spanned July-October, 2005 and will resume mid-June 2006 and 2007. Control occurred at two sites comprising some 130 acres within the Laguna and included three principle elements: herbicide treatment, harvesting of biomass, and disposal of biomass. The three-year effort is the first step in a larger attempt to restore ecosystem process and function in the Laguna making it more resilient to invasion. While the Foundation does not expect that control efforts will remove 100% of *Ludwigia* from the Laguna, it does expect the control effort to reduce the *Ludwigia* population to a point where restoration of natural ecosystem processes and vegetation can maintain it as a minor rather than dominant component of the natural community. In this presentation we discuss the methods used to control *Ludwigia* in this challenging and complex wetland environment and present preliminary results of the control effort.
Introduction: Riparian, or streamside, vegetation supports the richest array of wildlife species in California. Historically, riparian vegetation lined the major rivers of the Central Valley covering approximately one million acres when Europeans arrived in the mid 1800s. The rich, productive soils found along the Central Valley’s rivers have been developed to agriculture, resulting in the nearly complete conversion of riparian forests. Today, less than five percent of this original acreage remains. As a result, the restoration of riparian vegetation is a priority as a tool for restoring local wildlife populations by most land management agencies and an increasing number of private landowners.

Over the past 15 years riparian restoration has focused on establishing native riparian trees and shrubs on flood-prone land adjacent to Central Valley rivers. This has been largely successful. However, non-native invasive weeds typically remain in the understory after active implementation management has ceased. Significantly, an herbaceous understory composed of native species is an essential for the habitat of many wildlife species.

This report describes an adaptive management exercise that has resulted in the near complete coverage by native plants on a restoration project after three years. The location of the project is on the San Joaquin River National Wildlife Refuge (Refuge), approximately 12 miles west of Modesto. An 800-acres riparian restoration project (funded by CALFED) was initiated in 2002 on the Refuge to restore woody vegetation for wildlife habitat on flood-prone former farmland.

At several locations on the Refuge we observed patches of native herbaceous plants that excluded non-native weeds over relatively large areas of several hundred square feet. These included mugwort, (*Artemisia douglasiana*), gum-plant (*Grindelia camphorum var camphorum*), and creeping rye grass (*Leymus triticoides*). We decided to try to develop a method to install these species into the restoration planting in an effort to competitively exclude the non-native species.

Methods: An adaptive management approach requires that field experiments be conducted of possible methods to achieve desired results. The results of the experiments will guide implementation on the larger scale. Seed was collected of mugwort, gum-plant, and creeping rye grass from plants growing on the Refuge. These were planted in test-plots within the one-year old restoration planting to determine seed germination and seedling establishment success under the on-going implementation activities of irrigation.
and mowing. Test-plot results were encouraging because they showed that the three species withstood and prospered under the usual mowing and irrigation regime. Plots were mowed and irrigated six times between March and October 2003. With these results, we then decided that we could try to plant the three species over the entire 800 acre project.

Seed of mugwort and gum-plant are very small. In January 2004 seed of both species were mixed independently with rice-hulls and broadcast in separate aisles between the tree-planted rows at rates of approximately one-half pound of live seed per acre. Site preparation involved disking through the summer to provide a weed-free, bare-soil seedbed. Following broadcasting, the seed was not rolled into the soil. Both mugwort and gum-plant are short-lived perennials. First year growth of each species commences with rain that moistens the soil sufficient to keep the surface moist, typically by January. Growth is rapid through the winter and spring, and the summer with irrigation. A large first-year mugwort can be one foot tall, while a one-year old Gumplant reaches three feet tall. Both species commence growth with the first fall rains of the second growing season and quickly grow taller than winter weeds. They reach maximum growth in April-June completely shading the soil surface and suppressing summer weeds.

**Results:** Sampling of both density and cover occurred within permanently marked monitoring-plots established the previous year in each field. Sampling of density was performed using a 0.25 square meter frame placed ten times along a permanently marked transect every two months during 2004. Cover was sampled along the same transect and is based upon a belt one meter wide by ten meters long.

**Density:** First year seedling density of both species ranged from 40 to 150 individuals per square meter at the end of the first growing season.

**Cover: Gumplant:** By the end of 2004 gumplant grew to cover 40 percent of the average plot by the end of the first growing season, accompanied by a 45 to 65 percent cover of weeds. One year later in August 2005 gumplant covered virtually 100 percent of plots, with weeds covering less than 200 percent.

**Mugwort:** In August 2004 mugwort covered 15 to 40 percent of sample plots, with weeds covering 60 to 80 percent of the same plots. By August 2005 mugwort covered 98 percent of the plots, with weeds a less than two percent cover.

**Conclusions:**
Aggressive native herbaceous species can compete with non-native weeds to exclude them from actively managed restoration plantings. Critical to success is the preparation of a weed-free seedbed for broadcasting the seeds of the natives. This was accomplished by several diskings during the spring, summer, and fall prior to broadcasting the seeds.

Based on the densities of mugwort and gum-plant during the first year, a reduction in the seeding rate may be called for.

Future monitoring will determine the long-term effectiveness of this approach to weed control.
Egeria densa (Brazilian Egeria) is a fast growing submerged aquatic plant that is having a significant impact on shallow-water habitat in the Sacramento/San Joaquin Delta ecosystem. In the 40 years since E. densa was introduced into the Delta, it has grown to infest approximately 6500 surface acres or 13% of the 50,000 surface acres of the Delta. E. densa influences the Delta’s biological diversity, recreation, and agriculture. It crowds out native plants, slows water flows, entraps sediments, obstructs waterways, impedes anadromous fish migration patterns and clogs water intakes.

Water hyacinth (Eichhornia crassipes) is a non-native, invasive, free-floating aquatic plant belonging to the South American pickerelweed family (Pontederiacea). It grows in wetlands, marshes, shallow water bodies, slow moving waterways, lakes, reservoirs, and rivers. Under warm weather conditions this plant is the second fastest growing plant on the planet. It is able to double in individual size and total number of plants within five to ten days during the peak growing season. The plant often forms large, thick mats that crowd out native plants, slow water flows, entrap sediments, concentrate heavy metals, encumber agricultural uses, obstruct waterways, and impede anadromous fish habitats.

As a result of these aquatic invasions into the Sacramento-San Joaquin Delta, the California Legislature amended the California Harbors and Navigation Code (1982 for Water Hyacinth and 1997 for Egeria densa) to designate the Department of Boating and Waterways as the lead agency responsible for controlling these aquatic weeds.

Due to the potential threat to water quality and endangered species from the use of aquatic pesticides both programs operate under National Pollutant Discharge Elimination System permits issued by the Central Valley Regional Water Quality Control Boards and biological opinions issued by the US Fish and Wildlife Service and the National Marine Fisheries Service.
Cover crops can enhance soil properties in agricultural systems. Many studies have investigated effects of cover crops and cultivation on soil carbon and nitrogen dynamics, yet few have addressed effects of these practices in vineyards. Agricultural practices in the vineyard floor tend to be less frequent and intense than those in annual cropping systems. Thus, soil carbon and nitrogen dynamics in soils supporting cover crops may be distinct in vineyard systems. The study was conducted from Fall 2005 to Fall 2006 in Monterey Co. in a Chardonnay vineyard planted in 1997. The soil type was a Coarse-loamy, mixed, superactive, thermic Cumulic Haploxeroll. The three vineyard floor treatments included two cover crops [i.e., Trios 102 (Triticale x Triosecale); Merced Rye (Secale cereale)] and a clean, cultivated treatment. The cover crops had been planted annually for five years prior to this study. Soil respiration, dissolved organic carbon, soil nitrate pools, nitrification potential, nitrogen mineralization potential, and denitrification pools were measured in the three vineyard floor treatments. Merced Rye tended to support 1.5-2 times more aboveground biomass than Trios 102, but their aboveground biomass was similar just prior to mowing in April. Root biomass at peak aboveground biomass was approximately 2.5 times greater in Trios 102 than Merced Rye from 0-10 cm. Also, weed biomass was greater in the Trios 102 treatment than in Merced Rye, likely due to Trios 102’s relatively lower aboveground biomass that occurred during the growing season. Soil respiration and dissolved organic carbon were greatest in Trios 102, followed by Merced Rye, and the clean, cultivated treatment, respectively. This may be linked to the greater root biomass in Trios 102 than Merced Rye. In general, the two cover crops had greater rates of potential nitrification, potential nitrogen mineralization, and potential denitrification than the clean, cultivated soil. The cover crop treatments had similar rates among these factors. Thus, the presence of cover crops enhanced the biological function of the vineyard soils, but cover crop type did not affect nitrogen dynamics. Cover crop type did influence soil C dynamics as well as the associated weed biomass. Future analyses will determine short-term transformations of soil carbon and nitrogen pools in these vineyard floor treatments in response to both season and management. A next step is to understand potential links between these soil nutrient dynamics and grapevine health.
USE OF SUBSURFACE DRIP FOR WEED MANAGEMENT IN TOMATOES GROWN UNDER CONSERVATION TILLAGE

Anil Shrestha, IPM Weed Ecologist, University of California Statewide IPM Program
Kearney Agricultural Center, Parlier, CA 93648
Jeff Mitchell, Vegetable Crops Specialist, University of California, Davis
Tom Lanini, Weed Ecologist, University of California, Davis

Introduction

Soil and water conserving cropping systems are being developed in the San Joaquin Valley (SJV). Sub-surface drip irrigation (SDI) and conservation tillage (CT) are some techniques being included in these systems. SDI is a water management system that has been researched extensively in the SJV. This system has been shown to reduce percolation below the root zone and subsurface drainage while maintaining crop yields (Phene et al., 1987; Hanson and May, 2004) and providing more efficient water use than furrow irrigation (FI) (Phene et al., 1987; Yohannes and Tadesse, 1998). The moisture in a SDI system is generally confined to the area around the drip line thus keeping the surface dry (Hanson and May, 2004). On the other hand, majority of weed seeds in no-till systems have been found to be located in the surface of the soil (Clements et al., 1996). Because CT may limit weed emergence to the top few inches of soil and SDI may keep the soil surface too dry for weed emergence, these methods may have implications for development of weed suppressive cropping systems in the SJV.

Methods

A 2-year (2004 and 2005) field study was conducted at UC West Side Research and Extension Center, Five Points, CA to assess the effect of SDI and CT on weed densities and biomass in transplanted processing tomato (Lycopersicon esculentum Mill.) grown on raised 60 inch beds. The experimental design was a split-split plot with four replications. Tillage system [CT vs standard (ST)] was the main plot, irrigation system [SDI vs furrow (FI)] was the sub-plot, and herbicide [herbicide (WC) vs no herbicide (NWC)] was the sub-sub-plot.

The main plots were 280 ft long and 6 beds wide and were divided into two subplots (3 beds) for the tillage sub-treatments. The CT plots consisted of permanent raised beds without any bed top tillage. The ST plots consisted of standard tillage practices i.e., subsoiling, diskng, landplaning, and listing. Listing was done with a 3-bed Wilcox Performer. The subplots were divided into two sub-sub plots which were 3 beds wide and 140 ft long for the weed control treatments. Main plots were separated by 3 beds which served as a buffer.

After the beds were prepared, drip tapes were installed in the SDI plots. Queen Gil medium flow tape was buried 10 in below the surface in the center of the bed. Processing tomato (cv ‘H 8892’) seedlings was mechanically transplanted in late-April of each year. The FI plots were sprinkle-irrigated immediately after transplant to establish the seedlings. The SDI system was run immediately after transplant and no sprinkler irrigation was used. The SDI plots were
irrigated about 3 times a week while the FI plots were irrigated once a week. Ammonium sulfate was shank applied at the recommended rate in all the FI plots. The SDI plots were fertigated.

The furrows of all the plots were cultivated with a Sukup 9200 3-row cultivator on May 20, 2004. A band application of rimsulfuron (Matrix) was made at 0.5 oz ai/acre on May 20, 2004 in the crop row of the plots designated for weed control. The furrows of the FI plots were cultivated again on June 3, 2004. The SDI plots were not cultivated because there were very few weeds in the furrows. In 2005, the furrows of all the plots were cultivated on May 11. However, because of precipitation early in the season, there were comparatively more weeds in the furrows of all the plots in 2005 than in 2004. Therefore, the furrows of all the plots including the SDI had to be cultivated again on June 1. In 2005, the beds of the WC treatments were hand weeded on May 26 because the plots were too wet for equipment operation early in the season and by the time the plots dried, the weeds were too large for successful postemergence control with an herbicide that was safe enough to prevent injury to tomato plants.

Weed density and species composition were assessed twice during the growing season by randomly sampling 0.25 m$^2$ quadrat areas. The first sampling was done prior to weed control to assess initial densities and the second sampling to determine new weed emergence. Two random 0.25 m$^2$-samples were taken on the beds and two in the furrows of each plot. In 2004, the assessments were made on May 12 and June 4. Weed biomass was assessed prior to crop harvest by taking two random 0.25 m$^2$-samples in the crop row and two in the furrows of each plot.

The treatments were maintained in the same beds in the second year. The CT sub-plots used permanent beds without bed-top tillage. Whereas, after harvest, all the ST beds were stubble disked and mulched in late fall and reshaped with a Wilcox Performer. Glyphosate was applied on March 7, 2005 in all plots to control weeds that had emerged in the fall and winter. Similar fertilizer application methods were used as in 2004. Weed density assessments on the beds and in the furrows were made using similar techniques as in 2004. Tomatoes were mechanically harvested both years in late August.

**Results**

In both years, weed emergence in the furrows of SDI treatments were almost eliminated. Similarly, weed densities on the beds were 46 to 96% lower in the SDI than FI plots. Tillage did not generally affect weed densities but interacted with irrigation in 2005 when the SDI-CT plots had 87% fewer weeds than SDI-ST plots. Figure 1 shows typical weed densities under the various systems in the second year of the study. Weed biomass on the bed was not affected by irrigation or tillage system but the biomass in the furrows was 90% lower in the SDI than FI plots. Similar results were reported by Sutton et al. (2006). They also found that hand weeding time was 5 to 13 times greater in FI treatments compared to SDI treatments and weed biomass on the beds at tomato harvest was 10 to 14 times greater in the FI than the SDI systems.
This experiment showed that SDI could be used as a weed management tool for ST and CT tomato production. The weeds in the furrows could be almost eliminated with SDI. In years of low winter precipitation, the SDI plots did not require cultivation of the furrows whereas the FI systems required at least two cultivations. Total and marketable tomato fruit yields were lower under SDI compared to FI systems. However, tillage had no effect on either total or marketable fruit yield. The study showed that water management was an important factor in attaining comparable fruit yields between SDI and FI systems. Early irrigation cut-off and leakages in the SDI system may have been responsible for blossom-end rot in the tomato fruits and thus reduction in fruit yield. Tomato fruit quality was not affected by irrigation, tillage, or weed control. A combination of SDI, one-time cultivation in the furrows (based on weed densities), and a weed control treatment on the beds may be a successful weed management strategy in processing tomatoes in the SJV.

References:
Selectivity of Organic Herbicides in Broccoli and Onions

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

INTRODUCTION

Weed control in organic production is generally a two pronged approach that includes long term strategies such as managing the impacts of crop rotations and reducing weed seed deposits to the seedbank. In addition it encompasses short-term strategies to help the grower deal with weed issues that affect the profitability and productivity of the immediate crop. Examples of short-term weed control strategies include pregermination and cultivation, as well as other techniques such as use of mulches, flaming and solarization. Organic herbicides have not been utilized during the cropping cycle to a large degree. One exception is that they can be used as a post plant preemergence burn down of weeds prior to crop emergence. Current organic herbicides contain clove oil (eugenol), organic acids (citric and/or acetic) as well as other oils and acids either alone or in various combinations. These materials are contact herbicides that disrupt plant cell membranes and cause leakage of cellular fluids (Tworkoski 2002).

These materials are primarily effective on broadleaf weeds, and their effectiveness depends on plant size, spray volume and concentration of the material (Ferguson 2004). Percent control of organic herbicides declines precipitously as weeds grow beyond the two true leaf stage (Smith 2004). Broadcast applications of rates of organic herbicide high enough to achieve excellent weed control can be cost prohibitive (Boyd and Brennan 2006). However, weeding costs in organic vegetable production can be a significant part of the production budget (Tourte et al. 2004). Given limitations of organic herbicides and their cost, it is important that the materials be used in situations where they save organic growers time and money. The most cost effective use of these materials would be if they were able to kill weeds selectively in a crop. We initiated studies on onions and broccoli because these crops are routinely treated with weed control materials (i.e. contact herbicides or fertilizers) in conventional production at the two true leaf stage. They are able to withstand these chemicals due to the waxy cuticle on their leaves that sheds the spray. In this article we will report on studies conducted on their safety and weed control efficacy.

METHODS

Broccoli Trials: Trial results shown in Table 1 were conducted in 2004 and 2006 on commercial broccoli fields in Monterey and Santa Cruz Counties. Trial results in Table 2 were conducted on two organic farms in 2006 in Santa Cruz County. 2004 trials were conducted as part of larger weed trials in conventional fields and 2006 broccoli trial no. 1 was conducted on an organic farm and broccoli trial no. 2 was conducted as part of a larger weed trial. In the 2004 trials Xpress Organic (clove oil) was used and in 2006 Matran EC (clove oil) and Scythe (pelargonic acid) were used. Scythe is currently not an allowed organic herbicide but it is
scheduled to be reviewed by the National Organic Program in April 2007. Materials were applied at 30 to 35 days after seeding or transplanting (except for 2006 broccoli trial no. 2 which was applied at 45 days after seeding), and were applied over the top of the broccoli in 2004 and as a directed spray to the base of the plant in 2006. Weed evaluations were not available in 2004 trial no. 2 because the site was over sprayed with AN 20, but yield evaluations were conducted. Weed evaluations in 2006 trial no. 2 were not conducted because the materials were applied too late and the weeds were not susceptible to any of the materials that were sprayed. Table 2 shows the results of 2006 trials 3 and 4 which were conducted on an organic farm. The broccoli was transplanted and the plants had 4-5 true leaves at the time of spraying. In both trials conditions were good as weeds were small and the beds were smooth (no clods to block spray from contacting weeds). Matran EC was used in these trials at either one or two passes per seedline of an 8004 TeeJet nozzle directed to the base of the plant. All materials were applied with Humasol as a surfactant (@ 0.25%) with a one nozzle wand with an 8004 nozzle pressurized with a CO$_2$ backpack sprayer at 30 psi. Weed counts were made 14 days after treatment and weeding evaluations were made 20 days after treatment.

**Onion Trials:** Trial results shown in Table 3 were from trials conducted on commercial farms in Monterey County and were part of larger weed control evaluations (except green onion trial no. 2 which was conducted at the Hartnell East Campus research facility in Salinas). Unless otherwise noted noted applications were made at the 2$^{nd}$ true leaf stage which is typically 35 days after planting.

**RESULTS AND DISCUSSION**

**Broccoli Trials:** In the 2004 trials Xpress Organic was highly phytotoxic to broccoli in trial no. 1, but much less so in trial no. 2, as evidence by the yield evaluation (Table 1). In 2006 broccoli trial 1 the best weed control was obtained with two passes of a directed nozzle applying 3.5% of Matran EC. This treatment also had the lowest weeding time. In 2006 broccoli trial no. 2 all rates or application methods of Matran EC and Scythe yielded similarly and all yielded from 86 to 89% of the untreated control. Table 2 shows the results from trials 3 and 4 in which transplants were used and the Matran EC was effectively applied as a directed spray. For instance, two passes of an 8.1% solution reduced weeds by 99.5% and reduced weeding time from 34.9 hours per acre in the untreated check to 5.8 hours per acre; however, phytotoxicity ratings were unacceptably high in all herbicide treatments. In trial No. 4 the rate of Matran EC was reduced and phytotoxicity ratings were reduced to acceptable levels. Two passes of 3.5% of Matran EC provided 91.2% control of weeds, but given the high weed population it did not reduce weeding time as dramatically as was seen in trial no. 3.

**Onion Trials:** Onions cannot benefit from directed sprays as can be used in broccoli. All treatments are applied over-the-top of the crop and as a result greater selectivity is needed. In 2005 green onion trial no. 1 moderate weed control was achieved using a 10 to 20% solution of Matran EC. Both rates had modest phytotoxicity ratings and reduced time for weeding (Table 3). 2005 green onion trial no. 2 was located on a site with high weed pressure. Both Matran EC and
Scythe applied at the first true leaf stage had better weed control than second true leaf applications. Scythe had improved weed control over Matran EC. Both materials had moderate phytotoxicity ratings. All treatments improved the yield over the untreated control given significant stunting from severe weed competition. In the 2005 dry bulb onion trial Matran EC at 20% applied at the second true leaf provided low to moderate weed control and reduced hand weeding by 31% over the untreated control. It had low phytotoxicity ratings and yielded well. In the 2006 dry bulb onion trial we used Scythe at 3.0% at the second true leaf stage and saw no weed control and extremely high hand weeding time. This was due to the fact that, given the cool, wet weather in the spring of 2006, the onions grew slowly and the weeds much quicker than normal. As a result, even conventional herbicides had difficulties controlling weeds in 2006.

CONCLUSION

The organic herbicides examined in these studies are not safe for over-the-top use on broccoli. Low rates of these herbicides can be used on broccoli if they are applied as a directed spray to the base of the plant. If too much of the material gets up onto the foliage it can cause significant phytotoxicity. If however, the material is successfully applied acceptable yields can be achieved. Onions are different in that there is no way that the spray material can be directed to the base of the plants. As a result, there is greater need for selectivity for the onions and careful selection of appropriate rates. More effective weed control can be achieved if the organic herbicides can be applied at the first true leaf stage; however, we observed greater phytotoxicity on the crop when applied at this earlier growth stage. If applications go on too late and the weeds are too big, the low rates of organic herbicides that need to be applied in order to safeguard safety on the onions will not be adequate to effectively control weeds.

Clearly, there is more work that needs to be done to further evaluate the selective use of organic herbicides on broccoli and onions. If sprays can be effectively directed on broccoli, organic herbicides can be safely used on this crop. More work needs to be done on onions to further evaluate the rates of organic herbicides that can be used and the stage of growth that they can be safely applied.

LITERATURE CITED


ACKNOWLEDGEMENTS
We thank cooperating growers: Chris Drew, Sea Mist Farms; Bob Martin, Rio Farms, Bill Peixoto, Dick Peixoto Farms; and Jerry Rava, Rava Farms, as well as research assistants Tiffany Bensen, Pat Headley and Dave Miltz.
Table 1. Broccoli Trials: Summary of weed control, phytotoxicity, weeding time and yield of four trials on broccoli

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</tbody>
</table>

1 – Scale: 0 = no crop damage to 10 = crop dead; 2 – one directed pass per seedline; 3 – two directed passes per seedline.

Table 2. 2006 Broccoli Trials: Phytotoxicity and weed counts per five inch wide strip around each seedline by length of plot

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Material/A</th>
<th>Passes per seedline¹</th>
<th>Spray volume/A</th>
<th>Phyto²</th>
<th>Total Weeds 12.5 ft²</th>
<th>Percent weed control</th>
<th>Weeding Time Hrs/A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trial No. 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matran EC</td>
<td>5 gallons (10.8% v/v)</td>
<td>One</td>
<td>46 gallons</td>
<td>4.7</td>
<td>28.0</td>
<td>78.1</td>
<td>11.7</td>
</tr>
<tr>
<td>Matran EC</td>
<td>5 gallons (5.4% v/v)</td>
<td>Two</td>
<td>92 gallons</td>
<td>4.0</td>
<td>1.7</td>
<td>98.6</td>
<td>8.0</td>
</tr>
<tr>
<td>Matran EC</td>
<td>7.5 gallons (16.3% v/v)</td>
<td>One</td>
<td>46 gallons</td>
<td>7.3</td>
<td>2.7</td>
<td>97.8</td>
<td>6.8</td>
</tr>
<tr>
<td>Matran EC</td>
<td>7.5 gallons (8.1% v/v)</td>
<td>Two</td>
<td>92 gallons</td>
<td>5.3</td>
<td>0.6</td>
<td>99.5</td>
<td>5.8</td>
</tr>
<tr>
<td>Untreated</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>0.0</td>
<td>128.0</td>
<td>----</td>
<td>34.9</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td></td>
<td></td>
<td></td>
<td>2.1</td>
<td>27.1</td>
<td>----</td>
<td>3.4</td>
</tr>
<tr>
<td><strong>Trial No. 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matran EC</td>
<td>2.3 gallons (5.0% v/v)</td>
<td>One</td>
<td>46 gallons</td>
<td>2.7</td>
<td>54.7</td>
<td>59.1</td>
<td>49.7</td>
</tr>
<tr>
<td>Matran EC</td>
<td>2.3 gallons (2.5% v/v)</td>
<td>Two</td>
<td>92 gallons</td>
<td>1.7</td>
<td>18.7</td>
<td>86.0</td>
<td>39.4</td>
</tr>
<tr>
<td>Matran EC</td>
<td>3.2 gallons (7.0% v/v)</td>
<td>One</td>
<td>46 gallons</td>
<td>3.3</td>
<td>46.0</td>
<td>65.5</td>
<td>42.7</td>
</tr>
<tr>
<td>Matran EC</td>
<td>3.2 gallons (3.5% v/v)</td>
<td>Two</td>
<td>92 gallons</td>
<td>1.7</td>
<td>11.7</td>
<td>91.2</td>
<td>39.5</td>
</tr>
<tr>
<td>Untreated</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>0.0</td>
<td>133.7</td>
<td>----</td>
<td>68.5</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td></td>
<td></td>
<td></td>
<td>1.4</td>
<td>28.6</td>
<td>----</td>
<td>9.3</td>
</tr>
</tbody>
</table>

1 – number of passes per seedline with directed spray; 2 – Scale: 0 = no crop damage to 10 = crop dead
Table 3. Summary of weed control, phytotoxicity, weeding time and yield of four trials on green and dry bulb onions

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate</th>
<th>Weed Control % of untreated</th>
<th>Phyto&lt;sup&gt;t&lt;/sup&gt;</th>
<th>Weed Time Hrs/A</th>
<th>Yield % of untreated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005 Green Onion Trial No. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated</td>
<td>----</td>
<td>----</td>
<td>0.0</td>
<td>10.6</td>
<td>----</td>
</tr>
<tr>
<td>Matran EC 10% v/v</td>
<td>32.7</td>
<td>66.3</td>
<td>0.5</td>
<td>4.2</td>
<td>----</td>
</tr>
<tr>
<td>Matran EC 20% v/v</td>
<td></td>
<td></td>
<td>0.0</td>
<td>7.0</td>
<td>----</td>
</tr>
<tr>
<td>2005 Green Onion Trial No. 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated</td>
<td>----</td>
<td></td>
<td>0.0&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.0</td>
<td>----</td>
</tr>
<tr>
<td>Matran EC 20% v/v @ 1&lt;sup&gt;st&lt;/sup&gt; true leaf</td>
<td>5.7&lt;sup&gt;2&lt;/sup&gt;</td>
<td>2.3</td>
<td>----</td>
<td>244</td>
<td></td>
</tr>
<tr>
<td>Matran EC 20% v/v @ 2&lt;sup&gt;nd&lt;/sup&gt; true leaf</td>
<td>4.0&lt;sup&gt;2&lt;/sup&gt;</td>
<td>3.3</td>
<td>----</td>
<td>262</td>
<td></td>
</tr>
<tr>
<td>Scythe 5.0% v/v @ 1&lt;sup&gt;st&lt;/sup&gt; true leaf</td>
<td>8.3&lt;sup&gt;2&lt;/sup&gt;</td>
<td>4.8</td>
<td>----</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>Scythe 5.0% v/v @ 2&lt;sup&gt;nd&lt;/sup&gt; true leaf</td>
<td>7.0&lt;sup&gt;2&lt;/sup&gt;</td>
<td>3.0</td>
<td>----</td>
<td>270</td>
<td></td>
</tr>
<tr>
<td>2005 Dry Bulb Onion Trial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated</td>
<td>----</td>
<td></td>
<td>0.0</td>
<td>20.7</td>
<td>----</td>
</tr>
<tr>
<td>Matran EC 20% v/v</td>
<td>38.8</td>
<td>38.8</td>
<td>0.5</td>
<td>14.3</td>
<td>96.2</td>
</tr>
<tr>
<td>2006 Dry Bulb Onion Trial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated</td>
<td>----</td>
<td></td>
<td>0.0</td>
<td>97.3</td>
<td>----</td>
</tr>
<tr>
<td>Scythe 3.0% v/v</td>
<td>122.8</td>
<td></td>
<td>0.0</td>
<td>96.9</td>
<td>109.4</td>
</tr>
</tbody>
</table>

1 – Scale: 0 = no crop damage to 10 = crop dead; 2 – Scale: 0 = no weed control to 10 = complete weed control;
Update on DPR’s Environmental Justice Initiatives

Renee Pinel, Western Plant Health Association
4460 Duckhorn Dr., Ste. A, Sacramento, CA 95834, reneep@healthyplants.org

Environmental Justice is defined in California Law as “The fair treatment of peoples of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws and policies”. EPA created the State Environmental Justice Advisory Committee and Pilot Project Working Groups which will be used to shape the upcoming EJ pilot projects and future policies. The State Advisory Committee has agreed on some key definitions that will have to be integrated in all BDO’s regulations. These definitions include “cumulative impacts” and “precautionary approaches”.

Cumulative Impacts Definition:

- **Cumulative impacts means exposures, public health or environmental effects from the combined emissions and discharges in a geographic area, including environmental pollution from all sources, whether single or multi-media, routinely, accidentally, or otherwise released. Impacts take into account sensitive populations and socioeconomic factors to the extent where data are available.**

Of interest is the incorporation of consideration for socio-economic factors into the evaluation of cumulative impacts. Socio-economic factors include stressors like; unemployment, access to health care, dietary choices, etc. How and what level of science will be utilized to incorporate these issues into an evaluation of pesticide exposure rates, is uncertain and of concern.

Precautionary Approach Definition:

- **Precautionary approach means taking anticipatory action to protect public health or the environment if a reasonable threat of serious harm exists based upon the best available science and other relevant information, even if absolute and undisputed scientific evidence is not available to assess the exact nature and extent of risk.**

The major area of discussion within this definition is what “the best available science and other relevant information” means. From an industry standpoint, it is accepted that “the best available science” would mean “peer reviewed” science conducted by accredited scientists, incorporating the use of risk-assessment. Environmental Justice Advocates maintain that this phrase should include the presumption of fact as determined by the local community. The acceptance of this agreed upon fact by the community should be considered by regulatory agencies with as much standing as any scientifically peer reviewed data.
Environmental Justice Updates

Parlier Pilot Project:

As part of its Environmental Justice Action Plan, Cal/EPA is developing and conducting four types of pilot projects that incorporate some of the themes in the Governor’s Environmental Action Plan and focuses on environmental risk factors that impact children’s health. The Department of Pesticide Regulation (DPR) will lead a pilot project in the Central Valley city of Parlier, focusing on pesticides in a rural, low-income, minority population farming community.

CPDR & ARB will be monitoring a combination of 40 pesticides, fumigants, and their breakdown material. They will have monitoring stations at 3 local Parlier schools and plan to sample for air quality 3 times a week for the life of the pilot project. The goal of the project is to determine: If residents of the community are exposed to pesticides in the air? Which pesticides are they being exposed to? Do measured pesticide air levels exceed levels of concern to human health, particularly children?

For this project, DPR and the Office of Environmental Health Hazard Assessment (OEHHA), developed health screen levels for each pesticide that to be monitored. They would help to determine when it would be prudent to further access potential health effects of chemical exposure. A screen level does not indicate the presence or absence of a hazard, but detections above the screening level may point to the need for further evaluation.

Air monitoring began in January 2006 for the 40 pesticides and their compounds. DPR will review with LAG upon the release of data, the data that has not been analyzed or viewed in context of all other factors of the monitoring, and detections should not be considered indicative of a finding of harm. A comprehensive analysis will take place at the conclusion of the collection of all data gathered through December, 2006.

The report that was released in December is for data collected from January through August 16th, 2006. Overall, the results seem to indicate a high level of safety and protection to the community from the use of crop protection products.

Detailed findings indicate the following:

Of the 40 chemicals monitored, 22 pesticides or breakdown products were detected. Of those detected, 17 were believed to be detected because of use as a pesticide. The remaining 5 detections are believed to be from non-pesticidal sources (i.e., vehicle emissions, etc.).
Only two pesticides exceeded the acute screening level. Diazinon, which is used as a pesticide, exceeded the screening levels 1 day out of the 297 days monitored. Acrolein, the other chemical that exceeded the screening level, exceeded the acute screening level for almost all days monitored. Readings for acrolein were consistent with other monitoring being done around the state, and the detections & ascendencies are believed to be from non-pesticidal sources like vehicle emissions.

The chemical with the highest concentration level, although still not exceeding the acute screening level was formaldehyde. These detections were at less than 50% of the screening levels set, and like acrolein, it is believed that the formaldehyde detections were from non-pesticidal usage.

The chemical with the highest concentration of a chemical that was from a pesticidal use was MITC. All detections were below health screening levels, with the highest concentration still 87% below that of the health screening level.

DPR is also conducting well water monitoring to determine the effects of pesticides entering water systems via drift. There has been no indication of increased findings in this area.

**DPR Statewide Guidance Policy:**

DPR’s original guidance document was set aside last year by Cal-EPA for failure to adequately reach out to EJ communities. DPR is undertaking a new policy document by utilizing an Advisory Committee that will review DPR polices and procedures, and make recommendations to the Director for how DPR should revise its regulatory process to incorporate EJ principles.

The committee has been meeting since September, 2006. It is made up of environmental justice, anti-pesticide, and agricultural organization representatives, as well as representatives of regulatory agencies and university extension.

The advisory committee is looking at processes to allow for greater transparency within DPR’s regulatory process. It is also looking for ways to improve access for public participation in the regulatory process, and to improve communication and education between DPR and the environmental justice communities. The committee is expected to make its recommendations by the end of April, 2007.
AQUATIC NPDES PERMITS:

The State Water Resources Control Board (State Water Board) currently has two general National Pollution Discharge Elimination System (NPDES) permits that regulate discharges of aquatic pesticides into waters of the United States; one for vector control (mosquitoes), and another for aquatic weed control.

In November 2006 the United States Environmental Protection Agency (U.S. EPA) adopted a new regulation excluding vector and aquatic weed control pesticide applications from the requirement to obtain coverage under a NPDES permit.

In 2001, the Ninth Circuit court of appeals issued an opinion regarding whether the Talent Irrigation District that applied an aquatic herbicide to an irrigation canal that was tributary to a natural creek needed an NPDES permit. The court held that registration and labeling of a pesticide under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) does not preclude the need for an NPDES permit. The court went on to find that such an application constituted the discharge of a pollutant from a point source to waters of the United States, thus requiring an NPDES permit.

After the Ninth Circuit court’s decision U.S. EPA issued two guidance documents. One stated that civil enforcement under the Clean Water Act for direct application of pesticides to waters of the U.S. in accordance with FIFRA label instructions is a low enforcement priority. The second guidance document stated that the application of an aquatic herbicide consistent with the FIFRA label, to keep irrigation return flows clear, falls within the exemption for irrigation return flows from the definition of “point source” and therefore a nonpoint source activity.

In 2005 the Ninth Circuit issued another decision relevant to aquatic pesticides in Fairhurst v. Hagener, and after reviewing U.S. EPA’s guidance agreed that a pesticide that is applied consistent with FIFRA is not a “chemical waste.” The court stated that their decision was based on whether there is any “residue or unintended effect” from the pesticide application. The Fairhurst parties stipulated there was no residue or unintended effect from the use of antimycin. The court did not reverse its opinion in the Talent decision. The State Water Board interpreted this ruling to mean that an NPDES permit is only required if the application leaves a residue or has an unintended effect.
The State Water Board adopted the two general permits for discharges of aquatic pesticides in response to these court cases and guidance. The State Water Board found that the Ninth Circuit decisions appeared to require these permits and that the U.S. EPA guidance documents might not be a legal basis for a lack of coverage under an NPDES permit.

Now that U.S. EPA has adopted regulation codifying its Interim Statement and Guidance, the State Water Board’s Office of Chief Counsel has posted a five-page memorandum on our Website that explains how the State Water Board should respond to U.S. EPA’s new regulation. This memorandum suggests the State Water Board should maintain the permits pending any final judicial actions on the regulation, but publicize the regulation and allow dischargers the option of filing a notice of termination (these documents and instructions are also available on the web). This would immediately allow dischargers to terminate coverage, along with the obligation to conduct monitoring, pay NPDES fees, etc.

In the event a court decision invalidates U.S. EPA’s new regulation, those who chose to submit notices of termination could reenroll under the existing permits. If the courts uphold the regulation, the State Water Board may subsequently rescind the permits or allow them to expire. The State Water Board also has the authority to regulate these discharges under Porter-Cologne.

Aquatic NPDES Permit Reference Material and Contact Information:

- The five-page memorandum from the State Water Board Office of Chief Counsel to Acting Executive Officer Tom Howard is available at: http://www.waterboards.ca.gov/npdes/aquatic.html
  Scroll down the center of the page to News and click on Memorandum.

- Erin Mustain
  Water Resources Control Engineer
  Division of Water Quality, NPDES Program
  (916) 445-9379
  emustain@waterboards.ca.gov

AGRICULTURAL WAIVERS:

The federal Clean Water Act when adopted in 1972 exempted agricultural irrigation return flows from National Pollutant Discharge Elimination System permitting requirements.

The Regional Water Boards waived discharges from irrigated lands from waste discharge requirements in the early 1980’s as authorized by Section 13269 of the California Water Code.

In 1987, Congress added Section 319 to the federal Clean Water Act, which required states to develop nonpoint source pollution control plans. To comply with this section, the State Water
Board adopted its first nonpoint source control plan in 1988. This plan established a three tier system, the first tier being voluntary controls, the second tier being conditional waivers, and the third tier being waste discharge requirements.

In the 1990’s, environmental groups sued the U.S. Environmental Protection Agency for failing to establish total maximum daily loads (TMDLs) for various water bodies as required by the federal Clean Water Act.

Senate Bill 390 was signed into law October 6, 1999. The bill revised Section 13269 of the California Water Code. In general, the bill requires the regional boards to review the terms, conditions, and effectiveness of the waivers they have adopted; renew waiver policies and individual waivers by January 1, 2003 (failure to renew waivers automatically resulted in the termination); issue general or individual WDR's for ongoing discharges whose waivers have been terminated; enforce waiver conditions; and renew or terminate waivers every five years.

The number and type of waivers varied from region to region, but overall there were more than 40 between the nine regions, four of which have been the bulk of the focus in recent years; Dairy, Timber, Septic, and Irrigated Agriculture Runoff Waivers. With potentially millions of miles of agricultural drains and upwards of 80,000 growers with hundreds of commodities irrigated agriculture arguably poses the greatest challenges.

In February 1977, the State Water Board and the Department of Pesticide Regulation signed a Management Agency Agreement on their respective responsibilities for protecting water quality.

As stated earlier the State Legislature amended California Water Code Section 13269 in 1999. This amendment required the Regional Water Boards to review the conditions of their waivers of waste discharge requirements and to either renew the waivers or replace them with waste discharge requirements. The amendment also required enforcement of conditions in waivers and the re-adoption of waivers every five years. In addition, the State Water Board adopted the Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program (NPS Policy). This policy more clearly defined the stated requirements of the Water Code. All current and proposed NPS discharges must be regulated under waste discharge requirements, waivers of waste discharge requirements, or a basin plan prohibition or some combination of these administrative tools.

In 2003, California Water Code Section 13269 was again amended. The second amendment provided authority to the State Water Board to establish fees for waivers. These legislative actions are applicable to all waivers but placed particular focus on agriculture statewide. The fiscal year 2004-2005 State budget included up to 22 positions at a cost of $1.9 million for implementing agricultural waivers and specified that the funding for the positions would come from new fees to be established for waivers.
The Central Coast, Central Valley, Los Angeles and San Diego Regional Water Boards have adopted conditional waivers for wastewater discharges from Irrigated Agriculture. The other five Regional Water Boards have no immediate plans to adopt agricultural waivers but may do so eventually to implement TMDLs. Without a conditional waiver, growers are vulnerable to other regulatory actions such as waste discharge requirements (WDRs).

The Conditional Agricultural Waivers adopted by the Regional Water Boards use different regulatory models.

The **Central Coast Water Board** Conditional Agricultural Waiver requires each grower to:

1. Submit a notice of intent (NOI).
2. Take courses in water quality management (15 hours).
3. Prepare and implement a water quality management plan (*this is done during the 15 hour water quality management courses*).
4. Perform individual monitoring or participate in a group monitoring program.

The Central Coast Water Board has created a consensus building process with representatives from the agricultural and environmental communities.

The **Los Angeles Water Board** Conditional Agricultural Waiver is similar to the Central Coast Water Board’s waiver but encourages the formation of discharger groups or coalition groups. The Conditional Agricultural Waiver requires each grower to:

1. Submit a notice of intent (NOI).
2. Provision to participate in a coalition group who would submit one NOI on behalf of it’s membership.
3. Take courses in water quality management (8 hours).
4. Prepare and implement a water quality management plan.
5. Perform individual monitoring, or participate in a group monitoring program.

The **Central Valley Water Board** adopted two Conditional Agricultural Waivers at the request of agricultural interests and others: one conditional waiver for coalition groups and another for individual growers. The Central Valley Water Board renewed these two conditional waivers June 2006 for five years. The Coalition Conditional Waiver requires growers to:

1. Join coalition groups that assume the responsibility for conducting water quality monitoring.
2. Participate in grower education sponsored by their coalition.
3. Identify and implement necessary management practices to meet water quality objectives.

Growers in the Central Valley Region that do not choose to join coalition groups have the option of being covered under an individual grower conditional waiver or file a Report of Waste...
Discharge for waste discharge requirements. Both coalition groups and individual growers who have not joined a coalition must file a NOI and various technical reports as conditions of the waiver.

The **San Diego Water Board** Conditional Agricultural Waiver does not require the submittal of a NOI, and does not require water quality monitoring, but does require the implementation of management measures in accordance with State Water Board Nonpoint Source Implementation and Enforcement Policy. The Region is currently holding public workshops in anticipation of renewing the waiver with additional conditions.

The **Colorado River Basin Water Board** has implemented a Conditional Prohibition to address their sediment TMDL.

As previously stated, the Legislature decided waivers are to be supported by fee revenues rather than the State’s General Fund. As a result, the State Water Board adopted a Fee Schedule in June 2005 to fund the Conditional Agricultural Waiver Program at the State and Regional Water Boards. The 2006-2007 Governor’s Budget includes a one time $1.5 million general fund augmentation for the program.

Expectations for the Conditional Agricultural Waiver Program are:

1. A better characterization of the water quality in water bodies that receive agricultural discharges.
2. Identification of the sources of pollutants.
3. Development and implementation of management practices designed to control these sources.
4. Implementation of TMDLs through conditional waivers.

Agricultural Waiver Contact Information:

- **Daniel Merkley**  
  Agricultural Liaison  
  State Water Board, Executive Office  
  (916) 341-5501  
  dmerkley@waterboards.ca.gov

- **Johnny Gonzales**  
  Water Resources Control Engineer  
  Division of Water Quality, Irrigated Lands Program Manager  
  (916) 341-5510  
  jgonzales@waterboards.ca.gov
Drift Regulation in the Central Valley; Will This Fix It?

Martin D. Lemon, Monsanto, martin.d.lemon@monsanto.com

The central valley of California is one of our nation’s richest and most productive agricultural regions. But to say that it produces a great bounty each year would be only half of the story. The central valley produces a diverse mix of vegetables, nuts, fruits, grains, fiber, and pulse crops, all growing in close proximity to one another and many requiring different pest remedies, at different times of the year. The diversity of crops coupled with close neighbors and an assortment of different herbicide products challenges our ability to limit or prevent drift. Overwhelmingly, herbicide applications are done with precision and contact only the intended weed/field. But other times, under the wrong conditions, neighboring crops are damaged.

During the 80’s and 90’s drift problems seemed dynamic: high one year, down the next seven or eight. Of course, if you were the recipient of someone else’s drift then any given year could have been bad. Still, many different approaches to managing and limiting drift were tried by the agriculture industry. There was Continuing Education required of PCA’s, applicators, and pilots. Chemical industry reps calibrated spray rigs, preached on drift control and even gave out free “low-drift” nozzles. For the aerial applicators, fly-ins were required annually by some counties. These fly-ins were intended to assess the accuracy of both the pilot and his plane’s set up. They were effective at that and were picked up by local ag and community media as an interesting story, combining agriculture and environmental stewardship. Some of the “solutions” yielded better results than others, and sometimes it was hard to tell what was working and what wasn’t. This was because the bad drift year always seemed to come only every-so-often. Was what we implemented to combat the problem really working? Seven or eight years of success and then the bottom falls out. What went wrong?

Well, when you’re talking about drift, everyone has an opinion why it happened and what could/should have been done differently to avoid it. There’s an old saying that goes something like this, “We must always think about things, and we must think about things as they are, not as they are said to be.” This couldn’t be truer when discussing what causes drift. Stick around long enough and you’ll hear all manner of opinions. Interestingly, the Spray Drift Task Force (SDTF), formed in 1990 by 38 agriculture chemical companies in response to the U.S. Environmental Protection Agency spray drift data requirements, released a detailed report on the leading causes of agriculture spray drift in the mid 1990’s. The findings were widely heralded and supported by the large and diverse group of research participants and others. Incredibly though, many among us have forgotten the SDTF results and have proffered new reasons for drift. Like I said, stick around long enough and you’ll hear the same things over and over again. Just wait awhile!
The Spray Drift Task Force summarized their extensive research this way: “Overall, the SDTF studies confirm conventional knowledge on the relative role of the factors that affected spray drift. Droplet size was confirmed to be the most important factor. The studies also confirmed that the active ingredient does not significantly affect spray drift. The physical properties of the spray mixture generally have a small effect relative to the combined effects of equipment parameters, application technique, and the weather. This confirmed that spray drift is primarily a generic phenomenon, and justified use of a common set of databases and models for all products.” They reported that “drift levels could be minimized by: (a) applying the coarsest droplet size spectrum that provides sufficient coverage and pest control, (b) continuing the standard practice of swath adjustment, (c) controlling the application height, (d) using the shortest boom length that is practical, and (e) applying pesticides when wind speeds are low,” http://www.agdrift.com/PDF_FILES/aerial.pdf.

In spite of conclusive evidence about what causes drift and how to control it, we still had years where things didn’t go as planned. In what some opined was due to frustration and necessity, the Fresno County Agriculture Commissioner’s (CAC) finally took the bull by the horns in 2004. The previous year had been a tough one. Again, close proximity, different crops, and a need to control weeds resulted in a number of drift complaints needing investigation by the Ag Commissioner’s office. Some other central valley Ag Commission offices were tuned into the process too.

New “regulations” were going to be required, since all else seemed to have yielded, at best, spotty results. The Fresno CAC drafted a proposed permit and solicited input from all the stakeholders involved. Aerial and ground applicators, growers, grower and applicator associations, chemical company representatives, and regulatory staff all participated in the input process. The Fresno CAC scheduled public hearings throughout the summer of 2005 and lively discussion ensued at each meeting. Finally, the competing interests were able to reach a consensus about what needed fixing and what didn’t. After all was said-and-done, the Fresno CAC released their final permit requirements and conditions, Herbicide Application Restrictions, dtd, November 17, 2005. Other central valley counties, Kings, Madera, and Tulare, followed up with their own permit requirements and conditions. Hopefully, these new permit conditions will be the real thing. After all, we’re off to a good start; according to the Fresno CAC office, as of July there were no drift incidents in Fresno County in 2006.

Contact the CAC’s office in the county of interest for more information on herbicide application restrictions and permits required.
California Weed Science Society  
Income and Expense Jul '05 - Jun 06

Ordinary Income/Expense

### Income

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Amount</th>
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<td>4000</td>
<td>Registration Income</td>
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<td>4010</td>
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<td>Exhibit Income</td>
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<td>Sponsor Income</td>
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**Total Income**: 100,179.32

### Expense

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**Total Expense**: 94,101.18

**Net Ordinary Income**: 6,078.14

**Net Income**: 6,078.14
## California Weed Science Society Reserve Account Balances, 2005/06

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<th>Jul 11, 05</th>
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<td>Equity</td>
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<td><strong>TOTAL LIABILITIES &amp; EQUITY</strong></td>
<td>279,379.70</td>
<td>256,359.46</td>
<td>23,020.24</td>
<td>8.98%</td>
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CWSS HONORARY MEMBERS LISTING

Harry Agamalian (1983)  
Norman Akesson (1998)  
Floyd Ashton (1990)  
Alvin Baber (1995)  
Walter Ball *  
Dave Bayer (1986)  
Lester Berry  
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 *  
F. Dan Hess (2001)*  
Floyd Holmes (1979)  
Nelroy Jackson (1997)  
Warren Johnson (1977)*  
Jim Koehler  
Harold Kempen (1988)  
Don Koehler (2003)  

Butch Kreps (1987)  
Edward Kurtz (1992)  
Art Lange (1986)  
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)  
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 David Haskell & Lou Hearn
1997 Jim Helmer & Jim Hill
1998 Jim Helmer & Jim Hill
1999 Joe DiTomaso
2000 Kurt Hembree
2001 Steven Fennimore, Wanda Graves & Scott Steinmaus
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

*President’s Award for Lifetime Achievement in Weed Science