

2012 Proceedings of the California Weed Science Society

Volume 64

Papers Presented at the 64th Annual Conference

January 23, 24, & 25, 2012

Fess Parker's DoubleTree Resort

633 East Cabrillo Boulevard

Santa Barbara, California

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Preface

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

Table of Contents

California Weed Science Society and the Story of the Short Handled Hoe	7
<i>Norman D. Akesson, University of California, Davis</i>	
2012/2013 Board of Directors	9
2012 Conference Sponsors	10
2012 Conference Exhibitors	11
2012 Honorary Member – Stephen F. Colbert	12
2012 Award of Excellence Recipient – Rob Wilson	13
2012 Student Awards and Scholarship Recipients	14
In Memoriam – Alvin “Jack” Weems and Sam Armentrout	18
California’s Growing Marijuana Business Impacting Agriculture	20
<i>Article written by Harry Cline, Western Farm Press, February 8, 2012</i>	
Oral Paper Summaries	
WEED SCHOOL: THE ENVIRONMENTAL FATE OF HERBICIDES	
Chairs: Carl Bell and Guy Kyser	
Off-Site Movement of Herbicides.....	22
<i>Brad Hanson, University of California, Davis</i>	
Herbicide Translocation and Metabolism	26
<i>Scott Steinmaus, Ph.D, California State Polytechnic University, San Luis Obispo</i>	
STUDENT PAPERS	
Chair: Rob Wilson	
Weed Population Dynamics in Overhead and Sub-surface Drip Irrigated Conservation Tillage Cropping Systems	30
<i>Joy Hollingsworth & Anil Shrestha, California State University, Fresno; Jeff Mitchell, UC Davis; Kurt Hembree, UC Cooperative Extension, Fresno County</i>	
STUDENT POSTERS	
Chair: Rob Wilson	
Development of a Method to Evaluate Mortality of Black Mustard (<i>Brassica nigra</i>) Seeds Exposed to Volatile Compounds From Composted Greenwaste.....	32
<i>DeeAnn Kroeker, Stacy Betts, and Ruth Dahlquist, Fresno Pacific University, Fresno; James Stapleton, UC Kearney Agricultural Center, Parlier</i>	

A Field Trial to Evaluate Deleterious Effects of Composted Municipal Greenwaste and Soil Solarization on Black Mustard Seeds	33
<i>Kate Hernandez, Stacy Betts, and Ruth Dahlquist, Fresno Pacific University, Fresno; Megan Marshall, Pennsylvania State University, University Park, PA; Jean VanderGheynst, Chris Simmons, and Joshua Claypool, UC Davis; James Stapleton, UC Kearney Agricultural Center, Parlier</i>	

INDUSTRY POSTERS
Chair: Rick Miller

Solar Tents for On-Site Sanitation and Eradication of Rogued, Weedy Plant Propagative Materials	34
<i>James J. Stapleton, UC Kearney Agricultural Center, Parlier</i>	

GENERAL SESSION: THE VALUE OF WEED CONTROL: WHAT’S IT ALL WORTH?
Chair: Michelle Le Strange

The Global Value of Herbicides	35
<i>Leonard Gianessi, Crop Protection Research Institute, CropLife Foundation</i>	
Assessing the Return to Weed Control Expenses in California Agriculture.....	37
<i>Karen Klonsky, Extension Specialist, Agricultural & Resource Economics, UC Davis</i>	

AGRONOMY
Chairs: Andre Biscaro and Jesse Richardson

New Herbicides for Small Grains	40
<i>Jesse M. Richardson, Dow AgroSciences, Hesperia</i>	
Weed Control Challenges in Desert Areas of Southern California.....	41
<i>Tim Hays, Wilbur-Ellis Company, Lancaster</i>	
Weed Control Options for Corn Production	45
<i>Steve Wright, UCCE Tulare and Kings Counties</i>	
Recent Developments in Alfalfa Weed Control	48
<i>Steve Orloff, UCCE Siskiyou County</i>	
Innovations in Cotton Weed Management.....	51
<i>William McCloskey, University of Arizona, Tucson, AZ</i>	

AQUATICS
Chairs: Mike Blankinship and Dave Blodget

Aquatic Pesticide Permit Update	56
<i>Michael S. Blankinship, Blankinship & Associates, Inc., Davis, CA</i>	
Ditch Bank Weed Control.....	57
<i>Jason Robbins, Target Specialty Products, Chowchilla</i>	

South American Spongeplant is Invading California.....	58
<i>Patrick Akers, California Department of Food and Agriculture, Sacramento</i>	

<i>Egaria densa</i> Weed Control in the Sacramento-San Joaquin Delta	59
<i>Scott Shuler, SePRO Corporation, Carmel, IN</i>	

NURSERY AND GREENHOUSE

Chairs: Julie Newman and Karen Robb

Weed Control Practices in Nurseries	60
<i>Bruce Kidd, Consultant, Murrieta</i>	

Rotation Management Strategies for Nursery Weed Control	63
<i>Todd Burkdoll, BASF, Visalia</i>	

Evaluation of Herbicides for Weed Control Efficacy and Crop Safety in Field Production of Nursery Fruit and Nut Trees	64
<i>Joi Abit, University of California, Davis</i>	

Potential of Precision Weed Control.....	69
<i>Richard Smith, University of California Cooperative Extension, Monterey County</i>	

Steaming and Other Management Practices for Pre-Plant Weed Control in Nurseries	73
<i>Steven A. Fennimore, University of California, Davis</i>	

ROADSIDES, UTILITIES AND INDUSTRIAL SITES

Chairs: Will Harrison and Lonnie Munson

Indaziflam: A New Residual Herbicide for Roadside Weed Control	80
<i>Chris Olsen, Bayer Environmental Science</i>	

Maximizing the Efficiency of Hand Weed Spraying.....	81
<i>Carl Bell, UCCE San Diego County</i>	

TURFGRASS AND LANDSCAPE

Chair: Jim Baird

Controlling Annual Bluegrass in Bentgrass Putting Greens	82
<i>James H. Baird, University of California, Riverside</i>	

<i>Poa annua</i> Control Strategies in Cool Season Grasses.....	83
<i>Mark Mahady, Mark M. Mahady and Associates, Carmel Valley</i>	

Pre-emergent <i>Poa annua</i> Control in Non-overseeded Bermudagrass	88
<i>Hans C. Olsen, Bayer Environmental Science</i>	

Turf and Landscape Weed Control, Toward Integrated Weed Management	89
<i>Mike Lees, Dow AgroSciences, Granite Bay</i>	

Weed Control at Turf Establishment with Tenacity® Herbicide.....	90
<i>Dean Mosdell, Field Tech Manager, Syngenta Lawn and Garden</i>	

TREE AND VINE

Chairs: Ryan Allen and Brad Hanson

Effects of Spray Coverage and Nozzle Selection on Weed Control.....	92
<i>Kurt Hembree, UCCE, Fresno County</i>	

Benefits and Drawback of In-Row Cover Crops in Vineyards.....	93
<i>Richard Smith, UCCE, Monterey County</i>	

The Value of Residual Weed Control.....	97
<i>Hank J. Mager, Bayer CropScience, Fountain Hills, AZ</i>	

Weed Control in Nut Crops	98
<i>Mick Canevari, UCCE San Joaquin Emeritus Farm Advisor, Stockton</i>	

Determining the Yield Effect of Herbicide Drift on Dried Plum Trees.....	103
<i>Lynn Sosnoskie, University of California, Davis</i>	

FORESTRY, RANGE AND NATURAL AREAS

Chairs: David Chang and Heather DeQuincy

Partnering for Weed Removal on Santa Cruz Island.....	106
<i>Coleen Cory, The Nature Conservancy, Ventura</i>	

<i>Tamarix</i> Biocontrol and the Restoration of Riparian Ecosystems	107
<i>Tom Dudley, University of California, Santa Barbara</i>	

Nuance, Naysayers, and Twenty Years of Studying Species Impact.....	109
<i>Carla D’Antonio, University of California, Santa Barbara</i>	

Large Scale, Low Cost Restoration of Native Grasslands and Coastal Sage Scrub Using Herbicides	110
<i>Carl Bell, UCCE, San Diego County</i>	

Where the Weeds Are: Prioritizing Regional Response to Invasive Plants Using CalWeed Mapper.....	111
<i>Dana Morawitz, California Invasive Plant Council, Berkeley</i>	

VEGETABLE CROPS

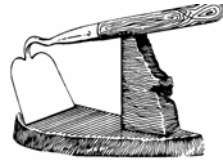
Chairs: Oleg Daugovish and Kate Walker

Weeds and Their Management in Vegetables: An Entomologist’s Perspective.....	112
<i>John Palumbo, University of Arizona, Yuma, AZ</i>	

Water Management Effects on Weeds in Vegetable Production	115
<i>Mike Cahn, UCCE, Monterey County</i>	

Weed Control as Part of Soil Disinfestation with Fumigants and Nonfumigants.....	118
<i>Steven A. Fennimore, University of California, Davis</i>	
A PCA’s Perspective on Weed Control in Vegetables	124
<i>Stan Tanaka, Tanaka Ag Consulting, Ventura</i>	
Industry Update on New Developments in Weed Control in Vegetables.....	126
<i>Jesse M. Richardson, Dow AgroSciences, Hesperia</i>	
LAWS AND REGULATIONS	
Chair: Maryam Khosravifard and Gary Maxwell	
Personal Protective Equipment for Pesticide Applicators	127
<i>Robert Krieger, Ph.D, University of California, Riverside</i>	
Laws and Regulations Jeopardy.....	128
<i>David Chang, Ag Commissioner’s Office, County of Santa Barbara</i>	
Guidance for Interpreting Pesticide Labeling	130
<i>Vic Acosta, CDPR, Sacramento</i>	
California Pesticide Issues Update.....	132
<i>Renee Pinel, Western Plant Health Association</i>	
Year End Financial Report	137
Honorary Members of the California Weed Science Society	138
Award of Excellence Recipients of the California Weed Science Society	140
List of 2012 CWSS Conference Attendees	141

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



*Norman D. Akesson
University of California, Davis*

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

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

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

The CWSS hoe probably started out as a work roughened model liberated from the tool shed at the University Farm by "Doc" Robbins and carried by him on his rounds of the farmer weed control meetings. In 1951 the hoe was spirited away, unbeknownst to Robbins by Walter Ball, a former student of Doc's when they were both at Colorado State. Walt had the hoe cleaned up (the blade and shank were cadmium plated) and polished to a mirror-like finish. At the 1951 California Weed Conference held in Fresno, CA, the hoe was presented by Walter to W.W. Robbins in honor of his many years of dedicated service to the science of weed control and to his

key role in founding the California Weed Conference. Walt provided an old well-worn brown duffel bag to hold and protect the hoe. W.W. Robbins died in 1952 and his wife, Barbara, returned the hoe to Walter who then presented it to the California Weed Conference with the stipulation that it be passed on from the outgoing President to the incoming President in memory of W.W. Robbins. Thus over a period of about 10 years, a progression of Conference Presidents dutifully accepted the hoe and passed it on to their successors as a part of an installation ceremony at the annual conference.

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

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

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

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

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

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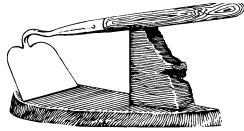
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- ★ **Helena Chemical Company**
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The California Weed Science Society wishes to thank the following exhibitors at the 64th Annual Conference.

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California Weed Science Society Honorary Member-2012

Stephen F. Colbert
DuPont Crop Protection
Stockton, CA



Stephen Colbert was awarded Honorary Membership in the California Weed Science Society at the 64th annual conference on January 24, 2012 in Santa Barbara, California.

Honorary membership is the highest honor awarded annually and recognizes outstanding service to Weed Science and the CWSS as determined by the Nominating Committee and approved by the Board of Directors.

Stephen was born in San Luis Obispo but raised across numerous states and countries including Colorado, Oregon, Indiana and Brazil. He grew up a self proclaimed “Treflan Baby” as his father (Floyd Colbert), was a research scientist with Elanco. Stephen spent many hours and weeks as “volunteer” labor in research plots before leaving for college.

Stephen received his Bachelor’s degree in Biological Sciences from Cal Poly, San Luis Obispo and completed both his Master’s and PhD from University of California, Berkeley, in Plant Pathology.

Stephen has served in product development roles for a number of basic manufacturers including Griffin Corporation, Eden Biosciences, Uniroyal Chemical and most currently DuPont. Stephen is DuPont’s Northern California Product Development Representative. He supports currently registered products and works in the development of new products such as Matrix herbicide for trees and vines, Altacor/Coragen insecticide, Fontelis fungicide and Perspective vegetation management herbicide.

Stephen was a member of the CWSS Executive Board from 2007-2011, where he served two terms as president. He comes from a family with a long and distinguished history of service to the California Weed Science Society. Floyd Colbert, his father, was the CWSS President in 1978, Award of Excellence recipient in 1987 and received Honorary Member in 1987. Stephen’s uncle Don received the Award of Excellence in 1986 and Honorary Member in 1987. Congratulations and thank you to Stephen for continuing the Colbert family legacy of outstanding service to the California Weed Science Society.

California Weed Science Society Award of Excellence-2012

Rob Wilson
Intermountain Research and Extension Center Director/Farm Advisor
Tulelake California



The California Weed Science Society has presented the 2012 Award of Excellence to Rob Wilson for his contributions and service to the society.

Rob is based at the Intermountain Research and Extension Center in Tulelake California where he is the Director/Farm Advisor. He started his career with UC ANR in 2001 as a farm advisor in Larsen County and transferred to Tulelake in May 2009. His specialty is weed management.

Rob's research and educational programs focus on management of Klamath Basin crops including potatoes, onions, peppermint, small grains, and alfalfa. His program also has a strong focus on invasive weed management in rangeland and wild lands. He earned his Bachelor and Master of Science degrees from Colorado State University.

Rob has been an active member of the California Weed Science Society since 2001. He has presented multiple times at the CWSS conferences, written articles in the CWSS journal and served on the Board of Directors since 2007 as the Student Liaison Director.

During his time as Student Liaison Director, Rob has significantly elevated the various CWSS programs designed to connect students with the society. Student posters, student papers, various scholarships and internships have all flourished with Rob coordinating the society's student outreach. Members of the society, along with dozens of weed science students from throughout California, share in the appreciation of Rob's efforts.

2012 Conference Student Awards

Presented by Rob Wilson, CWSS Director – Student and Commercial Liaison



Pictured left to right: Katrina Steinhauer, Sara J. Alatorre, Joy Hollingsworth, Kate Hernandez, DeeAnn Kroeker

Research Paper

(\$500) Joy Hollingsworth, CSU Fresno – Weed population dynamics in overhead and subsurface drip irrigated conservation tillage cropping systems

Research Poster

(\$500) DeeAnn Kroeker, Fresno Pacific University – Development of a method to evaluate mortality of black mustard (*Brassica nigra*) seeds exposed to volatile compounds from composted greenwaste

(\$300) Sara J. Alatorre, CSU Fresno – Use of recycled paper mulch for weed control during establishment of blackberries

(\$200) Kate Hernandez, Fresno Pacific University – A field trial to evaluate deleterious effects of composted municipal greenwaste and soil solarization on black mustard seeds

2012 CWSS Student Scholarship Recipients

Undergraduate Scholarship Awards

- \$1000 Sara J. Alatorre, California State University, Fresno
mssarajane@mail.fresnostate.edu
- \$1000 Sarah Gooder, California Polytechnic State University, San Luis Obispo
sgooder@calpoly.edu

Graduate Scholarship Awards

- \$2500 Rafael Munhoz Pedroso, University of California, Davis
rmpedroso@ucdavis.edu
- \$2000 Milton A. Garcia, University of California, Davis
alegarcia@ucdavis.edu
- \$1500 Joy Hollingsworth, California State University, Fresno
jnhollings@hotmail.com
- \$1000 Andrew MacDonald, University of California, Santa Barbara
andrew.macdonald@lifesci.ucsb.edu

Transition Awards (for students between undergrad & grad programs, awarded as recognition of excellent work in Weed Science)

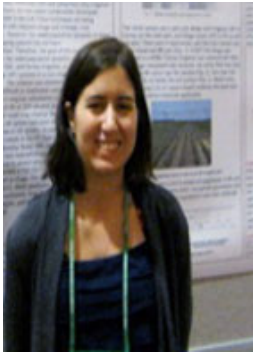
- \$500 Gerardo (Lalo) Banuelos, University of California, Davis
gbanuelos@ucdavis.edu
- \$500 Sonia Rios, California State University, Fresno
sonia_rios1@yahoo.com

2012 CWSS Scholarship Biographies



Rafael Munhoz Pedroso

I am a first-year Ph.D. student at the Department of Plant Sciences, University of California at Davis. I have a bachelor degree in Agronomy from the University of Sao Paulo, Brazil, and have been working under Dr. Albert Fischer's guidance at UC Davis since 2010. First as a Jr. Specialist and later as an MSc student, I worked with herbicide-resistant and susceptible biotypes of the troublesome rice weed *C. difformis* to parameterize and calibrate a relatively simple emergence model, which could allow growers to predict and plan for timing of their weed control and crop establishment; the results from my master's thesis will soon be presented to the broader weed science community. Being recently admitted to the Ph.D. program at UC Davis, I will implement a novel approach aiming at the elucidation of the impacts of herbicide-driven selection, which integrates plant biology, ecology and physiology; thus, my Ph.D. project, entitled "Effects of herbicide selection in noxiousness of *Echinochloa* spp. biotypes under elevated CO₂ and global warming", will evaluate germination and growth of rice cultivars and herbicide-resistant and -susceptible biotypes of *Echinochloa* spp. This research is essential for rice production regions where monoculture and a heavy dependence on herbicides has led to the proliferation of very difficult-to-control weeds, which in turn, have evolved resistance to most of the available herbicides. By enhancing our knowledge over major physiological changes imposed by global warming on rice and major weeds associated with this staple crop, I hope to offer new tools to better foresee growth constraints, in tune with my long-term career goals of improving food production efficiency and sustainability through enhancements on weed management.



Joy Hollingsworth

I am attending California State University, Fresno to pursue a Masters degree in Plant Science. My advisor is Dr. Anil Shrestha.

My thesis project is titled "Crop growth, development, and pest population dynamics in soil and water conserving cotton cropping systems in the San Joaquin Valley." After graduation, I hope to work in agricultural research.



Andrew MacDonald

My name is Andy MacDonald and I am a PhD student in the Department of Ecology, Evolution, and Marine Biology at the University of California, Santa Barbara. My dissertation research, under the direction of Dr. Tom Dudley and Dr. Cherie Briggs, is investigating the invasion and management of common reed (*Phragmites australis*) in the Southwestern US and coastal California. My project will include exploration of habitat requirements, insect herbivory and higher order interactions, as well as landscape variables on invasion success. In the future I hope to work with a governmental organization, applying my research and experience to the sustainable management of species invasions.



Sara J. Alatorre

I sincerely thank all the CWSS members for the support, it is greatly appreciated. I am currently attending California State University, Fresno, pursuing a B.S. in Plant Science with an emphasis in Plant Health. I would also like to thank my advisor, Dr. Anil Shrestha, weed scientist, for his support and guidance. My research includes the efficacy of recycled paper mulch, to find the most sustainable weed management practices. I am also beginning a project entitled, *Enhancement of Rimsulfuron (DuPont™ Matrix®) herbicide activity with Aquatrols® soil surfactant in transplanted tomatoes*. Upon graduation, I will earn a PCA license, CCA license, continue my education, and find ways to serve growers and the community.



Sarah Gooder

I am currently in my third year (at the time of the conference) at California Polytechnic State University, San Luis Obispo. I am pursuing a degree in Crop Science with an emphasis in Plant Protection Science. I look forward to the future when I will have my Pest Control Adviser License, Qualified Applicator License, and Pest Control Aircraft Pilot Certificate. Other future career goals include researching to improve the chemicals and pest control methods utilized today to guarantee an economical, efficient, environmentally-conscious, and productive tomorrow.



Gerardo (Lalo) Banuelos

In the fall of 2012 I will be continuing my higher education as graduate student at California State University, Fresno in their weed science program. Currently, I work as a SRA III for the University of California Cooperative Extension in Tulare County with farm adviser Steve Wright. For my thesis research, I will be working closely with professor Anil Shrestha. My ultimate goal is to become a farm advisor with a special interest in weed management. I would like to sincerely thank the California Weed Science Society for their support in my higher education.



Sonia Rios

In the fall of 2012 I will be continuing my higher education as graduate student at California State University, Fresno in their weed science program. Currently, I work as a SRA II for the University of California Cooperative Extension in Tulare County with farm adviser Steve Wright. For my thesis research, I will be working closely with professor Anil Shrestha. My ultimate goal is to become a farm advisor with a special interest in weed management. I would like to sincerely thank the California Weed Science Society for their support in my higher education.

In Memoriam

**Alvin “Jack” Weems
1925-January 8, 2012**

Jack, age 86, passed away at his home, surrounded by his family, on Sunday, January 8, 2012, after fighting a brief battle with cancer. Jack was born in Richmond, CA in 1925. His parents moved to Caruthers to be closer to family when he was two. He attended Roosevelt High School in Fresno and in 1943; Jack enlisted into the U.S. Army Air Corps where he was stationed on Guam as an air traffic controller during WW II. That experience cemented his love of flying and airplanes. He was widowed in 2010 from Bette, his wife of 61 years.

Jack began his career in 1959 as an ag-chemical salesman with Stauffer Chemical. Over the next 26 years, he attended numerous California Weed Science Society Conferences until his retirement in 1985. After Bette, the great love of his life was all about planes and flying. As his children were growing up, Jack bought and refurbished a 1946 Luscombe 8A airplane, giving his family many years of enjoyment. As the years progressed, Jack moved back to model airplanes where he spent many enjoyable hours building and crashing! His involvement with the Fresno Radio Modelers was his favorite pastime and he became an icon in the club. They became his strongest supporter after he lost his wife. His son Dave and wife Linda; a daughter; four grandchildren; and three great grandchildren survive Jack. Memorial contributions may be made to Nancy Hinds Hospice.

In Memoriam

Sam Armentrout

Former Madera mayor Sam Armentrout (61) lost his battle with leukemia Wednesday night at a local hospital. Armentrout, who was in his fifth term on the Madera City Council recently retired from the Madera Unified School District as the director of transportation/security, a position he held since 2005. Sam last served as Madera's mayor in 2009; holding the position three times since first being elected to the council in 1992.

Sam was a lifelong resident of Madera; he was a graduate of Madera High School class of 1968. Sam went on to receive his Associates of Arts Degree in Criminology. This degree led to a 20-year career as a member of the Madera Police Department Reserve Unit, where he retired with the rank of Captain.

He was a veteran of the U.S. Navy, having served during the Vietnam era. Sam later went to work for Madera Irrigation District. He was a licensed PCA and supervised district's aquatic and terrestrial vegetation management programs. He attended numerous California Weed Science Society Conferences through out the 1980's and 1990's. He was employed with the district for 29 years, retiring as a Maintenance Supervisor.

With his position on the Madera City Council, he was involved in numerous public service organizations in the Central Valley. He belonged to the Madera Elks Lodge. In his leisure time he enjoyed golfing.

He is survived by his wife of 40 years, Susan Armentrout of Madera, his two daughters, Melissa Cole of Madera and Samantha Armentrout of Fresno, siblings Jim Armentrout, Norma "June" Salas and Shirley Dilbeck of Madera, Liz Smith of Bakersfield and Wilma Golding of San Ramon, and three grandchildren.

California's Growing Marijuana Business Impacting Agriculture

Article written by Harry Cline, Western Farm Press, February 8, 2012 (reprinted with permission)

California prides itself on feeding America.

It also has the dubious distinction of being America's biggest dope supplier.

Approximately 75 percent of the marijuana sold in the U.S. is grown in California — not Mexico, according to Sgt. Mike Horne of the Ventura County (Calif.) Sheriff's Department narcotics bureau. Horne heads a six-man commando-like unit that uses helicopters and rugged all-terrain vehicles to search and destroy marijuana growing operations in the national forest of his county.

This is not the typical article you find in an agricultural publication. However, Horne made his comments in a very typical agricultural setting, the recent California Weed Science Society annual meeting in Santa Barbara, Calif. The weed Horne was talking about has likely never been the topic of the society's annual meeting in its 64-year history, where the presentations center around controlling unwanted weeds like horseweed, morningglory and Johnsongrass — not pot.

Horne was invited to speak on marijuana cultivation as the tentacles of these illegal operations pervade the rural, agricultural areas of the state. Marijuana cultivation has grown to the point where it is making it dangerous for government employees like University of California Cooperative Extension farm advisors to do their jobs.

Michelle Le Strange, UCCE farm advisor in Tulare County and immediate past president of CWSS, said she has been warned by county officials and law enforcement officers that she should be alert in driving a county vehicle in rural areas because marijuana plantation tenders might think she is a law enforcement officer, and she could be in danger.

Horne said Le Strange and any government officials driving vehicles with government plates should be concerned because these marijuana plantations are operated by Mexican drug cartels, the same lawless gangs who are responsible for thousands of murders each year in Mexico. These cartels actually scour the U.S. Forrest Service lands in search of ideal growing sites, often adjacent to running streams. The cartels stock these plantations with people, drip irrigation tubing and chemicals to farm the illegal weed.

Horne showed a video and photos of what his men have uncovered in the national forests. As

expected, there were neatly planted marijuana rows with drip irrigation tubing, the same as used by farmers. More chilling to the CWSS audience were the photos of not only automatic weapons confiscated in a raid, but pictures of chemicals and fertilizers used in these growing operations. The logos of many very prominent ag chem and fertilizer companies were clearly visible. There were also photos of ag chem products manufactured in Mexico, brought in by the cartels. Horne said many of those chemicals are not legal in the U.S.

Le Strange pointed out that chemicals and fertilizers used in these growing operations could well find their way in to streams and lakes. The unsuspecting public is likely to put the blame on agriculture for any contamination from these illegal chemicals or misuse of U.S. registered products.

The national forest marijuana problem is not new, but it is growing, becoming more sophisticated and more dangerous with the cartel involvement. Workers in these plantations are armed with automatic assault rifles.

In recent years, marijuana growing has flourished in California's rich agricultural valleys. This has been precipitated by California's new medical marijuana laws. Illegal drug dealers are operating under the guise of growing medical marijuana. One large-scale growing operation raided by county sheriff's officials just east of Fresno was in an area of small vegetable farms. On the fence surrounding the pot farm letters were posted professing that it was a medical marijuana operation. Many of the letters were duplicated and tacked on the fence of the raided farm. Sheriff's deputies had traced the marijuana grown there to illegal drug sales on the East Coast.

Horne said Asian gangs are leasing agricultural land for these marijuana operations.

Horne cited official statements that only 15 percent of marijuana growing operations on federal land are detected and destroyed each year. He disagrees with that, at least in his county, where he said his task force takes out 50 percent to 70 percent of the operations.

What he did not dispute is the size of the problem statewide. Horne said it has been estimated that there are 71,000 acres of marijuana under cultivation each year in California. That represents 121 square miles or an area equivalent to the size of Sacramento.

Horne said they are so plentiful, it is common for hunters and hikers to stumble across marijuana plantations.

These operations have also been linked to wildlife deaths from drinking polluted water and several have been linked to starting forest fires.

Off-Site Movement of Herbicides

Brad Hanson, University of California, Davis, Dept. of Plant Sciences, bhanson@ucdavis.edu

The fate of herbicides or other pesticides in the environment can be grouped broadly into “degradation processes” and “transfer processes”. *Degradation* implies one or more changes in chemical structure that alters the potency or activity of the compound. Usually this means reduced phytotoxic activity but there are cases where intermediate degradation products also have some level of activity. Generally speaking, all herbicides degrade in the environment but the rate of degradation can vary widely among specific herbicides and environments. *Transfer* processes, on the other hand, refer to changes in the location or availability of the herbicide not associated with changes in the chemical structure. There are four primary ways that herbicides can move off-site: volatilization, physical particle movement, water (leaching or runoff), and through uptake and removal in plants or animals. The potential for any type of off-site herbicide movement is greatly affected by the chemistry of the specific herbicide and the environmental conditions.

Off-target vs off-site:

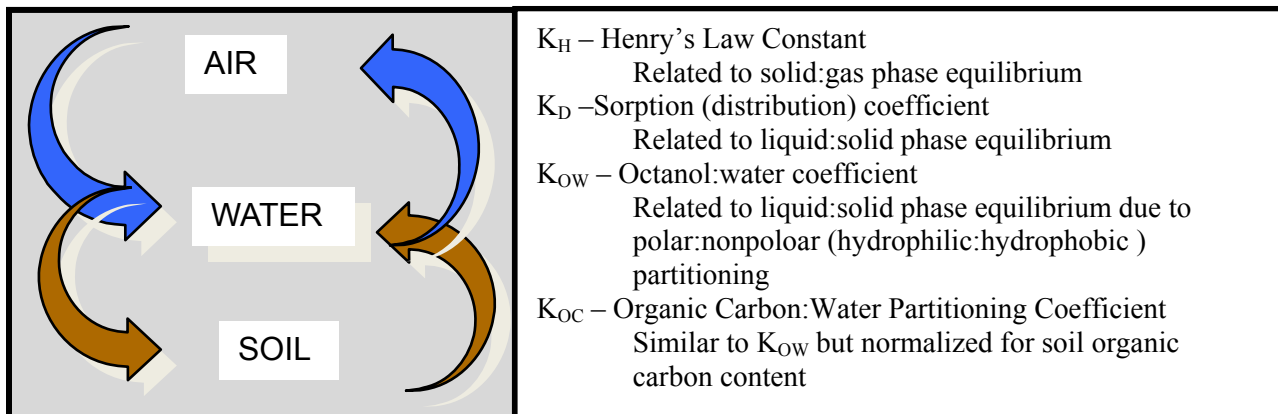
Two similar sounding terms have very different meanings in the context of herbicide applications. Off-target applications are those that miss the target site or zone. For example, the target of a post emergence herbicide is weed foliage. Thus, a post emergence herbicide that misses the plant and hits the soil technically is “off target”. Similarly, a soil-applied herbicide is usually targeted to the surface of the soil or a shallow three dimensional layer of soil to ensure that germinating seedling are exposed to the herbicide. Herbicides incorporated too deeply or not deep enough are not on target. While obviously these are not ideal situations, off target applications usually result simple cases of reduced weed control efficacy and wasted money. Of greater concern for the environments are cases of off-site herbicide movement. Off-site movement refers to herbicides that misses or moves from the treated zone. The intended treatment zone could include whole fields or portions of a field such as blocks, strips, berms, furrows. The intended site could also be defined areas such as road shoulders, fence rows, lawns, or landscape areas or even individual plants. Herbicides that move off site also reduce efficiency and economics of weed control but can also result in non-target plant injury, environmental contamination, legal issues, and negative public perceptions of weed management operations and agriculture in general.

Herbicide Chemistry:

The chemical structure and formulation of an herbicide can have a large impact on the potential for off-site herbicide movement and the most likely routes of movement. The chemistry of the herbicide directly impacts the solubility, volatility, stability, and phase equilibrium of the product in the soil and water environment. With any pesticide in a relatively stable environment, the

active ingredient will reach an equilibrium (not necessarily equality) among the solid, water, and gas phases of the soil or water environment. There can also be significant interaction between specific herbicides and the environment, especially soil type, texture, pH, organic matter content, and moisture.

Figure: generalized herbicide partitioning diagram and coefficients.



Information on the phase partitioning of many herbicides is available online or in resources such as the WSSA Herbicide Handbook. In general, herbicides with relatively lower Henry’s Law Constant (K_H) tend to partition into the liquid or solid phase while higher K_H values are associated with greater partitioning into the gas phase (more volatile). Compounds with high sorption coefficients (either K_d or K_{oc}) tend to be more tightly bound to soil particles or soil organic matter while products with low sorption are less tightly bound and tend towards the liquid phase. Lipophyllic herbicides (those with high K_{ow}) tend to bind to lipids, especially those in organic matter while low K_{ow} compounds are much more likely to be found in the water phase. It is important to remember that these are “rules of thumb” and behavior of any herbicide depends simultaneously on all of these coefficients and other factors.

Volatilization

Movement of volatile herbicides generally is due to herbicide active ingredients that “evaporate” from leaf or soil surfaces after deposition on the intended site. Herbicide movement in the gas phase is somewhat affected by air temperature, wind speed, and soil moisture (e.g. high temp, high wind, and high moisture tend to increase volatilization). However, vapor pressure, which is related to the chemical structure and formulation of the herbicide, is the most important factor affecting potential for off-site movement due to volatilization. In certain cases, formulation technology is used to change the volatility of herbicides. For example, the 2,4-D ester is considerably more volatile than the amine formulation. Relatively speaking, most herbicides are not especially volatile (Table) but we do tend to require incorporation of herbicides that are more volatile than 1×10^{-6} mm Hg to minimize losses due to volatilization. Proper herbicide selection

and understanding of factors influencing volatility, and timely incorporation can minimize the potential for off-site movement of volatile herbicides

Table. Vapor pressures for some herbicides and example compounds.

■ methyl bromide	vp	1640 mm Hg @25C
■ rubbing alcohol	vp	60
■ water	vp	20
■ EPTC	vp	3.4 x 10 ⁻²
■ clomazone	vp	1.4 x 10 ⁻⁴
■ trifluralin	vp	1.1 x 10 ⁻⁴
■ oxyflourfen	vp	2.0 x 10 ⁻⁶
■ simazine	vp	2.2 x 10 ⁻⁸
■ glyphosate	vp	4.3 x 10 ⁻¹⁰
■ sulfonylureas	vp	~ x 10 ⁻¹⁵

Physical Drift

Herbicide drift generally refers to the off-site movement of herbicide droplets before they are deposited on the target surface. This type of off-site movement is a common cause of problems if sensitive plants are growing near a treated area and is most subject to equipment setup and decisions made by the applicator in the field. Environmental conditions contribute to potential for drift; the effect to high wind speed should be fairly obvious but high temperature and low humidity can also lead to drift conditions because of rapid evaporation of the water droplets – small droplets are lighter and can move off-site more easily than large droplets. Occasionally, temperature inversion conditions can lead to very still air and very slow settling of fine spray droplets; these can also be prone to drift. Equipment setup and application decisions strongly affect the potential for drift. Nozzle type, orifice size, spray pressure, and nozzle orientation can all affect the size distribution of spray droplets. Similarly, boom height (whether ground or aerial) can affect drift because greater distances between nozzle and target allow more time for evaporation and lateral movement due to winds. The consequences of herbicide drift can vary depending on the level of drift, the activity of the herbicide, and the sensitivity of nearby plants. Physical drift can best be managed by setting up equipment to apply fewer fine droplets, leaving appropriate buffers to sensitive areas, and monitoring environmental conditions at the applications site. Above all, physical drift potential can be reduced by adequately training sprayer operators and avoiding applications during adverse weather conditions.

Off-site movement on soil particles:

Herbicides bound to soil particles can move off site along with soil eroded by wind or water. When significant off site herbicide movement occurs due to wind erosion, it is usually associated with dry soil conditions, very little vegetation cover, and high wind speeds. Injury is more common with herbicides that are persistent and active at very low concentrations and the

presence of highly sensitive non target plant species. Herbicides bound to soil particles can also be moved off site with surface water runoff – either irrigation tail waters or heavy rainfall conditions that surpass the infiltration rate of the soil. These herbicides tend to end up in the bottom of water courses or holding areas. Off-site movement of herbicides on soil particles is primarily managed by minimizing soil erosion through water and vegetation management, increasing water infiltration, and decreasing the total amount of surface water leaving the field.

Herbicide leaching or percolation losses.

Herbicides that move too deeply in the soil profile to be active on the target weeds are also “off site”. The usual target zone for soil-applied herbicides is the top inch or two of soil where most weed seeds germinate. Herbicides that are poorly soluble in water and strongly absorbed to soil tend to have low potential for leaching. Conversely, water soluble herbicides with weak binding properties can move to a greater extent in soil. Leaching potential is also affected by the timing and amount of irrigation or rainfall that occurs after the herbicide application. Large amounts of water on the soil surface shortly after the herbicide application is more likely to lead to leaching compared to delayed irrigation or precipitation because of time-dependant binding. Soil texture and structure also can affect leaching potential; coarse texture soils, channels, and cracks can lead to greater losses into the profile due to leaching or mass flow. Once herbicide moves beyond the root zone, they tend to be relatively more persistent in the soil environment due to more anerobic conditions, less microbial activity, and greater temperature stability. Leaching is best minimized through proper herbicide selection, effective and timely irrigation management, and soil management that minimizes channeling and cracks.

Plant and animal uptake and removal.

Off-site movement of herbicides due to plant or animal uptake and removal from a treated field is usually only a very small portion of the herbicide applied to a site. However, this route of herbicide movement can be economically important due to the potential illegal residues in the harvested commodity which is the primary reason for preharvest intervals (PHI), grazing, and crop residue use restrictions. Specific examples include very specific limitations on when and where certain herbicides can be used because of their persistence in plant tissue (even through the composting process) and potential damage to highly susceptible species.

There are many economic and environmental reasons to minimize off-site movement of herbicides. Increased weed control efficacy, economic efficiency, avoiding legal claims and disputes, stewarding soil and water resources, and protecting the environment. The potential for off-site herbicide movement can be greatly reduced through proper equipment setup, operator training, and weather and environmental monitoring. A basic level of understanding of the chemical, soil, and environmental factors that affect herbicide availability and potential routes of movement can lead to better herbicide recommendations, better applications, and more effective weed control treatments with fewer adverse effects on the environment.

Herbicide Translocation and Metabolism

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Barriers to herbicide absorption

Herbicides are applied to an appropriate site of entry into the plant from where they must move to the appropriate site of action. Sites of entry for soil applied herbicides are young root tissues especially root hairs on dicots (broadleaf) and the crown or coleoptilar nodes on monocots (grasses). The leaves and, to a lesser extent, stems are the sites of entry for above ground herbicide applications. Young root tissues do not have a cuticle so as to not impede water and mineral nutrient absorption. However, mature roots will have suberized tissues that prevent entry (and exit). The first significant barrier to entry for foliar applied herbicides is the cuticle, which is designed for protection and to prevent water loss from the plant. It is comprised primarily of epicuticular wax and cutin with pockets of embedded wax. Nonpolar (oil-like) lipophilic herbicides move more quickly through the waxy portions of the cuticle than the cutin. Polar (water-like) hydrophilic herbicides move more quickly through the cutin than waxy portions. Pectin strands and cellulose extending from the cell wall are the next significant barriers for lipophilic herbicides but pose a relatively easy conduit for hydrophilic herbicides. Once past the cuticle, herbicides can move further into the plant along the cell walls and not enter cells through the plasma membrane. Movement outside the plasma membrane is called apoplastic (i.e. the “dead” portion). Movement within the plasma membranes of living cells is called symplastic movement (i.e. “living” portion). Herbicides and other molecules can move from living cell to living cell remaining within the symplasm through plasmadesmata. Entering the symplasm is a significant barrier to herbicide entry, which is determined primarily by the herbicide’s partition coefficient, K_{ow} . The K_{ow} of an herbicide is the ratio of herbicide dissolved in octanol to herbicide dissolved in water. A high K_{ow} is indicative of low polarity and relative ease in passing through the plasma membrane (e.g. atrazine, oxyfluorfen, fluazifop-p-butyl). Herbicides such as glyphosate and paraquat have low K_{ow} ’s and thus have difficulty with this barrier.

Herbicide Movement inside Plants

There are three processes by which herbicides move inside the plant: diffusion, active transport, and bulk transport. Most herbicides enter plant cells from the apoplasm to the symplasm by simple diffusion: a passive process of random movement from high concentration to low. Sometimes protein channels in the plasma membrane provide a path of lesser resistance to herbicides and similar molecules than moving directly through the plasma membrane. Active transport requires an expenditure of ATP to drive a proton pump (e.g. ATP synthase) which ultimately establishes an electrical as well as chemical gradient on one side of a membrane relative to the other. Protein carriers imbedded in the plasma membrane then facilitate

transport of molecules including herbicides into the symplasm. A phosphate carrier is probably bringing glyphosate into the cell. An auxin efflux carrier transports the herbicide 2,4-D, whereas glufosinate is probably utilizing an amino acid carrier. Bulk transport is the process responsible for most long distance transport inside plants. This passive process (not counting the ATP expended for sugar loading and unloading) occurs apoplastically in the xylem or symplastically in the phloem.

The site of action for contact herbicides is the same as the site of entry because they do not move well within the plant. Systemic herbicides usually must move some distance inside the plant to the appropriate site of action. These herbicides use either the transpiration (water) stream of the xylem or translocation (sugar) in the phloem to travel long distances. All herbicides must eventually get to living cells to achieve herbicidal action. Systemic herbicides move in both the symplasm and apoplasm but preferentially in one. Polar (hydrophilic) herbicides tend to move better in the apoplasm because they move through cell walls easily. Nonpolar (lipophilic) herbicides tend to move better in the symplasm because they move easily through plasma membranes. Some herbicides such as paraquat and trifluralin do not move much at all in either symplasm or apoplasm whereas dicamba can move equally well in both. Symplastically (phloem) mobile herbicides are typically applied to the leaves (glyphosate, 2,4-D, sulfonylureas) whereas apoplastically (xylem) mobile herbicides are soil applied (triazines, phenylureas). Bulk transport in the symplasm (phloem) moves from photosynthetic sources primarily mature leaves to

growth and storage sinks such as flowers, roots, or young leaves. Directionality of transport is from nearest source to nearest sink. Thus upper source leaves tend to feed upper sinks and vice versa. Top to bottom (i.e. polar) transport is achieved for certain weak acids such as auxin according to the weak acid hypothesis (also called the chemiosmotic model or ion trapping). Essentially, protonated (un-dissociated) weak acids in low pH conditions such as occurs in the cell walls can pass into the symplasm with relative ease compared to the deprotonated

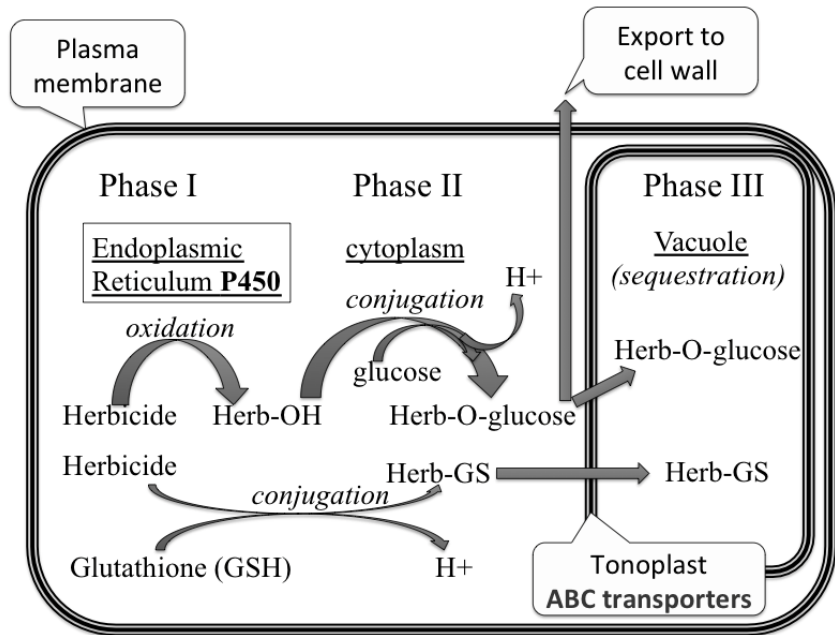


Figure 1. Summary of the three main phases of herbicide metabolism.

weak acid in high pH conditions such as the cytoplasm. An ATP-expending proton pump maintains low pH in the cell walls. Auxin efflux proteins (PIN and PGP) preferentially transport auxins and other weak acids such as 2,4-D from shoot tips toward the roots.

Metabolism

Herbicide metabolism describes the processes by which herbicides are detoxified or activated inside plants. That certain species are better or worse able to metabolize herbicides results in the selective activity of herbicides. Some herbicides such as glyphosate is not readily metabolized inside most plants which explains its broad spectrum activity. Herbicides such as atrazine can be degraded rapidly inside plants where some species are better able than others to detoxify it making it a selective herbicide. Though not common there are several examples of differential herbicide *activation* inside plants that can provide selectivity such as the use of 2,4-DB in legumes where sensitive weeds will beta oxidize 2, 4-DB to form 2,4-D. Differential breakdown is more common and can be divided into three phases summarized in Figure 1.

Phase I

A significant detoxifying mechanism in plants and animals are a family of proteins, which comprise the mixed function oxidases called cytochrome P450 in the endoplasmic reticulum. These enzymes are normally involved in biosynthesis of structural compounds such as lignin but can also oxidize herbicides. Figure 2 summarizes the main oxidation steps performed by these enzymes. Other phase I reactions include reduction by N-deamination (removal of an amino group).

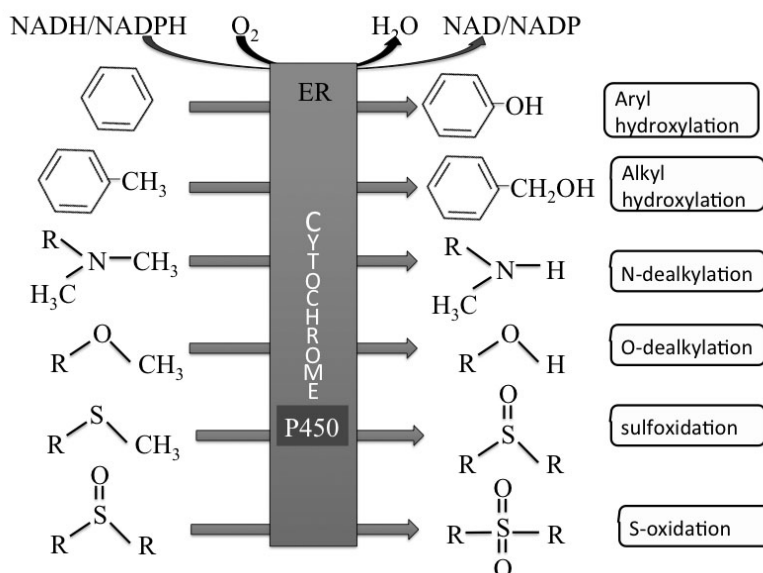


Figure 2. Summary of oxidation reactions that occur in the endoplasmic reticulum by the cytochrome P450 enzymes.

Phase II

Conjugation of oxidized herbicides to sugars, amino acids, glutathione or homogluthathione are examples of phase II reactions in plants. Some plant species can conjugate herbicides without them being oxidized where glutathione or homogluthathione are substrates and glutathione-S-transferase is the enzyme that works on the electrophilic centers of herbicides. Examples of herbicides that are conjugated in this way are the arylophenoxypropionates (-fops), triazines,

thiocarbamate (EPTC), and the chloroacetamides (e.g. metolachlor and alachlor). Triazine detoxification occurs readily in plants by one or a combination of three mechanisms: N-dealkylation (minor but may explain cotton and soybean tolerance), DIMBOA-mediated hydrolysis, and glutathione conjugation. Corn possesses all three of the mechanisms, which explains its tolerance of atrazine.

Phase III

Glucosylated herbicides (attached glucose) and glutathione-herbicide conjugates are moved to the extracellular matrix or transported to the vacuole for further processing or storage. The ATP binding cassette (ABC) transporters are responsible for conjugated herbicide transport. Often the final processing step is the attachment of a malonyl group to the conjugate before final transport outside the cell or into the vacuole.

Safeners

The idea to use chemical safeners as “antidotes” to herbicides was developed by Otto Hofman in the 1940’s. Most often safeners enhance glutathione conjugation or enhance cytochrome P450 enzymes for plants exposed to these chemicals. Perhaps increased activity of ABC transports is another mechanism of safening. Flurazole, dichlomid, benoxacor, and fenclorim are examples of safeners used in grass crops. They may be applied to the crop seed before planting or can be premixed with the primary herbicide. The reduced activity of herbicide mixtures associated with antagonism may be due to a safening effect whereby the herbicides in mixture may be enhancing herbicide metabolism inside plants. Conversely, synergism of herbicide mixtures may be due a decrease in metabolism as occurs in strawberries where teracil damage increases in the presence of fluazifop-p-butyl.

References:

California Weed Science Society. 2002. Principles of Weed Control 3rd Edition. Thomson Publications, Fresno, CA 630 pp.

Radosevich, SR, JS Holt, CM Ghera. 2007. Ecology of Weeds and Invasive Plants: Relationship to Agriculture and Natural Resource Management. 3rd Edition. John Wiley and Sons. Hoboken NJ 445 ppg.

Ross, MA and CA Lembi. 2009. Applied Weed Science: Including the Ecology and Management of Invasive Plants. Pearson Prentice Hall, Upper Saddle River, NJ 568 ppg.

Weed Population Dynamics in Overhead and Sub-surface Drip Irrigated Conservation Tillage Cropping Systems

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As resources such as water and fuel become more limited and expensive for agriculture in the San Joaquin Valley (SJV), farmers look towards technology for improved efficiency. Subsurface drip has become an increasingly popular irrigation method in row crops in the SJV. This technology conserves water, reduces runoff, and works well in minimum tillage operations. Further, it has been shown to reduce weed populations compared to furrow irrigation. This is because the soil surface and the top few inches of the soil profile where most weed seedlings emerge from is relatively dry with sub-surface drip. However, overhead irrigation systems (linear move and central pivot) are regaining popularity in the SJV for economic reasons. The possibility of combining overhead irrigation systems with conservation tillage (CT) has sparked a renewed interest in the technology. Water movement down furrows was often cited as an impediment to the adoption of CT systems in surface-irrigated row crop systems in the SJV. However, this problem may no longer be a concern in overhead irrigation systems. Therefore, the introduction of overhead irrigation in CT systems may enable the combination of water and soil conserving techniques and contribute to the development of sustainable cropping systems in the SJV.

Any change, however, in the prevalent cropping system may bring about changes in pest population dynamics, especially weeds. Pest population dynamics and management are important components of any cropping system that have not been adequately explored in overhead/sub-surface drip irrigated CT systems. Therefore, a study was initiated at the University of California West Side Research and Extension Center in Five Points, CA in 2008 to look at various components of different cropping systems. Initially, the system comparisons included no-till (NT) and standard tillage (ST) under overhead linear move or furrow irrigation in a corn-wheat rotation. In 2011, furrow irrigated treatments was replaced with sub-surface drip irrigation and all the plots were converted to strip-tillage and acala cotton was also introduced to the crop rotation. Therefore, the crop rotation over the years has essentially been wheat (silage) – Roundup Ready (RR) corn – wheat (silage) – RR corn – wheat (silage) – RR cotton. The only herbicides used in the rotation so far have been 2,4-D in wheat and glyphosate in RR corn and cotton. Although various components of these cropping systems were evaluated, this paper will only focus on weed population dynamics during the course of the study. Data on weed densities

by species were collected in each phase of the rotation and analyzed and statistical differences between the treatments were evaluated at a 0.05 level of significance.

Weed densities in the wheat phase of the rotation were similar between the irrigation and tillage systems. Similarly, no differences in weed densities were observed in the corn phase of the rotation in 2009 and 2010. The most prevalent weed species in the experiment were redroot pigweed (*Amaranthus retroflexus*), shepherd's purse (*Capsella bursa-pastoris*), London rocket (*Sisymbrium irio*) and field bindweed (*Convolvulus arvensis*). Weed densities at the onset of the experiment were fairly high as the wheat plots had up to 112 weeds/m² in mid-winter. However, the weed density has decreased over the years. This in part is due to the strategic rotation of the crops and the deliberate reduction in tillage. The broadleaf weeds were controlled by 2,4-D in the wheat phase and the wheat itself outcompeted many weeds. The remaining weeds, both broadleaves and grasses, were controlled with glyphosate in the RR corn phase.

In 2011, cotton was planted in the rotation after the furrow-irrigated plots were converted to sub-surface drip irrigation with the tape buried 12 inches beneath the soil surface. Once again, the crop rotation and weed management led to very few weeds in the cotton plots. However, there was a significant difference ($p < 0.05$) between the treatments. The sub-surface drip plots had an average of 1 weed/m² compared to 10 weeds/m² in the overhead irrigation plots. The most prevalent weeds were sowthistle (*Sonchus* spp) and field bindweed. However, volunteer corn emerged evenly in all the plots in cotton as it was a RR variety in RR cotton and glyphosate was unable to control them. Thus, the volunteer corn had to be removed by hand pulling. Cotton was harvested in October and wheat was planted in all the plots in November 2011. Cotton will be planted again in spring 2012 after green-chopping the wheat. In conclusion, weed densities in the experiment so far have diminished over the years due to the strategic rotation of crops and herbicides. Tillage and irrigation systems initially had no effect on weed densities but with the recent introduction of sub-surface drip irrigation, differences were observed between the irrigation systems. The CT system used in the experiment has not shown an increase in weed densities. The weed seedbank is currently being monitored to assess the belowground weed population dynamics.

Poster Title: Development of a method to evaluate mortality of black mustard (*Brassica nigra*) seeds exposed to volatile compounds from composted greenwaste.

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Abstract:

Disposal of municipal greenwaste is an increasingly important issue in California. Composting of plant residues could be manipulated to provide enhanced weed control when incorporated into soil. Compost can increase the efficacy of soil solarization, and one possible mechanism is the evolution and enhanced retention of biotoxic volatile constituents during decomposition. The goal of this study was to develop a method to evaluate the effect of volatile compounds from greenwaste compost on mortality of seeds of black mustard (*Brassica nigra* (L.) W. D. J. Koch) during heat treatment. We conducted three preliminary experiments to modify existing methods used in laboratory studies of weed seed thermal death. In all experiments, seed samples were placed in organo bags and loaded into replicated jars half-filled with the material being tested (sand, field soil, field soil amended with wheat bran, or field soil amended with compost and wheat bran). Jars were heated at a constant temperature of 42°C in a water bath. Each jar contained one bag of seeds suspended in the headspace of the jar above the material to estimate the effect of volatile compounds, and one bag of seeds filled with the same material as the jar and buried within the material to provide direct contact. After removal from jars, seeds were incubated for 14 days in a growth chamber to determine germination percentages. Experiment 1 evaluated the effect of compost maturity on seed mortality by comparing compost-amended soil incubated at two different temperatures. Field soil was amended with greenwaste compost and wheat bran and incubated for two days at either room temperature or in a refrigerator at 4°C. Seed mortality was significantly higher in compost-amended soil that matured at room temperature (60% in headspace seeds, 83% in buried seeds), compared to refrigerated compost-amended soil (20% in headspace seeds, 27% in buried seeds). There was no significant difference in mortality between seeds suspended in the headspace and buried seeds, indicating that volatiles contributed to mortality. Experiment 2 compared two materials for comparing seed mortality in compost-amended soil to a control material without compost. Jars were filled with field soil, field soil amended with wheat bran, or field soil amended with greenwaste compost and wheat bran. There were no significant differences in seed mortality between soil and soil amended with bran, indicating that non-amended field soil was an appropriate control. Experiment 3 obtained a preliminary estimate of the effect of volatiles from compost on seed mortality, using compost-amended soil incubated at room temperature (Experiment 1), versus non-amended field soil (Experiment 2) and sand as controls. Jars were filled with sand, field soil, or compost-amended soil. Seed mortality was highest in seeds buried in the compost-amended soil (47%) and lowest in seeds in the headspace of soil (14%) and sand (15%).

Poster Title: A Field Trial to Evaluate Deleterious Effects of Composted Municipal Greenwaste and Soil Solarization on Black Mustard Seeds

Hernandez, Kate^{1*}, *Stacy Betts*¹, *Ruth Dahlquist*¹, *Megan Marshall*², *Jean VanderGheynst*³, *Chris Simmons*³, *Joshua Claypool*³, and *James Stapleton*⁴. ¹Department of Biology, Fresno Pacific University, Fresno, CA; ²Department of Agricultural Engineering, The Pennsylvania State University, University Park, PA; ³Department of Biological and Agricultural Engineering, UC Davis; ⁴Statewide Integrated Pest Management Program, UC Kearney Agricultural Center (KAC), Parlier, CA. *kmh5@fpu.edu

Composting of municipal greenwaste provides products that may be combined with existing pest management techniques, such as soil solarization, for enhanced herbicidal efficacy. By itself, solarization can be a useful alternative to chemical herbicides for weed management in many areas of California. A replicated field trial was conducted in July 2011 to evaluate the effect of amending soil with greenwaste compost on mortality of seeds of black mustard (*Brassica nigra* (L.) W. D. J. Koch) during solarization. Organdy bags were filled with seeds and field soil, either alone or amended with 8% greenwaste compost and 2% wheat bran (dry basis). Bags were then buried in plastic, 1 gallon nursery plant bags containing the same mixture. The nursery bags were then buried at the experimental field site at KAC in Parlier, and the plots were irrigated and covered with clear plastic. Seed bags were sampled at intervals of 2, 3, 3.5, 4, and 22 days after the beginning of the field trial. Seed mortality, as determined by germination tests and tetrazolium staining, was much higher in the compost-amended, solarized soil, with an average of 78% mortality on the first sampling date and 100% mortality for all subsequent samples. Seed mortality in non-amended, solarized soil was relatively low (14-29%) for the first four sampling dates, and 100% mortality was not reached in soil by the 22 day sample. The higher seed mortality observed in greenwaste-amended soil could be due to increased heat from decomposition of the organic fraction of the mixture, or to seed exposure to toxic constituents of the compost. These preliminary results suggest that composted greenwaste may be useful in agricultural weed management, especially when combined with solarization.

Solar Tents for On-Site Sanitation and Eradication of Rogued, Weedy Plant Propagative Materials

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Solar tents, which are inexpensive, disposable, and nonpesticidal, can be used to inactivate unwanted weed plant propagative materials, on-site. Previous studies with imbibed weed seeds have shown effectiveness, but proof of efficacy on vegetatively propagative material has been lacking. During two field trials in Stanislaus County, in September 2010, solar tents produced diurnal temperature maxima within closed sample bags of 146-172 °F. The mean maximum temperatures within the sample bags were 91-108 °F higher than those of ambient air, and temperatures ≥ 140 °F were maintained for 3-6 hours each afternoon during the field trials. Rhizome segments, excavated and excised from a local infestation of johnsongrass (*Sorghum halepense*), were used for treatment evaluation. The rhizomes were completely destroyed following confinement within tents containing a moisture reservoir for three days. Solar tent construction used locally-available materials, similar to those which could be scavenged in many California ecoregions. In sufficiently warm climatic areas and weather conditions of California and elsewhere, similar tents, which employ passive solar energy, can provide a useful alternative for inactivating weed propagative materials. Potential uses include destruction of quarantined, propagative materials following regulatory roguing in remote locations, or routine roguing of limited scale areas to remove invasive weeds.

The Global Value of Herbicides

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When it comes to herbicides, the world can be divided into three groups of countries—developed countries that treat 90% of their acres with herbicides and have used herbicides for fifty years, rapidly developing countries, such as India and China, that treat 30-50% of their cropland with herbicides, and countries in sub-Saharan Africa, where herbicides are used on only 5% of cropland. Developed countries rapidly adopted herbicides in the 1960s due to shortages of farm labor for hand-weeding and the desire for increased food production. American cotton workers in the South migrated to the North for factory jobs. In California, the *Bracero* Program ended in the 1960s and the short-handled hoe used for weeding was banned in the 1970s. In Japan, Germany and other Western European countries, rebuilding industrial sectors after World War II required millions of new workers. In Italy, hand-weeding of rice became a social justice issue. The survival of agriculture in these countries depended on the timely arrival of herbicides. Concurrently, herbicides proved more effective than tillage for weed control in field crops (maize, rice, wheat) and yields increased dramatically.

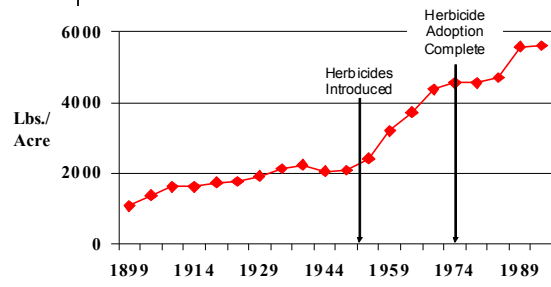
The same phenomena are driving rapid adoption of herbicides today in India and China, contributing to significant increases in crop yields in these and similar countries. Shortages of rural workers are occurring due to rapid industrialization. In the 1980s, China had an estimated 43 million hectares heavily infested with weeds, resulting in a loss of 18 million tons of grain annually. With herbicide use, wheat and maize yields have doubled since the 1980s.



It has been well known for many years that herbicide use by African farmers would dramatically increase yields. Yields on smallholder farms are one tenth that of African research farms where weeding is done at the right time. Subsistence farmers are only able to do half of the weeding required for optimal yields; poorly timed and suboptimal weeding results in yield losses of 20-100%. Despite years of trials demonstrating the benefits, herbicide use remains low due to several factors. First, weeding is seen as women's work and not taken seriously by governments. Additionally, international aid organizations have not made weed control a priority and generally do not support herbicide use in sub-Saharan Africa. As a result, weed science and extension support and spray services for weed control are not available to most African farmers.



U.S. Rice Yields



Assessing the Return to Weed Control Expenses in California Agriculture

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Weed control plays a vital role in California's diverse and vibrant agricultural sector. In 2009 the value of production was \$34.8 billion. Expenditures on inputs to agriculture totaled \$29.6 billion (Table 1). The net returns to California agriculture were \$8.8 billion. The factors of production include labor, capital and management. Some labor is hired labor or custom labor where cash payments for services transpire. Other labor includes unpaid family and operator labor. Similarly, capital inputs are comprised of owner's equity and borrowed capital which requires interest charges. Management is defined as the knowledge for planning, directing, evaluating, and bearing risk. Management may be a paid position or unpaid operator contribution to the farm business. The net return to farming is a return to the unpaid factors of production including unpaid family labor, unpaid operator labor, operator's capital (equity), and operator management including risk.

Annual production inputs such as seed, feed, pesticides, and fuel vary by crop. In order to maximize profit, theory dictates that each input should be used to the point where the value of one more unit of input measured as an increase in revenue equals the cost of that unit of input. Beyond that point, the added income resulting from adding more of the input is less than the cost of the input and the impact is to actually decrease profit. Therefore, the expenditure on inputs is equal to the return to the input if the input is used efficiently. Specifically, the value of weed control can be estimated by the expenditure on weed control.

An estimation of the expenditure on weed control in California is complicated by a number of considerations. In many cases, operations serve dual purposes. The most significant is soil fumigation used to control disease and nematodes while also acting as pre-emergent weed control. Other examples include ground preparation before planting, and cover crops that also provide habitat for beneficial insects, biomass, and nitrogen. Often herbicides are applied during the same operation as planting and/or disease control. What part of the equipment and labor for this operation should be allocated to weed control?

Based on cost and return studies from the University of California Cooperative Extension (available at <http://coststudies.ucdavis.edu>) the costs of weed control was estimated for a range of crops on a per acre basis. Not surprisingly, hand weeding is only used for the high value crops – processing tomatoes, broccoli, lettuce, and strawberries. Herbicide is used in all conventional crops except strawberries where weeds are controlled with fumigation and hand weeding (Table 2). The costs per acre range from a low of \$44 per acre for alfalfa to a high of \$760 in hand weeding for strawberries.

These costs were then divided into materials, labor, and depreciation on equipment to match the categories of expenses used in the CDFA farm expenditure values in Table 1. The expenditures for weed control were calculated as a percentage of all expenses for each crop. Then the expenditures were weighted by the income generated by each commodity group. From these values the expenditures on weed control were estimated. The total is \$901 million for 2009. This can be interpreted as the value of weed control in California agriculture.

Weed control also boosts the returns to other inputs in several ways. Most notably, weed control increases irrigation efficiency and fertilizer efficiency by reducing weed competition with crops for water and nutrients. Weed control also aids in the uniform distribution of water by allowing water to flow evenly through furrows and keeping weeds from interfering with sprinkler irrigation. With hay crops weed control increases quality and price received. These returns are captured by these complementary inputs in cost savings and should not be double counted, however in estimating the value of weed control.

Interestingly, the same crops that utilize hand weeding on a commercial scale for conventional agriculture are the only crops that use hand weeding for organic production. In other words, organic production does not substitute hand weeding for herbicides in crops where the revenue does not warrant such high labor costs. However, for organically produced crops relying on hand weeding, hand weeding is higher than for conventional crops. Most commonly, mechanical control substitutes for herbicide use in organic production (Table 4).

Table 1. CA Farm Income and Expenses – 2009 (\$Billion)

	Income	Expenses
Value of Crop Production	\$27.10	
Value of Livestock Production	7.7	
Revenue from services	2.9	
Government payments	0.6	
Feed and livestock		\$5.70
Purchased inputs - manufactured		4.2
Repairs, custom, marketing, misc.		9.2
Hired labor		6.1
Rent and real estate interest		2
Property taxes and DMV		0.9
Depreciation		1.6
Total	\$38.40	\$29.60
Net Farm Income	\$8.80	

Source: CDFA. California Agricultural Resource Directory 2010 – 2011

Table 2. Weed Control Costs for Selected Crops (\$ per acre)

	Mow	Cultivate	Hand Weed	Herbicide	Total
Tomatoes		34	67	113	215
Alfalfa				44	44
Corn		15		69	84
Broccoli		16	94	51	161
Lettuce		8	80	141	229
Strawberry *			760		760*
Raisins		16		102	118
Almonds	35			153	188
Walnuts	29			47	76

*Weeds controlled with preplant fumigation. Cost not included.

Source: various cost and return studies, www.coststudies.ucdavis.edu

Table 3. Estimated Expenditure on Weed Control in California (Million \$)

	Manufactured Inputs	Labor	Depreciation and Interest	Total
Field crops	5	94	31	170
Nursery	415	34	23	8
Fruits and Nuts	195	205	35	436
Vegetables	61	129	25	216
All Crops	342	464	93	901

Table 4. Weed Control Practices for Organic and Conventional Systems

	Mow	Disc	Hand Weed	Flame	Herbicide
Tomatoes		O C	O C		C
Alfalfa		O			C
Corn		O C			C
Broccoli		O C	O C		C
Lettuce		O C	O C		C
Strawberry *		O	O C		
Raisins	O C	O C			C
Almonds	O C			O	C
Walnuts	O C		O		C

New Herbicides for Small Grains

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Three new herbicides for small grains include Axial (pinoxaden), Express (tribenuron-methyl), and Simplicity[™] (pyroxsulam). Axial is a postemergence graminicide for wheat and barley, controlling weeds such as wild oat, foxtails, Italian ryegrass, barnyardgrass and canarygrass. Express provides postemergence control of broadleaf weeds such as common chickweed, common groundsel, coast fiddleneck, common lambsquarters, London rocket, redroot pigweed and shepherd's-purse. Simplicity provides postemergence grass and broadleaf weed control in wheat, including wild oat, Italian ryegrass, bromes, foxtails, canarygrass (suppression), mustards, pigweeds, common lambsquarters, nettleleaf goosefoot, shepherd's-purse, coast fiddleneck, common chickweed, burning nettle and groundsel. All three herbicides provide acceptable crop safety and excellent crop rotation flexibility.

[™]Simplicity is a trademark of Dow AgroSciences. Simplicity is not presently registered for sale or use in California.

Weed Control Challenges in Desert Areas of Southern California

Tim Hays, Wilbur-Ellis Co.

Lancaster, California

In the beginning, there were weeds. When I began my career in the mid nineteen seventies, there were many surprises awaiting me. The Primary Crop was Alfalfa for hay production. It occupies the most acres of irrigated land. Small grains for hay, sudangrass, onions, carrots, potatoes, stone fruits, pears and apples are also grown here.

Visiting alfalfa producers, I found several items that were troubling. Many growers had difficulty establishing good fields, many older fields had problems with serious perennial weeds. Control of summer and winter annual weeds was erratic. Many fields were being overtaken by dodder. There were weeds that people couldn't identify or control. Several steps would be needed to address these issues. First identify the weeds. Get help if needed, but that is the first step. Second, learn why these weeds are there. Third, come up with a plan to control these weeds if possible, using an integrated, agronomically sound system.

Weed identification was done mostly from academic training and resource books, at that time the Growers Weed Handbook was still coming out. The older Weeds of California was useful. Some local weeds required help from the County Ag commissioners and UC Extension to identify. The most important and common weeds were:

Annual Foxtail Barley, Downy Brome, Rescuegrass, Annual Bluegrass, Schismus Sps., Volunteer grains, London Rocket, Tansy mustard (flixweed), Red-stem filaree, Malva, Shepardspurse, Common Groundsel, Fiddleneck, tumbling mustard, Russian thistle, prickly lettuce, Annual Sowthistle, Thyme-leaved speedwell, Buckhorn Plantain, Dandelion, Lambsquarter, Pigweeds, Crabgrass, Setaria foxtails (millets), Watergrass, Dodder, Bermudagrass, Johnsongrass, and a mixture of strange, exotic and domesticated species.

Common Groundsel was present in abundance in several fields in the Antelope Valley area. Further analysis revealed that these growers had been using Diuron herbicides at low doses for many years. The groundsel thrived in this competition-free environment. Many of these growers were not aware that groundsel was toxic to animals. Some of this hay was sold to feed stores catering to horse owners. Several years later I was called as a weed expert to identify weeds in hay at a feed store. The concern was that about 20 horses had developed severe jaundice and were dying. Poison weeds were suspected. The analysis of the hay showed some marehail but no toxic weeds. The problem was that the damage was done months earlier when these horses had been fed groundsel-infested alfalfa. The symptoms can take months to show up, at which time it

is too late to save the animals. There was no way to track where the hay that really caused the problem came from. This incident became a major incentive to solve this problem. Another grower made “Premium Horse pellets” with groundsel infested hay. In subsequent years, the growers began to use Paraquat and then Velpar, with Diuron. This was a very effective treatment for groundsel. These mixtures are still our primary treatments for winter weeds. The Goundsel case is an example of weed selection by eliminating its competition.

Annual Foxtail Barley was the other major problem occurring virtually every year. Many fields had to have the first cutting sent to the hay grinders to be milled into pellets, at a substantial loss of income to the growers. The introduction of Paraquat and Velpar also greatly aided in control of this weed. Foxtail would germinate early in some years and become well enough established to survive diuron treatment, adding Paraquat or Velpar would control these tough weeds.

Control of the regular winter annuals has been generally good with the existing tools, but we are seeing reduced effectiveness and selection pressure in favor of perennials over time. It has been many years since we have used new materials in this market. Chateau is being used a little in our area, but is very expensive and not as effective as our standard treatments.

Dodder has been a constant problem, although today many people forget how bad it was. The main reasons it was so bad were that most High desert hay was grown in long rotations, patches were allowed to go to seed and there was no effective preemergent control for many years. Growers blamed birds, sheep, their neighbors and a host of other reasons. The real main culprit was cheapskates who bought homegrown seed from their neighbors that was infested with dodder seed. Some farmers tried deep plowing, but this usually was not effective. Burning was the main method used to control attached dodder. This was not fun on a 110 degree desert day. Later, Dow General was used mixed with oil as a contact killer. This was easier than burning, but required repeat treatments and was eventually banned by the EPA. Fail mowing was found to be effective if done all the way to the ground, and is still the best non-chemical treatment. In the early 1980's Treflan herbicide was made as a 10% Granule. This product was very interesting because it offered a way to pre-emergently control grassy weeds like Setaria sps. that were infesting a lot of alfalfa in California. We applied some for grass control and found it also worked quite well on dodder. Steve Orloff got hold of this information and ran with it. He did research on when dodder germinated, when treatments should be applied and what materials were most effective. To this day, that is the gold standard on dodder recommendations. Prowl was shown to be even better than Treflan. Today we apply Prowl H2O at 2 to 4 quarts per acre per year and get excellent results. Results are much better on newly planted fields than older fields with many dead spots. The development of Roundup Ready Alfalfa will also help, as this treatment will control attached dodder. My personal opinion is that we should still control dodder with pre-emergent materials and follow up with Roundup-ready where this is an option. Previous attempts to go with a post emergent only program have not been very successful. The contaminated seed problem continues to this day. Some growers have achieved very good

control for many years, then rotated out of alfalfa, and planted back after 3 years and been badly infested again. When they did tillage, they brought up buried seed that came from the earlier years of heavy infestation. This problem will be with us for a long time.

Many of the weed problems come from less than optimum farming practices. In the earlier days, we stressed cultural practices and the effect they had on weeds. Many people have gotten used to good herbicide results and tried to get by with shortcuts. A thick stand of healthy, well fertilized vigorous Alfalfa is still the best weed control we have. Poor stand establishment was a problem for many growers. Some tried to compensate by increasing seeding rates, but this was not effective, because Alfalfa self-thins to the same population density. Weed competition in newly planted Alfalfa is very harmful to stand life and overall profitability. This has been one of the most difficult aspects of Alfalfa production.

Early practices focused on 2 materials post emergent: 2,4-DB and IPC(chem.-hoe). These were effective but had many problems: timing was critical, irrigation management was very complicated and they could adversely affect the growth of the alfalfa. Balan and Eptam were used as pre-plant treatments, but were poor choices for fall planted hay in our area. Kerb was developed and used for several years as a replacement for IPC. Finally Poast was approved and this was a big step ahead, a safe and selective effective post-emergent material. Poast has declined in use and today Selectmax (or generic forms) dominate this use. Pursuit and Buctril were developed to replace 2,4-DB. They are outstanding on many weeds, especially mustards, malva and filaree. But they miss Prickly lettuce and Sowthistle, so if these weeds are a problem, Buctril or 2,4-DB can be tank mixed. Many growers are using low rates of all 3 together. Raptor is the follow up to Pursuit. It adds grass control and less carryover. Pursuit is still popular because it gives longer residual control than Raptor. Some people are combing low rates of these two products to get broad spectrum and long residual. We also use Selectmax, even with Raptor, to go after seedling Bermudagrass. Often volunteer grain emerges early and in abundance, so we will apply Selectmax early and come back with a second application for the other weeds.

Time of seeding has been a critical issue in the High Desert. The optimum time is late August or early September. If planting is delayed, seedling growth is slowed significantly. 2 weeks can make all the difference. The competitiveness of the Alfalfa is reduced and the danger of severe wind damage is greatly increased. Unfortunately, we have seen many fields literally blow away in the winds of October and November. Spring planting usually is a disaster. Cover cropping is a good insurance measure on sandy soils. Typically, small grains are used for this and controlled by herbicides before they can damage the stand. In some years, we will see low temperatures of 0-10 degrees. Some fields have been winter-killed. Variety selection is also important in this regard. Other important cultural controls used in this area are: Time of cutting management, Good weed control in rotational crops(use 2,4-D when you can), avoidance of nitrogen fertilizers if possible, plowing down manure applications instead of top-dressing and planting clean seed.

Roundup-Ready Alfalfa is being planted on a limited basis. Some growers export hay and they want to avoid it. Many growers feel that their existing practices are working fine and don't like the added expense. The advantages in seedling establishment, spot control of dodder and effectiveness on perennial weeds will make RR more popular in the future. Our experiences so far show us great results on seedling weed control, although follow up treatment will be needed. I believe an approach of using RR Alfalfa and residual Herbicides will be the future direction we need to go in.

It is very important that we retain our older products also. 2,4-DB has come and gone a couple of times. We keep finding uses for it, even though it is 50 years old. The cost of development of new herbicides is ridiculous. The chicken little-activists will keep going after our essential products because their paranoid fear is greater than our ability to explain the truth to them.

Application practices have changed over time. Today many products are applied by chemigation, where approved. Center Pivots have enabled this to be quite effective, although very good management and skill are needed to make it safe and effective. Most products are applied by ground-rigs. Air application has virtually ceased in this area. Weed control results have generally been better by ground. The high winds and low humidity can be very challenging at times. The desert water sources, mostly ground water, can have very high pH and mineral contents. Adjuvant use is essential with many products.

We have made some major steps ahead in the quest for high quality hay in our region. This is a good legacy to pass on to future farmers and those that work with and advise them.

Weed Control Options for Corn Production

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Introduction

In California, 640,000 acres of corn was grown in 2011, two-thirds of it planted for silage. The acreage grown for grain is very price dependent. The majority of the corn was planted in the Central Valley. No single weed control regime is effective for all growing conditions. An integrated weed management program utilizes a combination of cultural, mechanical, and chemical methods for consistent, effective weed control. It also helps prevent the development of weed resistance to herbicides and the emergence of a few dominant weeds. Some of the major weeds include pigweeds, tall and Wrights annual morningglory, common and horse purslane, barnyardgrass, and purple and yellow nutsedge. The major grass weeds include barnyardgrass, sprangletop, Johnsongrass, and volunteer wheat. Purple and yellow nutsedge are controlled using halosulfuron or glyphosate in combination with sweep type cultivators. Accent gives excellent control on Johnsongrass and small barnyardgrass when applied to up to 20 inch tall corn, then after that using drop nozzles to 36 inches.

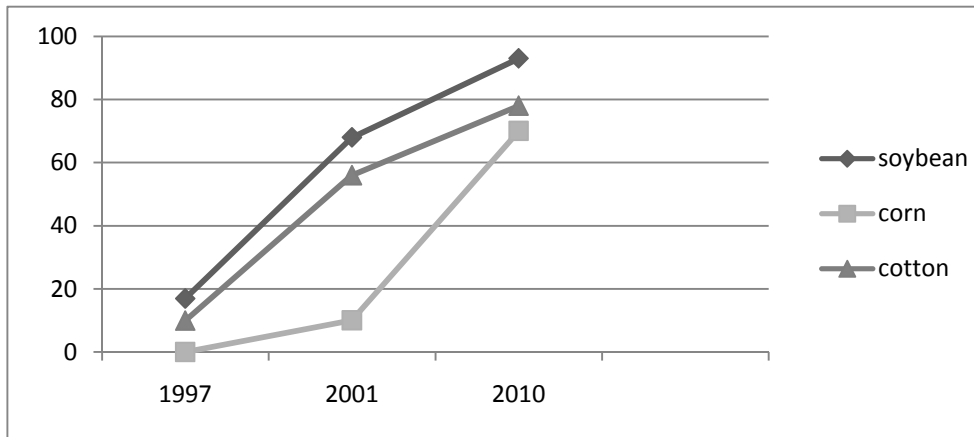
Cultural practices play an important role in corn weed management. In California, a well-managed corn crop is extremely competitive with most weeds. Good cultural practices, including timely cultivations, often control weeds sufficiently to maximize yields and profit.

Growing corn under no-till or reduced tillage may reduce weeds because the soil is not disturbed, thus reducing the number of seeds that germinate. Preirrigation prior to planting and controlling volunteer cereals and emerged weeds will get the crop off to a good start, although this practice delays planting. For weeds that do emerge, postemergent herbicides can be applied. In practice though much of the reduced tillage corn has uncomposted manure spread on the fields, fields are irrigated up, and often a single mode of action (glyphosate) is used, leaving fields very weedy by the end of the growing season.

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

Transgenic Corn. Herbicide-tolerant varieties represent approximately 60% of corn grown in California and provide additional options for weed control. The Roundup Ready technology has provided growers with an excellent tool for managing many annual and perennial grasses. Glyphosate can be applied post emergence so growers can wait and see the weeds present. There are no plant back restrictions nor is it listed as a restricted material like several other corn herbicides. There is substantial fuel savings, as tillage operations are reduced. In Roundup Ready varieties, glyphosate can be applied over the top to corn up to the V8 stage of corn or 24 inches. Drop nozzles are recommended for corn taller than 24 inches. Keep spray out of whorls after corn is 30 inches tall. Rates depend on formulation and weed type and size.

Fig. 1. Percent of soybean, corn and cotton acreage planted with glyphosate resistant crops in the United States



Kassim Al-Khatib

The following herbicides are used in corn:

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

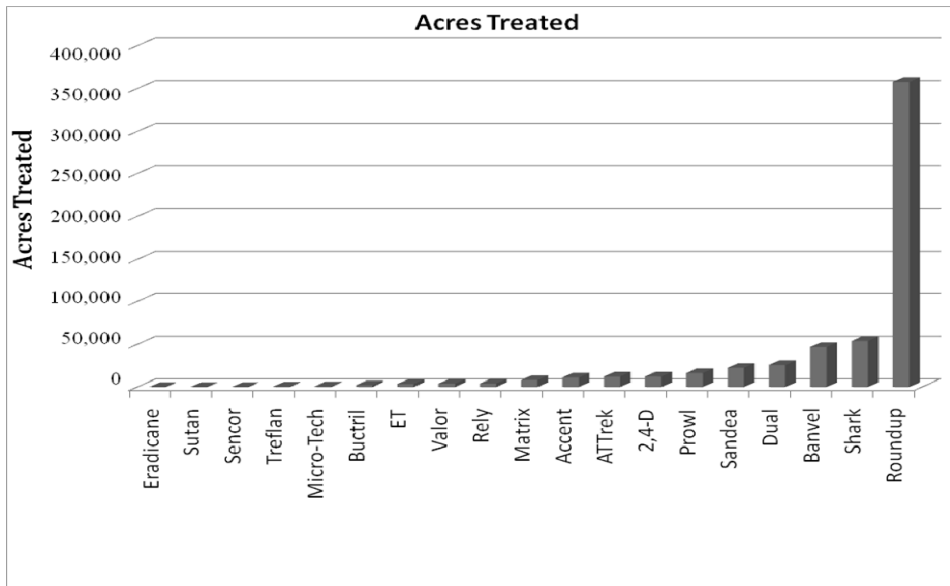
At Planting: Micro-Tech, Aatrex, Atrazine, Dual Magnum, Roundup, Gramoxone Inteon, Eradicane

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

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

An over-the-top application can be used, but some products or tank mixes require a directed spray on corn larger than 8 to 12 inches in height to keep the herbicide out of the whorl and to minimize the risk of corn injury. Postemergent herbicides commonly used in corn include 2,4-D, bromoxynil (Buctril), carfentrazone (Shark), dicamba (Clarity), dicamba/halosulfuron (Yukon), diflufenzopyr (Distinct), halosulfuron (Sandea), metribuzin (Sencor), nicosulfuron (Accent), and foramsulfuron (Option). It is important, however, to pay close attention to application guidelines on the labels to avoid phytotoxicity to the crop, especially with carfentrazone (Shark). Fig. 2 demonstrates the acreage of various herbicides used in California. Even though there are many herbicide options to use in corn, the chart demonstrates the dominance of a one mode of action approach. Research conducted in 2011 with Matrix (rimsulfuron) as a post plant but either preemergent or postemergent to the weed demonstrated excellent weed control. Hopefully this herbicide will be registered and add to the options available for corn growers.

Fig. 2. 2010 Herbicide Usage in California Corn



Summary

Weed management in corn should incorporate resistance management strategies that include crop rotation, herbicide rotation, and control of weed escapes by tillage or hand. In Roundup Ready crop systems in other states, weed shifts and weed resistance occurs. Weed shifts occurred when an herbicide program was used repeatedly, resulting in the survival of only weeds that are tolerant of the herbicide. Weed shifts were associated with reduced tillage systems and not rotating herbicides nor including tillage even when that was the most appropriate weed control tool.

A major concern is the development of resistance to glyphosate (Roundup) in lambsquarter, pigweed species, horseweed, fleabane, and Italian ryegrass in California. Rotating glyphosate-resistant corn with another glyphosate-resistant crop such as cotton or alfalfa will only increase this problem. To help prevent the development of herbicide-resistant weeds and prevent weed shifts from occurring, it is important to incorporate tillage into your weed management practices, as well as alternating herbicides that have a different chemical mode of action. The use of residual herbicides should be considered. Manage field edges as many of these weed seeds can blow into neighboring fields.

References:

Wright, S., D. Munier, M. Canaveri, 2010. Weed Control in Corn. University of California IPM Pest Management Guidelines in Corn Publication.

Wright, Steve, 2010. Integrating Weed Control in Cotton and Corn. California Weed Science Society.

Wright, Steve, R. Vargas. 2008. Integrating Weed Control in Cotton and Corn. California Weed Science Society.

Recent Developments in Alfalfa Weed Control

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Weed control practices in alfalfa are continually evolving to develop more effective weed management systems. Recent developments in alfalfa weed control include the reintroduction of Roundup Ready (RR) alfalfa, research on the control of summer annual broadleaf weeds such as pigweed, and research on the use of Sharpen (saflufenacil) in established alfalfa.

Roundup Ready Alfalfa Survey Responses

The release of Roundup Ready alfalfa has been more contentious and disputed than the other RR crops. After its initial release and the subsequent injunction prohibiting further plantings, RR alfalfa was just released again in February of 2011. Alfalfa growers now have a full production cycle (3-6 years) of experience with the initial plantings and a season or partial season's worth of experience with the new plantings that have occurred in 2011. A survey was conducted in the fall of 2011 to better understand alfalfa-grower attitudes and perceptions regarding RR alfalfa. The full survey responses and background information can be found at: <http://alfalfa.ucdavis.edu/+symposium/proceedings/2011/11-332.pdf>.

Of the 381 people who completed the survey, 113 of them had grown RR alfalfa. The results indicated that a large majority (90%) were either satisfied, very pleased, or felt that the technology far exceeded expectations. Eight responded that they were disappointed, and two extremely disappointed. A majority (71%) said that they would plant it again, while 20% said maybe, and 9% said no. Better weed control, simplicity, and flexibility of weed management were the key advantages cited by respondents. Cost of seed was cited by 80% of all respondents as the major negative. This response was more than four times more popular than any of the other choices which included weed control was not effective, Roundup resistant weeds, don't like the technology use agreement, and varieties don't seem to yield well. The least popular response was difficulties in marketing RR alfalfa, indicating that this has not been a significant problem for those who have grown RR alfalfa.

It appears that alfalfa growers are becoming convinced of the risks of herbicide-resistant weeds. Forty-one percent of respondents indicated a concern for Roundup-resistant weeds as a consequence of the use of the technology, while only 25% indicated that it is not a concern. The rest indicated that they were not sure but that maybe resistant weeds are a concern.

The RR alfalfa system greatly simplifies weed management in alfalfa. Depending on the grower's philosophy toward GE crops, their market, and the weed pressure encountered, the RR system has been shown to have significant benefits for many producers. It has

proved to offer some important environmental benefits for those areas where traditional herbicides are problematic.

Pigweed Control in Established Alfalfa

Summer grasses, such as green and yellow foxtail and barnyardgrass, have been the most troublesome summer annual weeds in alfalfa fields. These weeds are still a major problem but there appears to be an increase in some broadleaf weeds as well, primarily pigweeds (both redroot and Palmer amaranth) and to a lesser degree lambsquarters. Winter dormant soil-residual herbicides generally do not persist long enough to adequately control these weeds. With center pivot irrigation some fields stay wetter between cuttings than they would with wheel-line or flood irrigation, allowing these broadleaf weeds to emerge and get a foothold between cuttings. For the same reason, rain between cuttings also encourages pigweed and lambsquarters infestations. Another major contributing factor is the use of manures. There are weed seeds in the manure and nitrogen in manure encourages weed growth.

A trial was conducted in the High Desert by UC Farm Advisor Andre Biscaro to evaluate pre- and post-emergence control of pigweed in established alfalfa. The most effective pre-emergence treatments were a split application of Prowl H₂O, a tank mix of Prowl and Chateau, and the longest lasting treatment was the herbicide prodiamine (not registered for alfalfa), which provided near perfect control for the entire season (Figure 1).

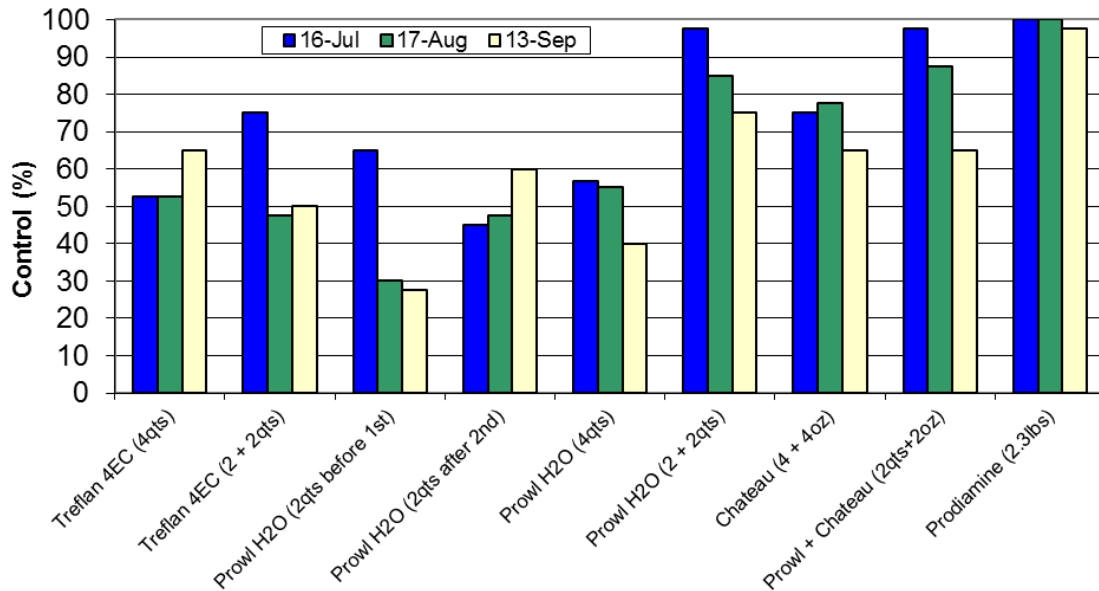


Figure 1. Pre-emergence control of pigweed in established alfalfa in Hinkley, CA. Andre Biscaro. 2010.

None of the post-emergence treatments were highly effective. Pursuit initially provided 80 percent control but as the season progressed, control fell to less than 40 percent. The best control, 90 percent early season and 80 percent mid- and late-season, was achieved with a tank mix of Raptor and Pursuit with each being applied at 3 oz. per acre.

Winter Weed Control in Established Alfalfa

There are few effective post-emergence herbicides to use in established alfalfa for broadleaf weed control. Paraquat (Gramoxone) is the primary herbicide, but oftentimes it does not adequately control some problem weeds, common groundsel being a prime example. Research was conducted by Mick Canevari, Farm Advisor Emeritus in San Joaquin County, to evaluate the use of Sharpen and standard dormant-season herbicides for controlling common groundsel and other problem weeds. Sharpen caused a high degree of initial necrosis and stunting, more than that observed with paraquat. These effects lasted longer than with paraquat or the other winter dormant herbicides, but the alfalfa recovered by harvest time. Sharpen was much more effective than Gramoxone for controlling common groundsel (Figure 2). Combinations of Sharpen with Chateau or Velpar were especially effective providing perfect control at all evaluation dates.

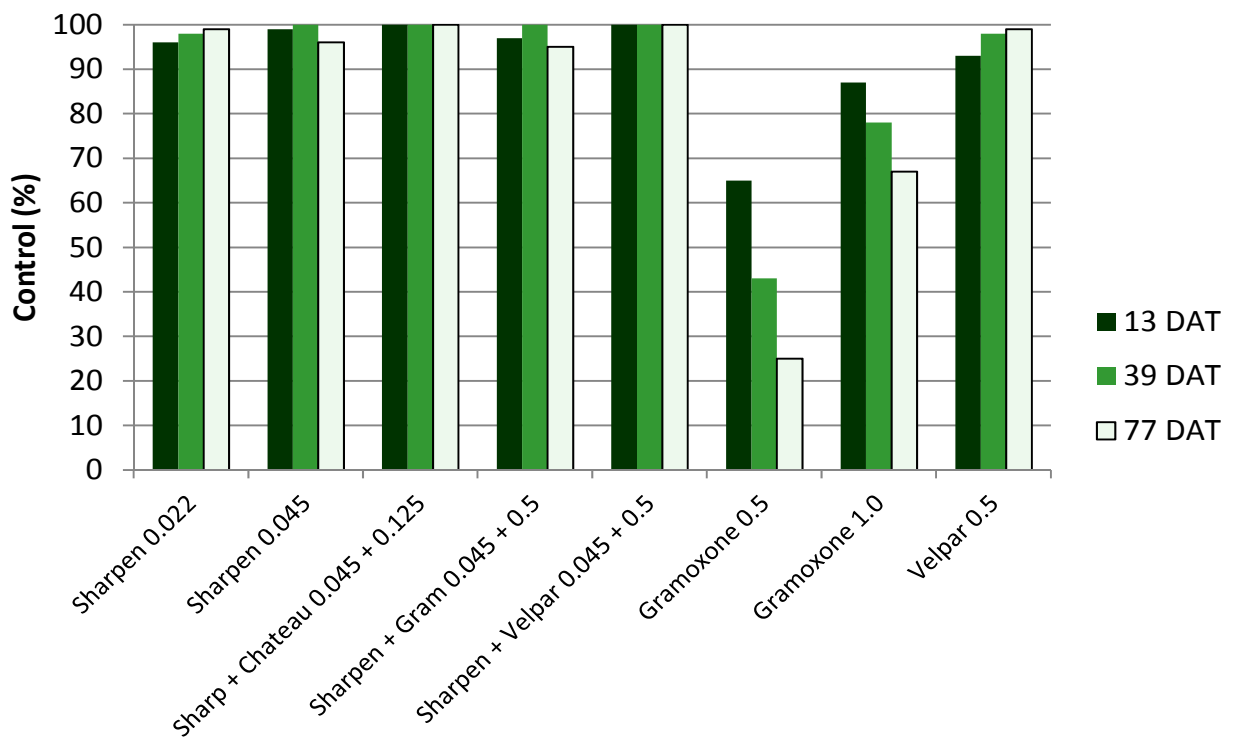


Figure 2. Common groundsel control in alfalfa in established alfalfa. San Joaquin County. Treated on 12/10/2010. Mick Canevari. 2011.

Sharpen was also effective for controlling annual sowthistle and hairy fleabane, however, late emerging plants escaped control. Sharpen alone did not adequately control shepherd's purse. A Sharpen plus Gramoxone tank mix was similar to Sharpen alone for groundsel control, but shepherd's purse control was improved. Sharpen, especially when combined with soil-active herbicides, shows potential for controlling groundsel and other problematic weeds in alfalfa.

Innovations in Cotton Weed Management

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The development of herbicide resistant weeds in southeastern U.S. cotton fields presents serious challenges to cotton producers across the country. The number of herbicide resistant weed populations has steadily increased for over the last 40 years and the number of glyphosate resistant weed populations has increased dramatically since 1996 to 21 resistant weed biotypes in early 2012 (11 grass and 10 dicot species). The current status of herbicide resistant weed populations worldwide can be found at www.weedscience.org. Palmer amaranth (carelessweed, pigweed, *Amaranthus Palmeri*) resistant to glyphosate, the active ingredient in Roundup products, is the most widespread and difficult to manage in cotton due to its fast growth rate and prolific seed production. This weed can increase production costs as much as \$100 to \$200 per acre through increased costs for chemical, hand labor, fuel and equipment.

Common cotton production practices in western states such as tillage, furrow irrigation, in-season cultivation and diverse crop rotation sequences have delayed the development of herbicide resistant weeds in the west. Western farmers have the opportunity to be proactive and adopt management practices that can avoid or delay the development of herbicide resistant weeds. The concept of diversity is the key to managing herbicide resistance in weeds. No-till cotton farmers that used only postemergence glyphosate (e.g., Roundup) sprays for weed control were the first to develop glyphosate resistant Palmer Amaranth populations.

Diversity means using a combination of tactics to reduce the selection pressure imposed by any single weed control practice. Diversity means using mechanical, cultural and biological practices in addition to herbicides. Diversity in herbicide use is achieved by applying several herbicides in a season that have different mechanisms of action but will control the same target weed or weeds. The development of herbicide resistance can be delayed and perhaps avoided by using a few or several of the tactics listed in **Table 1**. One of the best ways for western cotton producers to increase their diversity of herbicide use is to apply preplant-incorporated residual herbicides such as trifluralin or pendimethalin at the beginning of the season. Another is to continue to use tillage; both preseason tillage for field preparation and in-season cultivation for weed control.

Preemergence herbicide experiments conducted in 2004 to 2008 at the University of Arizona Maricopa and Safford Agricultural Centers (MAC and SAC) investigated the early season weed suppression of Palmer Amaranth (AMAPA) and ivyleaf morningglory (IPOHE) resulting from different methods of applying pendimethalin and trifluralin in RR Flex cotton and Liberty Link cotton. The herbicides were simultaneously applied to flat ground (i.e., broadcast)

and incorporated with a field cultivator or were applied with a roto-mulcher following listing (i.e., bed formation). When applying the herbicides with the mulcher, TeeJet XR8001VS or XR8015VS 80 degree flat fan nozzles were mounted to spray a band that was 50% of the row spacing centered on the listed bed and the rate in the sprayed band was double the broadcast rate of the treatments applied with the field cultivator. Thus, after the mulcher incorporated the herbicides and redistributed the soil, the herbicide rates were comparable on a broadcast area basis.

The preplant incorporated (PPI) application of pendimethalin with a field cultivator prior to bed formation provided excellent control of Palmer amaranth (AMAPA) and suppression of ivyleaf morningglory (IPOHE) in terms of both reduced weed density and slower growing weeds. These two effects resulted in a longer early season topical glyphosate or glufosinate application window and improved weed control later in the season. For example at MAC in 2005 at 34 DAP (days after planting), AMAPA plants were 6.8 cm tall with 8.8 leaves per plant and there were 205 plants m^{-2} in the absence of pendimethalin compared to plants that were 2.5 cm tall with 6 leaves per plant with a density of 5.2 plants m^{-2} in the presence of pendimethalin (1.06 kg/ha). Similarly, at 34 DAP, IPOHE plants were 4.8 cm tall with 4 leaves per plant and there were 48 plants m^{-2} in the absence of pendimethalin compared to plants that were 2.0 cm tall with 2 leaves per plant and a density of 13.3 plants m^{-2} in the presence of pendimethalin. The effects of pendimethalin on weed size resulted superior Palmer amaranth control after early season topical herbicide applications and in greater suppression of ivyleaf morningglory after two sequential postemergence herbicide applications (either glyphosate or glufosinate).

In a dry-plant experiment at MAC in 2008, the control treatment not treated with a dinitroaniline herbicide contained 85 and 79 AMAPA and IPOHE plants m^{-2} , respectively, 40 DAP (i.e., after the germinating irrigation). Treatments that had pendimethalin (0.92 kg/ha) or trifluralin (0.7 kg/ha) applied with the field cultivator had 0.2 and 0.2 AMAPA plants m^{-2} and 37 and 18 IPOHE plants m^{-2} at 40 DAP, respectively. Similarly, treatments that had pendimethalin (0.92 kg/ha) or trifluralin (0.7 kg/ha) applied with the roto-mulcher after bed listing had 0.8 and 1.3 AMAPA plants m^{-2} , respectively, and 27 and 35 IPOHE plants m^{-2} at 40 DAP, respectively. The herbicide treatments had significantly fewer weeds compared to the control but the differences in AMAPA and IPOHE densities as a function of herbicide application method (field cultivator versus roto-mulcher) were not significantly different. Thus, in furrow-irrigated cotton production systems, growers can eliminate a preplant pass across cotton fields by combining preemergence herbicide applications with roto-mulching that is necessary as a part of bed formation thereby reducing crop production costs.

Another tactic that can be used to reduce the risk of developing or selecting for herbicide resistant weeds is secondary tillage or in-season cultivation for weed control. Previous precision

tillage research conducted in Arizona cotton in the 1990s prior to development of GPS-RTK systems determined the equipment needed (e.g., articulated electro-hydraulic quick-hitch and wands that sensed location of cotton plants/seed-line) and documented the benefits in terms of improved weed control, faster operating speeds, reduced operator fatigue and reduced costs. However, the system had limitations including that it could not be used until cotton stems could withstand the force applied by the wands (i.e., about 1 foot tall) and that equipment maintenance and training workers proved to be too difficult for most adopters of the system.

The maturation of GPS-RTK tractor auto-steer technology and widespread availability provide growers with an opportunity to increase the use of steel and reduce the reliance on postemergence herbicides. When this technology is used for all field operations (i.e., listing, roto-mulching, bed-shaping and planting) growers have precise knowledge of the location of the cotton seed-line (i.e., the A-B line) and this information can be used to conduct precision in-season tillage for weed control. In small cotton (2 to 4 leaf) a rigid, 3-tool-bar cultivator frame with two disk-stabilizers mounted on the rear bar can be used with the following tools (front to back): disc openers, banana knives (facing away from the crop row and mounted on the front of the middle bar) and Alabama sweeps. The disk openers should cut a shallow slot that the banana knives run in to avoid moving surface soil around the cotton seedlings and damaging their stems. Typically the uncultivated band around the seed line in coarse textured soils is 5 to 6 inches.

Precision tillage and in-row weeding can be conducted with tools such as Bezzerides Spring Hoe weeders or Torsion Bar weeders in bigger cotton with several inches (>3”) of woody bark at the base of the stem (normally cotton > 1 foot tall). A rigid 3-bar cultivator frame with two disk-stabilizers can be used with the following tools (front to back): disk openers, beet knives (mounted on the front of the middle tool bar) with the points facing the crop row and the vertical shank away from the crop row, Bezzerides Torsion Bar Weeders mounted on the back of the middle bar) with Alabama sweeps on the rear bar. A typical gap between the ends of the beet knives is 3 to 4 inches and they should run about 2 inches deep to undercut the roots of weeds. The torsion bar weeders are set to slightly overlap the cotton seed line and run about 1 to 2 inches deep. Fertilizer injection knives can also be mounted on the front of the rear tool bar and a tank and pump system mounted on the cultivator to simultaneously cultivate and side-dress nitrogen fertilizer in one pass through the field. Special clamps may be needed in the latter situation to provide enough room for the tools on the rear bar.

Precision tillage can be combined with the use of postemergence herbicides sprayed in narrow bands to reduce the amount of herbicide used and the consequent selection for herbicide resistant weeds since steel is non-selective. Keys to making precision tillage work are an understanding of the GPS-RTK system and the use of disk stabilizers on the cultivator so that the soil engaging tools do not twist the tractor on its radial tires and cause “cultivator blight”. The 3-

point hitch sway blocks must be used to lock the cultivator into position directly behind the tractor so there is no sideways motion and yet allow the cultivator to be lowered to the appropriate working depth. The beet knives and torsion bar weeders should be running about two inches below the soil surface during operation. Stable depth control is best achieved with gauge wheels.

Additional tactics that can reduce the selection for herbicide resistant weeds is to choose and use herbicides with different mechanisms of action and to use the full labeled dose of herbicide when spraying. (A ***herbicide mechanism of action is the biochemical site within a plant with which a herbicide directly interacts.***) The Weed Science Society of America (WSSA), the EPA and primary herbicide manufacturers have collaborated to develop a mechanism of action group numbering system for herbicides (see the WSSA website; <http://www.wssa.net/Weeds/Resistance/index.htm> and click on the link for “[WSSA Classification of Herbicide Mechanism of Action](#)”). These group numbers are on most major manufacturer labels but not yet on all generic herbicide labels. Using herbicides with different trade names but the same group number is NOT using herbicides with different mechanisms of action and will not reduce the risk of developing herbicide resistant weeds. The development of Liberty Link Cotton which is resistant to glufosinate (Liberty) and GlyTol cotton that has resistance traits for both glyphosate and glufosinate provide growers with an alternative to continuously using glyphosate herbicides in cotton production.

When spraying weeds the full label rate specified on the label should be used. As defined by the Weed Science Society of America the “***full labeled rate***” is the rate or range of rates set by a manufacturer that consistently provides effective control of a weed species across growth stages and site conditions. Using low herbicide rates repeatedly over time can lead to the evolution of a herbicide-resistant weed population by allowing some treated plants to survive, reproduce and disperse seed. As defined by the WSSA, a “***low rate***” is a rate applied below the labeled rate that may provide effective control at an individual location, but will not provide consistent control over a wide range of conditions. Weeds may be exposed to low rates due to: 1) the intended use of low rates, 2) spraying plants larger than those recommended on the label, 3) inadequate spray coverage of weeds because of size, density and/or crop cover, and 4) errors in sprayer calibration, faulty equipment, or mixing errors.

Table 1. Weed management tactics that can delay the development of herbicide resistance.

Tactic	Strategy	Action
Herbicide	Use multiple herbicides with different mechanisms of action	MIX: tank mix herbicides with different mechanisms of action and spray them together. For example, mix prometryn with glyphosate when making post-directed sprays midseason.
		SEQUENCE: use a sequence of herbicides with different mechanisms of action. For example, use a residual “yellow” herbicide (trifluralin or pendimethalin) preplant incorporated followed by postemergence herbicides or use a residual herbicide at layby.
		ACROSS SEASONS: use different herbicide mechanisms of action across seasons. For example, grow Liberty Link Cotton one year followed by Roundup Ready Flex Cotton the next year.
Mechanical	Use steel to kill weeds; steel kills both herbicide susceptible and resistant weeds (<i>clean implements between fields</i>)	PRE-PLANT: use primary tillage to prepare fields for planting and start the season with a clean field.
		IN-CROP CULTIVATION: use steel to kill weeds that may have escaped chemical treatment and maintain a clean furrow.
		IN-ROW WEEDING: when cotton has several inches of bark at the base of the stem, consider using precision guidance and in-row weeding tools such as Bezzersides Spring Hoe Weeders or Torsion Bar Weeders.
		POST-HARVEST: use tillage at the end of the season to kill surviving weeds.
Cultural and Biological	Maximize crop growth and competition against weeds; minimize pollen and seed movement	CROP ROTATION: rotating crops exploits differences in tillage practices, crop competitiveness and herbicide choices for controlling weeds.
		PLANT POPULATION: an optimum crop plant population maximizes competition against weeds.
		ROW SPACING: Narrower rows result in more rapid shading of the furrows; wider rows require longer periods of weed control.
		COVER CROPS: cover crops planted before the primary crop may suppress weed growth through physical presence or release of allelochemicals that affect weed germination and growth.
		SANTITATION: remove weeds growing around field margins or borders to prevent pollen movement between resistant and susceptible plants. Prevent movement of weed seeds and vegetative propagules (e.g., tubers and rhizomes) between fields by cleaning equipment.

California NPDES Aquatic Pesticide Permit Update: What's New?

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Aquatic weed specialists working for drinking water, flood control, restoration and the irrigation community manage algae and a variety of aquatic weeds including submersed, floating, emergent and riparian species. These weeds can create flow restrictions in irrigation canals and flood control structures and pose taste, odor and aesthetic problems in drinking water storage and conveyance facilities. Intentional introduction of pesticides into Waters of the US to control these weeds requires a permit. Details of permit requirements will be presented with examples.

Ditch Bank Weed Control

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Managing vegetation along irrigation ditch banks and roadways can be extremely challenging. If weeds are allowed to grow unchecked, problems arise inside the canal by restricting the flow of water and causing water levels to rise. Weed seeds could easily spread with the water flow to nearby fields and re-germinate.

Vegetation that grows at the waterline inside the canal has been controlled by glyphosate for many years and are now showing resistance to this material.

In recent years this has been an increasing problem because of the lack of registered chemicals that will effectively control these waterline weeds. Fleabane, Marestail and Mexican Sprangletop are weeds that are well known to anyone who manages vegetation for a living.

Management of these weeds truly takes a new approach to your spray program. Products that will effectively control them are difficult to use around irrigation canals. Many of these sites are too close to agricultural crops for safe use, and not registered for use on flowing water structures.

This presentation will discuss the importance of managing vegetation along irrigation canals and the practices involved. Additional topics will include how to develop a good weed control program, management of resistant weeds in hard to control areas, and common products used in vegetation management.

References:

SePro Corporation, *Clearcast product label* www.sepro.com

Target Specialty Products materials list www.target-specialty.com

South American Spongeplant is Invading California

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South American spongeplant (*Limnobium laevigatum*) is a water hyacinth wannabe that may have the potential to be even more persistent and widespread in California than hyacinth itself. Unlike hyacinth, it produces many seeds and very small seedlings, so it moves more easily than hyacinth. The seeds can also lay dormant for at least four years, so it returns quickly after control measures if a seed bank has been established.

In the last several years, South American spongeplant has advanced its establishment in California, especially in the Central Valley.

Spongeplant first appeared in 2003 in a single 5-acre pond in Redding. The plant was easily controlled with diquat, but this initial infestation still requires treatment after six years.

Beginning in 2007, spongeplant began to pop up in well-separated locations in the San Joaquin Valley, centered in the Fresno area including the San Joaquin River. Infestations in any one location are relatively easy to eradicate if they are caught early, but the plant's mobility and ready recovery from seeds present challenges to eradicating it from the state.

This talk will describe the spread of the plant and some of the control efforts.

***EGERIA DENSA* CONTROL IN THE SACRAMENTO-SAN JOAQUIN DELTA**

Terri Ely and Ken Yelle, California Department of Boating and Waterways
Lars Anderson, United States Department of Agriculture – Agricultural Research Service
Scott Shuler and Dave Blodget, SePRO Corporation

The California Department of Boating and Waterways (DBW) has been treating *Egeria densa* throughout the Sacramento-San Joaquin Delta (Delta) since 2001. The herbicide of choice for Egeria control in the Delta is fluridone (Sonar Aquatic Herbicide) based upon numerous environmental impact studies completed to meet Endangered Species Act requirements. Fluridone requires a contact time of six to twelve weeks for control of Egeria making treatment in a riverine delta system challenging. In the early years of the program, mainly small scattered sites were treated and with permit restrictions these treatments did not start until July. In 2006, permit modifications allowed treatment in some areas to begin in April. Treatment effectiveness improved dramatically. In 2007, armed with early start dates the program decided to try large regional type treatments. The area chosen was Franks Tract State Recreation Area in the Central Delta. The treated area was approximately 3000 acres. This was done over two consecutive seasons and was very successful. The Egeria control program has overcome many challenges related to endangered species, flow within the delta, agricultural irrigation intakes and understanding how to apply fluridone to sustain concentrations that will provide control. In the 2011 season we were again in Franks Tract and surrounding sloughs as well as the western portion of Discovery Bay. Preliminary results indicate a successful treatment. The Egeria program is poised for success and further progress once the Federal Permits are renewed this year.

Weed Management Practices in Nurseries

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Weeds are persistent problems in the production of ornamental plants and in the landscapes where these plants are sold. A relatively small number of species account for the most common weeds encountered in nursery culture. For instance, a report on weeds in container nursery stock in the UK cited Hairy bittercress (*Cardamine hirsuta*), Willowherb (*Epilobium sp*), Pearlwort (*Sagina recumbens*), Groundsel (*Senecio vulgaris*), and Chickweed (*Stellaria media*) as among the most common weeds found. This report could just as easily have been written to describe the most common weed problems in California, with the addition of a few local favorites such as Prostrate spurge (*Euphorbia supina*), Common woodsorrel (*Oxalis corniculata*) and Sowthistle (*Sonchus arvensis*). The occurrence of similar weeds in nursery production from widely differing geographies suggests that similar cultural practices play a major role in determining nursery weed survival and proliferation.

Plant growth requirements such as water, fertilizer, light and favorable temperatures are rarely lacking in the nursery environment. Conditions designed to promote rapid ornamental growth are ideal for weeds that tend to germinate, grow and reproduce faster than the crop, which is often more delicate and less competitive than the weeds. Weed competition is constant and transferable to the next crop, the next year and beyond. A nursery manager frustrated by weed problems knows that the weeds he's seeing have been selected by his cultural practices, which are designed to grow perfect plants. For that reason, weed control in nurseries is addressed through a combination of manual and chemical operations throughout the life cycle of the crop.

When it comes to preventing or removing weeds, crop safety is paramount. Hand weeding seems like an easy and obvious solution except that the high cost of repeated hand labor for stubborn weeds like spurge, oxalis and sowthistle may exceed the value of the crop. On the other hand, some weeds such as willowherb are relatively easy to pull due to their height and small root systems, but difficult to control with herbicides. The real challenge may be as simple as getting a crew to do it before the weeds proliferate and scatter new, windblown seed. Prostrate spurge is almost impossible to hand weed effectively due to sheer numbers and an easily breakable stem that leaves viable roots and stem pieces to regenerate in the soil. Most nurseries ultimately rely on hand labor plus selective herbicides, but with great attention to product label support for the intended use. As pesticide salespeople quickly learn, nurserymen may forgive you for lousy weed control, but not for crop injury.

Nurseries who view weed management as an ongoing program tend to get better results than nurseries who manage weeds reactively, after weeds have become established. In field grown roses, for example, preplant herbicides are broadcast over the field, and followed months later by post-emergence, directed sprays after the crop becomes established. Still, lay-by treatments often fail to completely control weeds like twining Morning glory (*Ipomea sp.*) that interfere with harvest. There are few herbicide solutions

for established weeds in nurseries, especially considering that a nursery may grow hundreds of different species and varieties of ornamentals. It may be possible to control weeds in field grown culture with timely applications of non-selective treatments, but in containers, only selective, pre-emergence herbicides can be used safely.

In a container nursery production cycle, there are predictable windows of opportunity when weeds should be addressed. These include 1) during liner propagation, 2) site preparation before setting containers on ground, 3) at potting, 4) approximately one month after potting.

- 1) Liner propagation is the process of establishing rooted cuttings or seedling plants in small pots or flats prior to transplanting to larger containers. Weeds such as bittercress that grow and reseed rapidly in moist shade can be tremendous problems in liner production, with the added consequence of transplanting these weeds or their seeds into the finished containers or field, where the weeds can increase and spread. Step One in a weed management program involves keeping the entire propagation area as clean as possible. Contact herbicides such as Scythe are labeled for use in greenhouses and propagation areas for control of weeds on the ground or under benches, but liner stock itself is usually too immature for herbicides and needs to be handweeded. Soils used in liner propagation should be clean and weed free. The goal should be for zero weeds going to seed in the propagation area, and zero live weeds leaving it.
- 2) Prior to setting out containers that may sit for months or years prior to sale, nurserymen should have a block-by block plan for managing weed competition from resident weeds that have eluded previous control measures, or simply blown in anew from outside the nursery. Airborne weed seed from fleabane (*Conyza bonariensis*) and sowthistle are notorious for re-infesting sites nurserymen thought were clean. These weeds may emerge in containers or on the ground among containers. The ground may be anything from bare soil, to soil covered with gravel, or the nursery may invest in weed mats as a longterm weed prevention measure. Weed mats must be maintained to repair holes and seams and kept clean or weeds will germinate in spilled soil on top of the mats. To prevent weeds growing up between the containers, nurseries often treat the growing area first with broadcast combinations of glyphosate to kill existing weeds plus pre-emergence such as Gallery (isoxaben), Dimension (dithiopyr), or prodiamine (Barricade). This helps get the crop started clean.
- 3) When the liner stock is mature enough, the plants are transplanted to larger containers or established directly in the field. Many nursery ornamentals can be treated safely over-the-top at this point with selective, pre-emergence herbicides, usually in granular form. Granular formulations of herbicides such as Snapshot (trifluralin + isoxaben) or OH2 (oxyfluorfen + pendimethalin) are often considered safer and easier to apply than spray applications of the same active ingredients, but granules are more expensive than sprayables. The usual sequence is to pot the plants up and settle the soil with a good irrigation before treatment. Treatment should be done as soon as possible after potting up

because the weeds won't wait. Delaying a week or two after potting before applying herbicides allows fast-emerging weeds like chickweed and spurge to germinate and become established, and most selective herbicides lack sufficient "reach-back" activity to catch them from behind. Following application, the plants should be watered overhead to remove granules or spray off the foliage, and begin the process of herbicide activation in the soil.

- 4) About a month after the new crop been treated with pre-emergence herbicides, Plan B begins. Plan B is a planned inspection plus hand weeding or cultivation to remove any weeds that have escaped control thus far. This is an important step, and an opportunity not to be missed, as 95% control still means 5% rapidly growing weeds, and you want to deal with them when they're small. Plan B emphasizes that you can't make a treatment and just turn your back on it. In general, herbicides tend to last about half as long in nursery culture as they do in landscapes, due to microbial breakdown aggravated by constant irrigation, fertilization and the use of high organic soil mixes that adsorb herbicides. This means a product label that promises six months control in landscapes may deliver only three months under nursery culture. Nurseries often need 2-4 treatments per year. Treatments should be timed as one season is ending and another is beginning, and weeds should never be allowed to go to seed.

In the end, weed management, like most pest control, is all about sanitation. Weeds may be a sign to some of healthy biodiversity, but they are also alternate hosts for insects, mites, diseases and nematodes. Their physical presence may shade the crop, impede worker access and disrupt air movement in the crop canopy, which creates conducive conditions for other problems. A tolerance for weeds may indicate a tolerance for other, more serious problems, and runs contrary to the quality standards nurseries seek to instill in their workers and project to their customers. Even if the growing area is clean, nurserymen still need to control weeds around the perimeter of the nursery, targeting weeds whose seed might blow in the wind towards the compost pile or growing area.

An old saying warns that "one years seeding means seven years weeding". This is because weeds not only invade but defend niches where the crop is not competitive. Waiting to spray till weeds are mature and have set seed may be satisfying for revenge, but it is not good weed control.



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Course Outline For: Getting the Most Out Of Your Preemergent Herbicide Application

Todd Burkdoll, BASF Tech Services

This presentation will discuss the properties of common pre-emergent herbicides used in landscape and non-crop sites. The importance of proper application timing, herbicide incorporation, rotation management and weed ID will be discussed.

Common preemergent herbicide properties such as mode of action, water solubility, soil adsorption, vapor pressure and factors affecting herbicide persistence will be discussed for various herbicide families.

(45 min.)

BASF Corporation
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Research Triangle Park, NC
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Evaluation of Herbicides for Weed Control Efficacy and Crop Safety in Field Production of Nursery Fruit and Nut Trees

Joi Abit and Brad Hanson, University of California, Davis, Dept of Plant Sciences, Davis, CA 95616, mabit@ucdavis.edu and bhanson@ucdavis.edu

Introduction

Weed control is an ongoing management problem facing nursery growers of field-grown fruit and nut trees. Competition from weeds can decrease crop productivity and interfere with field and harvest operations. Control strategies currently rely on methyl bromide, pre-emergence herbicides, hand labor and multiple tillage operations. Soil fumigation alone often does not provide and maintain a consistently high level of weed control over the entire 1- to 3-year nursery tree-cropping cycle. Some weed species are not well controlled by fumigants due to their biology (impermeable seed coat, dormancy), ecology (airborne invasion, large seed bank), or response to environmental conditions (dry soil). This problem likely will be compounded by use of fumigants other than methyl bromide which is being phased out due to environmental concerns. Hand labor can effectively control weeds within rows of nursery stock 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.

Therefore, weed control chemicals and techniques will likely become an important part of an integrated pest management strategy in nursery crops as methyl bromide is phased out and fuel and labor cost increase. Several herbicides are labeled for use in tree and vine nurseries but during the critical rootstock emergence and early-season growth period, residual herbicide choices are limited by number of registered materials and by crop safety concerns. Some herbicides can injure either perennial crop root growth (stunting or malformations) or above-ground growth (meristem damage, stem malformations, stunting, chlorosis, or death). Because nursery-grown tree and vines that are produced in the ground are dug up and sold, e.g., as bareroot stock, any root or stem damage is unacceptable to the buyers and these plants are not marketable. Several new herbicides have been registered in orchard crops for control of a broad spectrum of weeds; however, these herbicides are not currently labeled for tree nursery production.

The goals of these field trials were to evaluate weed control efficacy of several pre-emergence and post-directed herbicide treatments, evaluate nursery root-stock safety of the herbicide treatments, and determine the effect of treatments on the health, vigor and productivity of the field-grown fruit and nut trees at harvest. Ultimately these experiments will provide growers and researchers information on weed control efficacy and crop safety with these herbicides.

Methodology

Field trials were conducted from 2009 to 2010 and 2010 to 2011 at commercial nurseries with Nemaguard peach (seeded) and Krymsk86 plum/peach hybrid (cuttings) rootstocks. Prior to planting, nursery blocks were fumigated with either methyl bromide or a dual application of Telone II. Each experiment was arranged in a randomized complete block design with four replications and individual herbicide plots were 3 feet by 25 feet containing a single tree row. Several pre-(PRE) and post-emergence (POST) applications of registered and unregistered herbicides were applied (table 1). PRE treatments were applied after seeding the rootstock but before emergence using a CO₂-pressurized backpack sprayer calibrated to deliver 25 to 50 gallons per acre in a 3-foot band. In the POST trials, herbicides were applied using a directed or shielded spray boom as appropriate to minimize crop exposure to the treatment.

Crop injury and weed control were monitored throughout the 14-month growing season. Prior to harvest, established trees were counted and trunk caliper was measured.

Results and Discussion

In 2009 to 2010, low weed populations were observed due to either effective fumigation or handweeding operations in all sites. Control of grasses was effective in all treatments except those treated with isoxaben or the low rate of oxyfluorfen, while broadleaf weed control was generally poor with low rates of pendimethalin and oxyfluorfen and both rates of isoxaben (table 2). All treatments resulted in similar Krymsk86 rootstock trunk diameter and demonstrated excellent safety except the high rate of oxyfluorfen which caused significant visual injury. Overall, the most promising materials from a crop safety and weed control standpoint were thiazopyr, dithiopyr, rimsulfuron, and pendimethalin + oxyfluorfen.

From 2010 to 2011, all PRE treatments except oryzalin and low rates of indazaflam and penoxsulam provided good to excellent control of broadleaf weeds (table 3). Among the herbicide treatments, foramsulam at all rates caused the least injury to Nemaguard peach seedlings (fig. 1). One month after PRE applications, significant stunting and malformation were observed in plots treated with dithiopyr, penoxsulam + oxyfluorfen, and high rates of indaziflam and penoxsulam. Low seedling establishment was observed in plots treated with rimsulfuron and in plots treated with the highest rates of indaziflam and penoxsulam. Due to large variability in tree establishment throughout this field, no differences in final tree trunk measurements were observed.

The study showed that application of PRE and POST herbicides provided good to excellent weed control in tree nurseries and caused little injury to rootstocks planted as cuttings but safety was lower in seeded rootstock. However, considerable work on herbicide rates, timing and method of application are needed before these materials can be safely applied to newly planted rootstock on a more broad scale.

Fig. 1. Seedling establishment and weed control in a plot treated with (A) indaziflam at 0.032 lb. a.i./acre for the lowest rate and (B) foramsulfuron at 0.044 lb. a.i./acre two months after treatment. Herbicide treatment applied: January 8, 2011.



A

B

Table 1. Herbicide products used.

2009-2010		2010-2011	
Common name	Trade name	Common name	Trade name
carfentrazone	Shark	indaziflam	Alion
dithiopyr	Dimension	oryzalin	Surflan
flumioxazin	Chateau	rimsulfuron	Matrix
isoxaben	Gallery T&V	penoxsulam	Tangent
oryzalin	Surflan	oxyfluorfen	Goaltender
oxyfluorfen	Goaltender	penoxsulam + oxyfluorfen	Pindar GT
paraquat	Gramoxone Inteon	dithiopyr	Dimension
pendimethalin	Prowl H ₂ O	foramsulfuron	Option
rimsulfuron	Matrix		
thiazopyr	Visor		

Table 2. Effects of POST directed herbicide applications on Krymsk86 plum/peach cuttings in a tree nursery trial in 2009 – 2010.

Herbicide treatment ^a	Rate	Crop injury ^b	Grass control ^b	Broadleaf control ^b	Trunk diameter ^c
	lbs ai/acre	%			mm
untreated	-	0	0	0	15.3
isoxaben	1.0	5	63	28	17.1
isoxaben	1.3	1	82	71	15.8
dithiopyr	1.0	14	98	96	16.9
dithiopyr	2.0	6	97	97	17.4
pendimethalin	1.0	0	88	62	16.6
pendimethalin	2.0	0	94	84	16.0
oxyfluorfen	0.5	6	71	79	17.0
oxyfluorfen	1.0	28	97	91	18.0
thiazopyr	0.5	0	99	84	16.7
thiazopyr	1.0	8	99	97	16.7
pendimethalin + oxyfluorfen	2.0 + 0.5	0	97	89	16.4
pendimethalin + oxyfluorfen	2.0 + 1.0	15	99	98	18.3
rimsulfuron	0.016	5	99	92	15.4
LSD (0.05)		15	19	24	NS

^a Treatments applied: March 5, 2009

^b Evaluated: May 24, 2009

^c Measured: October 30, 2009

Table 3. Effects of PRE herbicide applications on Nemaguard peach seedlings in a tree nursery trial in 2010 – 2011.

Herbicide treatment ^a	Rate	Broadleaf control ^b	Seedling injury ^b	Established trees ^c	Trunk diameter ^d
	lbs ai/A	no./plot	%	no./10 ft	mm
untreated	-	13	-	17	15
indaziflam	0.032	10	9	15	15
indaziflam	0.065	3	48	13	17
indaziflam	0.085	2	43	14	15
indaziflam	0.17	1	71	4	20
oryzalin	2.0	11	13	18	16
rimsulfuron	0.016	5	53	7	17
penoxsulam	0.015	9	49	12	15
penoxsulam	0.03	3	48	5	16
penoxsulam	0.06	4	74	1	16
oxyfluorfen	0.25	4	20	16	17
penoxsulam + oxyfluorfen	0.03 + 0.25	4	53	10	14
dithiopyr	2.20	3	55	14	14
foramsulfuron	0.022	4	0	18	14
foramsulfuron	0.044	2	0	19	14
foramsulfuron	0.088	1	3	18	15
LSD (0.05)		4	24	5	NS

^a Treatments applied: January 8, 2011

^b Evaluated: April 8, 2011

^c Plot size: 3 feet by 25 feet

^d Measured: October 18, 2011

Potential of Precision Weed Control

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Growers strive to improve crop production and harvest efficiency as well as crop yield and quality. Barriers to achieving these goals include the availability of registered herbicides and the accessibility and cost of labor for weed control. The accessibility and cost of labor is greatly affected by State or Federal immigration policy and the economy; the availability of registered herbicides is affected by the chemical registrants' expected sales revenues (which may be low for specialty crops and may not offset registration costs) and projected liability to the registrant if the crop is injured by the herbicides, as well as environmental issues. Immigration policy, the economy and pesticide registration decisions are factors that are difficult or impossible for growers to control or influence. Fortunately, labor issues and the availability of herbicides are less of a hindrance to weed control when growers adopt new technologies that can increase labor-use efficiency.

The application of computer technology to row crop production has been an active area of research and development, and has made significant progress with respect to weed control. Mechanical weed control machines are becoming available that utilize cameras to detect crop plants on a bed. The camera then sends an image of the bed to a computer, which analyzes the data and records the location of crop plants on each bed. Present technology relies on size differences between the crop and the weeds. Computer-assisted mechanical weed control machines are therefore more effective when used on transplanted crops than direct-seeded because transplanted crops are initially larger than the weeds that emerge after planting. Once crop plants are recognized, the machines use a variety of techniques to remove the weeds from the seed line: swinging, spinning, or opening and closing blades, or other techniques such as flaming and the use of timed chemical sprays. All of these mechanisms are designed to avoid crop plants and remove weeds between the crop plants in the seed line. Currently, there are two notable computer-assisted mechanical weed control machines either on the market or close to being commercialized for row crop production. In the following two examples, we describe these machines and our efforts to evaluate efficacy or provide a demonstration opportunity for growers.

Example 1

In 2009 and 2010 we evaluated a commercially available unit, the Tillet Weeder, which is fabricated in England (Garford Corp, <http://garford.com/>). This computer-assisted mechanical weed machine uses a spinning blade with a notched cut-out on one side. The blade travels in the seed line removing weeds, but when it encounters a crop plant, it spins around it by placing the plant in the notch (fig. 1). We evaluated the efficacy of this machine for weed control, crop safety and impact on hand weeding in trials on leafy green vegetables and tomatoes as compared

to standard cultivation with knives and sweeps, which do not remove weeds from the band that is left around the seed line. In one trial with transplanted radicchio, the Tillet removed 64% of the weeds in the seed line and reduced subsequent hand-weeding time by 3.7 hours per acre (table 1). The mechanical action of the Tillet in this trial did not reduce the stand or the yield of radicchio. In contrast, in direct-seeded lettuce, although the Tillet Weeder reduced weed densities by 69% and hand-thinning times by 24% compared to the standard cultivator, the crop yield in the Tillet cultivator treatments were 11.7% less than the standard cultivator treatments. The Tillet cultivator worked much better in transplanted lettuce, where hand-weeding times were only 10% less than in the standard cultivator treatments, but lettuce yields were not affected by cultivator type (data for lettuce are not shown).

In most of our trials for direct-seeded and transplanted lettuce and tomatoes, the Tillet was able to reduce thinning and hand-weeding costs per acre between 15 and 30% over standard cultivation. However, as previously mentioned, the Tillet also reduced yields in a number of trials, resulting in lower net returns to growers. Some fine-tuning of this technology would be helpful in minimizing yield reductions, which in turn may improve net returns to growers. Comparable savings in thinning and hand-weeding costs observed in these trials may be achieved in field-grown flowers if they are planted in bed configurations that are similar to the plant spacing used in the evaluated vegetable crops (double rows on 40-inch beds with 10 to 12 inches between plants in the seed line). Attention to total yield and net returns must be factored into any decision for use of this technology.

Example 2

In May, 2011 we held a field day demonstrating a second type of technology that is soon to be commercially available which is a prototype of an automated weeder/thinner developed by the University of Arizona and Mule Deer Automation (New Mexico). Instead of using a blade to remove weeds as in the Tillet cultivator example, this machine sprays a chemical in a band application to remove unwanted plants. Various chemicals can be used in this machine such as acid or salt-based fertilizers (e.g., phosphoric acid or ammonium nitrate [see fig. 2]) or herbicides such as paraquat or pelargonic acid (Scythe®); organic herbicides can also be used. A number of growers at the field day expressed interest in testing and buying this machine when it becomes commercially available.

Conclusion

In general, computer-assisted mechanical weed control machines will continue to develop and improve in the coming years. This technology has been shown to be useful to vegetable crops and could be used in field-grown cut flower production as well because many of the production practices (e.g., bed configuration and spacing, plant density per acre) are similar. Computer-assisted mechanical weed control machines can provide an alternative option for weed control that reduces the need and cost for labor, as well as help growers cope with the limited availability and loss of effective herbicides due to regulation constraints and issues.



Fig. 1. The Tillet Weeder is a commercially available mechanical weed control machine that uses computer technology and a spinning blade to remove weeds. Note the disc-shaped cultivation blade with a notched cut-out to allow the blade to spin around transplanted cabbage.

Table 1. Effect of the Tillet Weeder on weed control, hand-weeding time and crop yield in transplanted radicchio in 2009. Weed counts pre- and post- cultivation were made in the seed line only — the standard cultivation does not remove weeds in the seed line.

Treatment	Pre-cultivation weed counts Aug 5	Post-cultivation weed counts Aug 7	% weed control	Hand weeding Aug 7	Hand weeding Aug 14	Total weeding time	Stand count Aug 7	Stand count Oct 7	Yield mean head Oct 7	Yield total weight Oct 7
	Total Weeds	Total Weeds	%	hr/A	hr/A	hr/A	Plant/A	Plant/A	lbs/head	tons/A
Standard	40.3	NA	NA	8.4	6.9	15.3	31,245	29,628	0.84	12.4
Tillet	47.6	16.9	64	5.9	5.7	11.6	30,721	29,119	0.88	12.7
LSD 0.05	NS	NA	NA	0.7	0.8	1.3	NS	NS	NS	NS



Fig. 2. Lettuce thinned and weeded with the University of Arizona/Mule Deer Automation prototype. The unwanted plants were treated with ammonium nitrate (AN20) fertilizer (in dark gray rectangular areas) and will die in a matter of days.

For further information and to see videos clips of some of the implements to the following websites:

- Frank Poulsen Engineering
<http://www.visionweeding.com/Products/Intra%20Row%20Weeding/ROBOVATOR.htm>
- Frato Machine Import (torsion weeders) <http://www.frato.nl/UK/torsiewieder-UK.htm>
- Garford Agricultural Equipment <http://www.garford.com/index.html>
- Kress Company (finger weeders) <http://www.kress-landtechnik.de/>
- Ramsey Highlander <http://www.ramsayhighlander.com/products/spinach-spring/spinach.htm>
- Red Dragon http://www.flameengineering.com/Agricultural_Flamers.html
- University of Arizona (Mark Siemens) <http://extension.arizona.edu/programs/specialty-crops-mechanization>
- University of California, Davis (David Slaughter) <http://bae.engineering.ucdavis.edu/pages/faculty/slaughter.html> and <http://baesil.engineering.ucdavis.edu/BAESIL/AutoWeedControl.html> (videos of the implement)

Steaming and other Management Practices for Pre-Plant Weed Control in Nurseries

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Introduction

Weed seed are the means by which annual weeds reproduce and disperse. The seed buried in the soil is referred to as the seedbank. Most seed in the soil seedbank were produced in the same field or greenhouse. Some of the seed in the seedbank moved there through the actions of wind, water, animals or the activities of man. Annual weeds usually regenerate from seed stored in the soil seedbank. The seedbank reflects the effectiveness of recent weed management practices in the field or greenhouse and will determine future weed infestations. This article will outline some of the factors that influence weed seedbanks and how to use steam to kill weed seeds.

Weed Seedbanks

Harper (1977) viewed the soil seedbank much as a bank account to which deposits and withdrawals can be made (fig. 1). Deposits occur as weed seed enter the seedbank from local production or dispersal. Withdrawals occur by germination, death and consumption by birds or insects. Only a small fraction of the seedbank is capable of germinating at any given time.

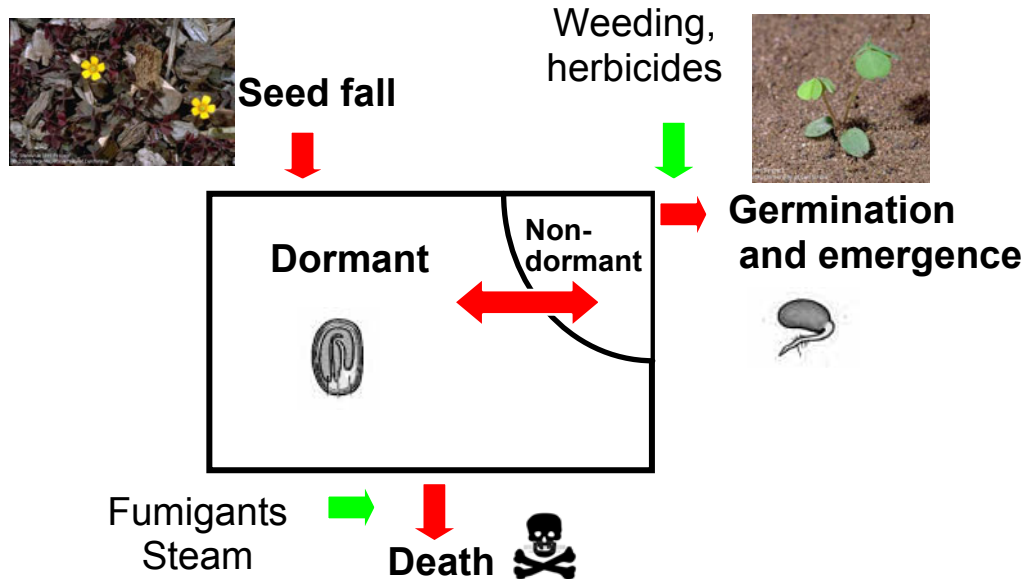


Fig. 1. Flow chart for the dynamics of weed seeds in the soil (Harper 1977).

When we discuss greenhouses we are not talking about “weed seedbanks” as they exist in an agricultural field, but weed seed that are anywhere in the greenhouse — under the bench, in the gravel under pots and in the soil or potting mix. The ecosystem in a greenhouse is much less variable than in an open field, but many of the concepts that weed ecologists have developed to talk about weed seedbanks in the field hold true for greenhouses. Generally seedbanks are composed of a few weed species that make up 70% to 90% of the total. A second group of species comprises 10% to 20% of the seedbank, but is not adapted to the current production system. The final group of seed consists of newly introduced species and seed from previous crops (Wilson 1988).

Soil seedbanks are what we target when we use soil fumigants or steam to disinfest soil. We use steam to eradicate the seedbank in the soil mix. However, after steaming or fumigation, the potting mix can become reinfested with weed seed. Many weed species are well suited for dispersal into greenhouses by wind from uncontrolled weeds surrounding the greenhouse, or by human-aided dispersal such as muddy work boots or tires. If we utilize cultural practices that minimize introduction of weed seed into the greenhouse by using preventative practices such as controlling weeds in and around the greenhouse, we practice preventative weed management rather than reactive weed control. A grower who does not tolerate weed seed set in and around the greenhouse minimizes the risks of higher production costs due to higher handweeding costs. For example a grower with a relatively weed-free greenhouse may have lower production costs due to lower hand-weeding bills.

Additions to the Seedbank

Seed can enter the seedbank by many means, though the largest sources are weeds producing seed within the field (Cavers 1983). Most seed in the seedbanks of farmland came from annual weeds growing on that same land (Hume and Archibold 1986). Just as in open agricultural fields, most weeds that infest greenhouses likely come from seed that were produced in the same greenhouse. Individual weeds can produce large numbers of seed when grown without competition (Table 1). I do not have the data for greenhouse weeds, but the concepts are the same — if weeds are given the chance to set seed they will.

Table 1. Seed production and seed survival (Wilson 1988).

Weed species	No. of seed produced per plant (Stevens 1954, 1957)
Common lambsquarters	72,450
Common purslane	52,300
Common ragweed	3,380
Pennsylvania smartweed	19,300
Prickly lettuce	27,900
Redroot pigweed	117,400
Shepherd’s-purse	38,500
Wild oat	250
Yellow foxtail	6,420

Weed seed can enter a field from external sources such as mud on equipment or shoes, contaminated crop seed, animals, wind, and manure. Many weed seeds have special attachments that allow them to be dispersed by wind, water or animals (Fig. 2). Wind dispersal (Fig. 2 a–d) allows a few seed to move great distances, however, most seed remain close to the mother plant. Windblown seed such as common groundsel can easily blow into the greenhouse from surrounding fields. The introduction and dispersal of noxious weeds is the greatest threat from dispersed seed.

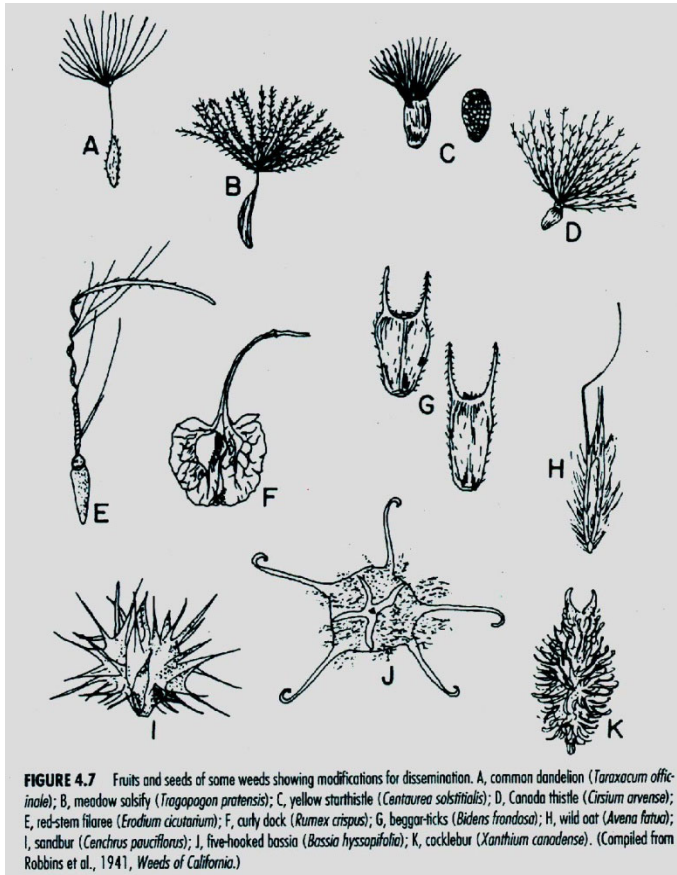


FIGURE 4.7 Fruits and seeds of some weeds showing modifications for dissemination. A, common dandelion (*Taraxacum officinale*); B, meadow safsify (*Tragopogon pratensis*); C, yellow starthistle (*Centaurea solstitialis*); D, Canada thistle (*Cirsium arvense*); E, red-stem filaree (*Erodium cicutarium*); F, curly dock (*Rumex crispus*); G, beggar-ticks (*Bidens frondosa*); H, wild oat (*Avena fatua*); I, sandbur (*Cenchrus pauciflorus*); J, five-hooked bassia (*Bassia hyssopifolia*); K, cocklebur (*Xanthium canadense*). (Compiled from Robbins et al., 1941, *Weeds of California*.)

Fig. 2. Characteristics that aid dispersal of weed seed (Robbins et al. 1941).

Seed Losses

Although seed of many weed species have the potential for long-term survival in the seedbank, most seed have a short life (Murdoch and Ellis 1992). Factors accounting for the loss of weed seed in the soil include germination, decay and predation. The relative importance of each factor varies with species and environmental conditions (Buhler et al. 1997). Fumigation and steam are also means of accelerating the loss of viable seeds in the seedbank (fig. 1).

In a weed management program we are primarily interested in those seed that germinate and seedlings that emerge. Germinated weed seed can result in new plants that may reduce crop yields and require control. Most weed seed in the soil seedbank are dormant with a small fraction of nondormant seed capable of germination at any one time. Several types of dormancy exist and most weeds possess one or more types (fig. 3).

From the moment a seed is shed its dormancy status is one of the key factors that determine when the seed will germinate. Seed dormancy is a means by which a plant species enhances its probability for successful reproduction in a changing environment. Dormancy is relieved by appropriate environmental conditions such as chilling, afterripening, light or scarification.

Embryo dormancy is often reversible and represents a flexible system that allows a weed seed to adapt to its environment. The induction of secondary dormancy is the response of many weeds species to unfavorable environmental conditions. Secondary dormancy and weather conditions are responsible for much of the variation in weed germination from year to year.

Weed Management

Weed seed densities can be greatly reduced by eliminating seed production for a few years; conversely, soils with low seed densities can be quickly reinfested with weed seed if plants are allowed to produce seed. Burnside et al. (1986) found that broadleaf and grass seed density declined 95% after five weed-free years. In the sixth year, herbicide use was discontinued and seedbank density rebounded to within 90% of the original density. Although seed production from most weed species can be reduced by management factors, seed production will likely remain high enough to maintain or increase the seedbank with low to moderate weed infestations. Hartzler found that velvetleaf grown at densities of 2 and 4 plants per 100 square feet and allowed to set seed in year 0 resulted in as many as 1,800 plants per 100 square feet during years one to four, even though no velvetleaf plants were allowed to set seed during that period (Hartzler 1990).

Weeds can survive in a greenhouse either by using seed dormancy or seed dispersal to allow some individuals to escape control and produce seed. Seed dormancy is a characteristic that allows weeds to survive. In a weed species that has seed dormancy, weed seed germinate at a low rate over long periods of time, increasing the chance that a few individuals elude control and reproduce — thus replenishing the seedbank. Another weed survival strategy is dispersal. With the dispersal strategy, some viable seeds find a safe place to reproduce. Management of weeds with seed dormancy requires reducing the seedbank population to low levels, such as with fumigants or steam sterilization, and then maintaining strict weed control measures indefinitely to prevent reestablishment of the weed population. With weeds that have seed that disperse widely, the seed population in the greenhouse seedbank must be reduced and survivors controlled. At the same time the surrounding area must be kept as weed-free as possible to reduce the incidence of new weed seed dispersing into the greenhouse.

Preemergence herbicides kill germinating seeds and therefore act on only a small portion of the soil seedbank. Similarly, postemergence herbicides and tillage can only kill emerged weeds. Therefore, most of our weed control tools do not affect the dormant weed seeds in the soil seedbank. There are some exceptions: soil fumigants and steam can act on the entire seedbank including dormant and nondormant seed (fig. 1).

Steam heating of soil or potting mix uses heat to kill weed seeds. In this process steam is mixed with air and injected into the soil mix to heat it to 180°F for 30 minutes (Baker 1957). Length of time and temperature are critical if weed seeds are to be controlled. The pile must be

covered with a tarp so that the entire pile, including the outer edges, reaches 180°F (Wilén and Elmore 2009; Baker 1957). The moisture of the soil or mix to be steam sterilized is also important — uniform heating of the soil is necessary if we are to kill weed seed throughout the soil mix batch, and moist soil conducts heat more readily than dry soil. Further, weed seed are more easily killed when imbibed with moisture. This includes ungerminated weed seed that are swollen with high water content, which facilitates heat conduction from the seed surface to the embryo, and imbibed weed seed that germinate in the moist soil.

Crop Rotation

Crop rotation is effective for weed management because changing patterns of disturbance diversifies selection pressure. This diversification prevents the proliferation of weed species well suited to the practices associated with a single crop. To better manage weeds one needs to change practices regularly. For example, if you are growing a container plant that requires two years to prepare for the market, this is plenty of time for weeds to become adapted. It is convenient to leave the long-cycle crop in the same greenhouse, but a better strategy is to move a short- and long-cycle crop around so that the production cycle in a greenhouse is varied. Short crops provide frequent dry conditions in the greenhouse between crops that will kill weeds, and the empty greenhouse space between each crop cycle will allow the use of nonselective herbicides to kill weeds.

Conclusions

- Seedbanks are the source of most annual weed species.
- Most seedbanks are dominated by one or two species.
- Most weed seeds in the seedbank were produced in the same greenhouse.
- The greatest threat from weed seed dispersal is the introduction and spread of noxious weed species.
- Seed losses occur from germination, decay and predation.
- Dormancy is a key factor that determines when a seed will germinate and allows weeds to persist in the environment.
- A small number of weeds can produce many seeds and given the opportunity can restore the weed seedbank to high levels in a short time.
- Steam heating of soil or potting mix can kill dormant and nondormant weed seed.
- Crop rotation minimizes the opportunities for one weed species to dominate a field or greenhouse.

Fig. 3. Dormancy Terms

Dormancy: Absence of germination in otherwise viable seed under conditions of light, temperature, water and oxygen that would normally favor germination.

Primary dormancy: Freshly harvested seed that is dormant.

Secondary dormancy: The condition of a formerly nondormant seed that encountered unfavorable conditions such as anoxia or high temperature that induced dormancy.

Coat-imposed dormancy : Seed dormancy is maintained by plant structures that enclose the embryo. Little mallow has this type of dormancy.

Embryo dormancy : Control of seed dormancy lies within the embryo itself.

Afterripening: The release of dormancy under warm-dry conditions.

Chilling (stratification): The release of dormancy in low temperatures (34°F to 50°F) and moist conditions.

Light: Many seed, especially small seed, require light stimulus to relieve dormancy.

Temperature: All species have optimal germination temperatures below and above which the germination rate slows. Temperature controls the rate of dormancy release in a seed population, and temperature can control the rate of secondary dormancy induction.

Water: Required for germination in moderate amounts. Heavy rains or irrigation can create anoxia and induce secondary dormancy.

Source: Bewley and Black, 1994

References

- Alrich RJ, Kremer RJ. 1997. *Principles in Weed Management*. Iowa State University Press, Ames, IA.
- Baker KF. 1957. *The U.C. System for Producing Healthy Container-Grown Plants*. Manual 23. UC ANR Agric. Exp. Sta., Berkeley, CA.
- Bewley JD, Black M. 1994. *Seed: Physiology of Development and Germination* (2nd ed). Plenum Press, New York, NY.
- Buhler DD, Hartzler RG, Forcella F. 1997. Implications of weed seedbank dynamics to weed management. *Weed Sci.* 45:329-336.
- Burnside OC, Moomaw RS, Roeth FW, Wicks GA, Wilson RG. 1986. Weed seed demise in soil in weed-free corn (*Zea mays*) production across Nebraska. *Weed Sci.* 34:248-251.
- Cavers PB. 1983. Seed demography. *Can. J. Botany.* 61:3578-3590.
- Wilén CA, Elmore CL. 2009. UC Pest Management Guidelines: Floriculture and Ornamental Nurseries – Container Nurseries. UC ANR Publication 3392. Available online at www.ipm.ucdavis.edu/PMG/r280701211.html.
- Harper JL. 1977. *Population Biology of Plants*. Academic Press, London, UK.
- Hartzler RG. 1996. Velvetleaf (*Abutilon theophrasti*) population dynamics following a single year's seed rain. *Weed Tech.* 10:581-586.
- Hume L, Archibold OW. 1986. The influence of a weedy habitat on the seedbank of an adjacent cultivated field. *Can. J. Bot.* 64:1879-1883.
- Murdoch AJ, Ellis RH. 1992. Longevity, viability, and dormancy. In: Fenner M (ed.). *Seeds: The Ecology of Regeneration in Plant Communities*. CAB International, Wallingford, UK. p 193-229.
- Robbins WW, Bellue MK, Ball WS. 1941. *Weeds of California*. California State Department of Agriculture, Sacramento, CA.
- Wilson RG. 1988. Biology of weed seed in the soil. In: Altieri MA, Liebman, M (eds). *Weed Management in Agroecosystems: Ecological Approaches*. CRC Press, Boca Raton, FL. p 25-39.

Indaziflam: a New Residual Herbicide for Roadside Weed Control

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Indaziflam (Esplanade 200 SC) is a newly registered herbicide for pre-emergent control of annual grasses and broadleaf weeds in areas such as roadsides, industrial sites and railroads. Indaziflam is a cellulose biosynthesis inhibitor (CBI), and represents a novel mode of action for resistance management and long-term residual activity. Indaziflam provides broad-spectrum control of over 75 weed species, including grasses, broadleaf weeds and annual sedges. Research trials have shown the long-term performance of indaziflam tank mixes on tough broadleaf weeds such as marestail (*Conyza canadensis*), kochia (*Kochia scoparia*), Russian thistle (*Salsola tragus*) and yellow starthistle (*Centaurea solstitialis*), as well as annual grasses such as annual bromes (*Bromus* spp.), wild barleys (*Hordeum* spp.), medusahead (*Taeniatherum caput-medusae*) and sprangletop (*Leptochloa* spp.).

Maximizing the Efficiency of Hand Weed Spraying

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Applying herbicides with hand-held equipment, such as a backpack sprayer or a hose-end sprayer, is a common vegetation management practice in non-crop sites. But how accurate or efficient is the use of these types of equipment? Especially when most applications are based upon a percent concentration of herbicide rather than trying to use a specific rate of herbicide? We wanted to find out, so we conducted four herbicide sprayer calibration schools, with about 20 experienced applicators in each school in 2009/10. The schools were designed to train the participants on a simple calibration method, but also to investigate their application skills. The answers we obtained indicated the actual practice is not too good. The mean value for gallons per acre (GPA) for the spray school students over the four schools varied greatly between the types of equipment (see Table below). The last column in the table is the actual amount of glyphosate applied per acre if the concentration of the herbicide in the tank was 1% of the total spray mix, a commonly used concentration. The 1% concentration in the glyphosate label (Roundup Pro in this case) is meant to be roughly equivalent to 0.5 gallons per acre of herbicide product. On average the backpack spray was a little below this target rate while the orchard gun was nearly three times higher. The spot spray, which we calculated as the amount applied to treated plants, not the whole area, was more than 12 times the target rate. In all cases, the variation between students is large; more so with the orchard gun than with the backpack sprayer and off the charts when spot spraying.

So, what does all this mean and what can be done to improve efficiency? In the first place, applying the wrong amount of herbicide is a bad idea. Apply too little and it won't work, which usually means another trip to get the job done right. Too much and you waste product, time, haul more water than you need to the site, and increase the chances of environmental contamination or off-site movement. The two key factors that can eliminate this inefficiency are learning to apply herbicides according to a rate rather than a concentration and to calibrate the sprayer (which means the equipment and the applicator) before applying herbicide. We used the 128th acre calibration method in our training with our spray school students. It is a simple, no math method that is easy to use. Go to http://ucanr.org/sites/socalinvasives/Research_Papers/Brochures/ for a worksheet for the method.

Table. Gallons per acre (GPA) data from herbicide sprayer calibration training; mean of 80 students.

Sprayer type	Mean GPA	GPA Range	1% glyphosate Gallons/acre
Backpack	41	10-100	0.41
Orchard Gun	127	24-352	1.3
Spot Spray	628	80-1560	6.3

Controlling Annual Bluegrass in Bentgrass Putting Greens

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Annual bluegrass (*Poa annua* L.) is a ubiquitous turfgrass species throughout the world, and especially in coastal climates in California. Although perennial biotypes can provide superior playing surfaces on golf courses, *Poa annua* remains more susceptible to biotic and abiotic stresses than species like creeping bentgrass (*Agrostis stolonifera* L.). Along coastal northern California, annual bluegrass is particularly susceptible to damage caused by *Anguina* nematodes on putting greens, which is causing an increasing number of golf courses to rebuild and re-grass with creeping bentgrass. Thereafter lies the challenge of maintaining *Poa*-free bentgrass turf in an environment that is highly conducive for *Poa* growth and re-infestation.

Selective *Poa* control in putting greens is particularly challenging given the added stresses of low mowing heights and concentrated, intensive traffic. As a result, most chemicals that provide both effective and selective control in taller cut turf can cause objectionable and often serious bentgrass injury on greens and thus are not labeled for use.

Methiozolin (experimental name: MRC-01) is a new herbicide under development in the U.S. by Moghu Research Center, South Korea. It provides selective control of primarily *Poa annua* and some other grassy weeds in nearly all other major cool- and warm-season turfgrass species, regardless of height of cut. On putting greens, methiozolin is particularly effective because of its selectivity and slow activity that allows bentgrass to fill in voids left by *Poa annua*. Methiozolin is an isoxazolinone compound, a new family of herbicide chemistry for turf. It is primarily root-absorbed and provides both pre- and post-emergence activity by disruption of cell wall biosynthesis. Methiozolin is currently registered in South Korea and Japan. It is considered a “Reduced Risk Category” pesticide and plans are underway for registration in the U.S. in the near future. The University of California, Riverside has been studying methiozolin extensively since 2010. On putting greens, excellent (90-100%) control has been achieved with four or more sequential applications of 0.5 to 1.0 lb ai/A applied on 3- to 4-week intervals. Applications made more frequently or when average daytime temperatures exceed 85F on a regular basis should be avoided to ensure bentgrass safety. Methiozolin appears to be more efficacious when applied in late fall vs. spring. There appears to be no synergistic or additive effects when methiozolin is tank-mixed with paclobutrazol, FeSO₄, or other herbicides. Colonial and velvet bentgrasses appear to be more sensitive to methiozolin than creeping bentgrass. Ongoing studies are looking more closely into methiozolin tolerance among bentgrass species and cultivars, as well as developing integrated *Poa* management programs using methiozolin.

**Field Research Results to Support Successful
Poa annua Control Strategies in Cool Season Grasses**

**Prepared for the 2012 CWSS Conference
Santa Barbara, CA**

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Introduction

Annual bluegrass (*Poa annua* or *Poa*) is a cool season grass native to Europe. This highly invasive species continues to be the number one grassy weed problem in cool season turfgrasses.

Annual bluegrass falls within two broad taxonomic classifications. Annual biotypes of *Poa annua* referred to as *Poa annua var annua* exhibit true annual seasonal growth response, light green color, broad leaf texture, shallow rooting and prolific seed production. Perennial biotypes of *Poa annua* referred to as *Poa annua var reptans* exhibit a perennial growth response, darker green color, limited seed head production, finer texture and a more stoloniferous growth habit.

The objectives of this presentation are to present the answers to the following three key questions:

1. When does annual bluegrass germinate in California?
2. Which preemergent herbicides exhibit the most effective *Poa annua* control?
3. Which postemergent herbicides exhibit the most effective *Poa annua* control?

The *Poa annua* control information presented is based on the results of 12 replicated field trials conducted from 1997 to 2010 throughout California by Mark M. Mahady & Associates, Inc.

Question #1: When does annual bluegrass germinate in California?

The following replicated preemergent field research trials conducted in Southern and Northern California described the interaction between application timing and preemergent performance for *Poa annua* control.

Southern California

Location #1: Desert Dunes Golf Club, Desert Hot Springs, CA, 1997: OVS Bermuda

	3/30/98 <u>% Poa Control</u>
Barricade 0.75 lb ai/A applied 6WBOVS on 8/20/97	86.8%
Barricade 0.75 lb ai/A applied 6WAOVS on 11/12/97	19.6%

- Take Home Message: 80% Poa germination by 11/12/97
- High level of control with August application
- Very poor and unacceptable control with the November application
- November is too late to apply a preemergent for acceptable Poa control

Location #2: Springs Golf Club, Desert Hot Springs, CA, 1997: OVS Bermuda

	3/30/98 <u>% Poa Control</u>
Barricade 0.75 lb ai/A applied 6WBOVS on 8/20/97	86.9%
Barricade 0.75 lb ai/A applied 4WAOVS on 11/13/97	40.7%

- Take Home Message: 60% Poa germination by 11/13/97
- High level of control with August application
- Very poor and unacceptable control with the November application
- November is too late to apply a preemergent for acceptable Poa control

Northern California

Location #3: Carmel Valley, CA, 2002: Non-OVS Bermuda

	5/17/03 <u>% Poa Control</u>
Barricade 0.75 lb + 0.38 lb ai/A applied on 8/27 & 11/14/02	93.0%
Dimension 0.5 lb + 0.25 lb ai/A applied on 8/27 & 11/14/02	94.0%

- Take Home Message: 7.0% Poa germination by 8/27/02
- High level of control with August application

Location #4: Ruby Hill Golf Club, Pleasanton, CA, 2004: Non-OVS Bermuda

	5/17/05 <u>% Poa Control</u>
Barricade 1.0 lb ai/A applied on 9/17/04	43.2%
Barricade 1.0 lb ai/A applied on 10/15/04	22.2%

- Take Home Message: both mid-September and mid-October Barricade applications are too late for effective preemergent control of *Poa* in Northern California.
- Mid-August application timing is most effective for preemergent control of *Poa* in both Northern California and the low desert region of Palm Springs.

Question #2: Which preemergent herbicides exhibit the most effective *Poa annua* control?

Barricade (prodiamine: Syngenta) and Dimension (dithiopyr: Dow AgroSciences) are highly effective preemergent herbicides for control of *Poa annua* in cool season grasses when deployed in a timely manner (August 15 to August 20).

Sequential applications of Barricade 0.75 lb + 0.38 lb ai/A applied on 8/27 and 11/14/02 resulted in 93.0% *Poa annua* control in Northern California. Sequential applications of Dimension 0.5 lb + 0.25 lb ai/A applied on 8/27 and 11/14/02 resulted in 94.0% *Poa annua* control in Northern California.

When comparing properly timed single versus sequential treatment programs, results from replicated field trials in the Palm Springs golf market indicate that the first application is the most critical for highly effective *Poa annua* control. Based on field data there is not a dynamic or statistically significant increase in percent *Poa annua* control when a sequential treatment is deployed. The key factor is a properly timed initial application.

Question #3: Which postemergent herbicides exhibit the most effective *Poa annua* control?

Ethofumesate (Prograss 1.5 EC and PoaConstrictor 4SC) is an active ingredient that has been used successfully for postemergent control of *Poa annua* in solid stand perennial ryegrass fairways and perennial ryegrass overseeded bermudagrass fairways for many years. Perennial ryegrass is very tolerant to ethofumesate applications.

Previous field research conducted by Mark M. Mahady & Associates, Inc. in Northern California showed that three sequential treatments of Prograss 1.5 EC applied at a rate of 1.95 pounds active ingredient per acre (lb ai/A) at 21-day intervals beginning approximately October 1, resulted in very high control levels (90%-94%) of perennial biotypes of *Poa annua* in solid stand perennial ryegrass fairways.

Previous field research conducted by Mark M. Mahady & Associates, Inc. in the Palm Springs, California perennial ryegrass overseeding market, showed that two sequential treatments of Prograss 1.5 EC applied at a rate of 1.125 lb ai/A at 21-day intervals beginning approximately December 7, resulted in very high control levels (90%-95%) of annual biotypes of *Poa annua* control in perennial ryegrass overseeded bermudagrass fairways.

Presently, Trimmit 2SC (paclobutrazol: Syngenta) is the industry standard for suppression of *Poa annua* in creeping bentgrass fairways. With multiple applications, Trimmit 2SC (10-14 oz/A), a plant growth regulator, selectively suppresses the growth of *Poa annua*. *Poa annua* plants treated with paclobutrazol are more diminutive and less competitive. This plant growth regulation effect changes the competitive balance between *Poa annua* and creeping bentgrass allowing the more vigorously growing creeping bentgrass to grow over and into the highly regulated *Poa annua*.

Velocity (bispyribac-sodium: Valent) inhibits ALS enzyme development, provides foliar activity and no soil activity. Velocity is rain fast in 6 hours, exhibits yellowing on *Poa annua* in 3-7 days with maximum effect 21-28 days after treatment. Apply Velocity during spring/summer with air temperatures between 65 and 80° F. Velocity is not registered for use on greens. Field research conducted by Mark M. Mahady & Associates, Inc. on creeping bentgrass fairways in Northern California showed the following:

- Velocity: 20 g ai/A (2x): a 60.4% reduction in percent Poa cover 112 DAA2.
- Velocity 10 g ai/A + Trimmit 10 oz/A (2x): a 66.7% reduction in percent Poa cover 112 DAA2.
- Velocity 15 g ai/A + Trimmit 10 oz/A (5x): a 77.0% reduction in percent Poa cover 21 DAA5.

Summary and Practical Perspectives

For the best *Poa annua* management program results in cool season grasses utilize a two-prong preemergent and postemergent control program. For control of *Poa annua* in solid stand perennial ryegrass:

- Preemergent: apply Barricade 4F 0.6 lb ai/A on 8/15-8/20 followed by a sequential Barricade treatment at 0.3 lb ai/A 8 weeks later.
- Postemergent (late summer): apply three sequential treatments of Prograss 1.5 EC at 1.3 gal/A at 21-day intervals beginning approximately 10/1.
- If overseeding in late summer, it is important to know that Prograss does not affect perennial ryegrass germination or percent cover.
- Do not hollow-tine or open up the canopy after 8/15. Solid tining is acceptable.
- Consider two spring applications Prograss (March) or 2-3 applications of Trimmit 2SC (8-10 oz/A) at monthly intervals.

For control of *Poa annua* in creeping bentgrass fairways:

- Preemergent: apply Barricade 4F 0.5 lb ai/A on 8/15-8/20. Do not make a sequential treatment in the fall or spring.
- Postemergent: during spring/summer (air temperatures between 65 and 80 degrees F) apply 3-5 sequential applications of Velocity 10 g ai/A + Trimmit 10 oz/A at 21-day intervals. During the late summer/fall season apply monthly treatments of Trimmit 12-14 oz/A at 21-day intervals.
- Do not hollow-tine or open up the canopy after 8/15. Solid tining is acceptable.

Be open minded, but always question performance claims when considering the use of new products and/or new agronomic strategies. Always test new products and programs on a small scale before moving to larger acreage.

* * *

Pre-emergent *Poa annua* Control in Non-overseeded Bermudagrass

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Poa annua is an endemic weed in US golf turf and is a significant weed problem for non-overseeded Bermudagrass. Control measures are simplified if climatic conditions provide dormant Bermudagrass each winter as low cost post-emergent options can be employed. However, complete dormancy is not predictable in most California locations and pre-emergent herbicides are an especially critical tool. Several pre-emergence herbicide options are available but timing is critical for optimum performance.

Due to the climatic and micro-climatic differences between and within golf courses in California proper timing in relation to fall *Poa annua* germination is more complicated than in other parts of the US. A compilation of research trial results from the Southeast indicates application in August or September is effective. However, trials in CA have shown that September can be too late for some sites some years. A review of conditions that trigger germination may help provide guidelines for specific sites and various fall conditions. Bruce Branham showed that germination primarily occurs when soil temperatures (0-2 inch) are between 60 and 72 degrees F. Ron Calhoun indicated that peak germination was 68-72 degrees at 0-2 inch soil depth and is minimal below 58 degrees and above 78 degrees F.

If one considers that fall germination can begin at the end of summer as soil temperatures at 0-1 inch drop below 78 degrees F (and near optimum at 72 degrees) then mid to late August timing for a pre-emergence herbicide makes sense for many locations in southern CA and mid-September can be too late. A recent entry into the market, Indaziflam (Specticle 20 WSP), simplifies timing as it provides effective pre-emergence control plus post-emergence control of *Poa annua* seedlings. Indaziflam allows for a broader window of application for *Poa annua* control as compared to other pre-emergent herbicides registered in California. Research indicates that indaziflam application in September through early October is effective for *Poa annua* control in California.

Turf and Landscape Weed Control, Towards Integrated Weed Management

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Management of weeds in turfgrasses and landscapes has evolved over the last 100 years. Grazing pastures were gradually converted to more meticulously manicured aesthetic areas and gardens were built to approximate natural landscapes to beautify homes and public areas. Along with this evolution have come changes in the tools and practices used for weed control. This presentation explores some of these changes and the impact on current and future practitioners of weed control. The widespread use of herbicides for weed control didn't become commonplace until the late 1950s and 1960s. Initial herbicides were very harsh materials and very difficult to handle and use. Gradually more user-friendly materials were developed in the 1970s and 80s. By this time turf and landscape weed managers began relying heavily on these products for selective control of grass and broadleaf weeds. But societal changes have also caused more close scrutiny of the products being used. Past evaluation focused on the efficacy of potential herbicides but more and more attention was focused on non weed control properties such as non-target effects, persistence and impact on the environment. The weed manager today must not only produce healthy, weed free turf and landscape but also be concerned with how they produce these results. This presentation focuses on several topics that should be considered when planning a weed management program. Three examples are given to spur the audience to think about some of these areas in addition to simple control of weeds. Substituting a new reduced risk low rate herbicide for a former multiple active ingredient standard delivers excellent weed control with more than a 200 fold reduction in pounds of pesticide used per acre. In the second example, understanding the biology of the pest and expanding uses of a current pre-emergent herbicide into postemergent control allows replacement of a phased out herbicide and could possibly provide control of a second major weed pest with a single herbicide application. In the final example, by adding a residual herbicide to a standard contact herbicide programs for weed control in landscape areas, fewer applications are required and risk of weed resistance is reduced. By knowing the biology of pest weeds and the properties of available control tactics, weed manager have the best chance of succeeding in managing weeds and providing these results in the context of ever more stringent oversight and regulations.

Weed Control at Turf Establishment with Tenacity® Herbicide.

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Successful renovations of turfgrass stands require a weed management plan. Existing weeds can be controlled prior to renovation with a non-selective herbicide, but once the turfgrass species is seeded, water and fertilizer will also encourage weed seeds in the soil to germinate. Unless weeds are controlled, the end result of the renovation will be weed contamination of the desired turf grass species. Key reasons to control weeds at seeding or establishment include:

- Less competition from weeds, faster turf establishment
- Weed (seed) bank in the soil can be significant in a perennial stand like turfgrasses
- Not all seeding can be done in the fall, when competition from annual grasses is minimal
- Turf (like weeds) can be more sensitive to herbicides at the seedling stage, limiting post-emergence weed control

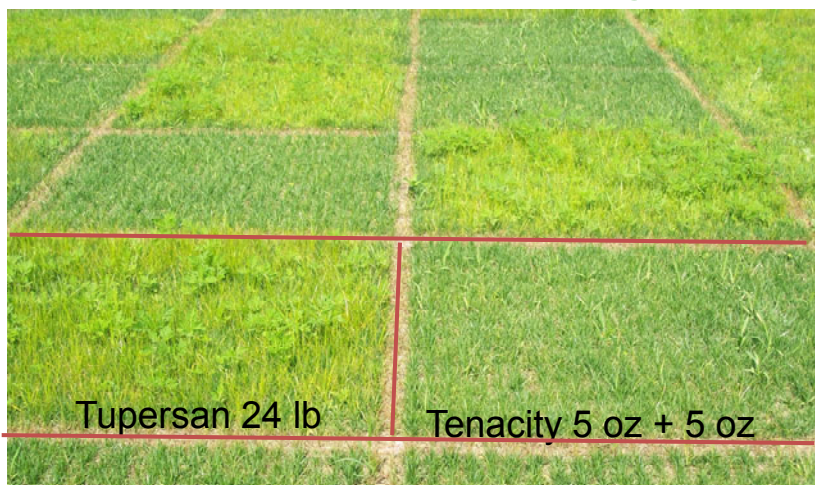
There are very few herbicides that can be safely applied prior to or at seeding of most turfgrass species. Siduron, a substituted urea herbicide, is labeled for use on cool-season species to control annual grasses such as crabgrass, foxtail and barnyardgrass. Rate of application is 6 lbs ai/A at seeding. Siduron, trade name Tupersan®, will not control dicots weeds or *Poa annua* which can be an issue depending on weed pressure. Quinclorac, trade name Drive®, can be applied at seeding of tall fescue, bermudagrass and perennial ryegrass while other turf species are limited to a 28-day post emergence restriction. It is a synthetic auxin herbicide with use rate at seeding of 0.75 lbs ae/A for control of crabgrass, foxtail, barnyardgrass and several dicot weed species.

Mesotrione herbicide was discovered when a Syngenta scientist in Mountain View, CA observed fewer weeds growing under his callistemon shrub than could be explained by shading. The allelochemical isolated from the callistemon plant was the first precursor to what eventually became mesotrione herbicide, trade name Tenacity® in turf. (**Tenacity in not currently registered in CA**). Mesotrione is a HPPD inhibitor (p-Hydroxyphenylpyruvate dioxygenase), which interferes with plastoquinone synthesis, and ultimately carotenoid production. Without carotenoids, light energy breaks down chlorophyll and generates excess energy within the cells. These result in the new growth turning white and susceptible weeds eventually die. Tenacity can

be applied at seeding of several cool-season turf species for control of annual grasses such as crabgrass and foxtail plus many dicots weeds at 0.156 lbs ai/A. It is also labeled for control of yellow nutsedge and suppression of *Poa annua*. The weed control spectrum of Tenacity makes it a valuable tool to manage weeds at turf establishment.

Attached is a picture of a tall fescue seeding trial comparing Tenacity to Tupersan. Both herbicides exhibited excellent safety, however control of ragweed and yellow nutsedge was only observed in the Tenacity treatments.

Tenacity – New Option for weed control at Seeding



syngenta

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Drive® is a trademark of BASF Corp.

Effects of Spray Coverage and Nozzle Selection on Weed Control

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Herbicides play an important role in weed control efforts in California orchards and vineyards. Effective weed control with herbicides is influenced by many factors, but hinges on one's ability to apply sprays accurately, uniformly, and efficiently. Spraying with minimal drift and adequate coverage are important factors that influence herbicide performance. Spray droplet size influences both spray drift potential and spray coverage. Spray droplets <200 microns in diameter are light, remain airborne a long time, and are the most prone to drift. To help avoid spray drift, weed sprays should be applied using spray droplets larger than 225 microns (at least medium-sized). As a general rule, nozzles, tip sizes, and operating pressures should be selected to produce large enough spray droplets that reduce the risk of drift, while giving adequate coverage for the herbicide type (contact, systemic, or preemergent) used. Selecting a larger tip size to produce more volume per acre, may or may not be an effective way of mitigating reduced coverage where large spray droplets are used.

Recently, new spray nozzle designs have been introduced to help reduce drift potential by producing larger spray droplets. These new nozzle designs include extended range (XR), chamber (also referred to as "turbo"), venturi I (air assisted), and venturi II (combination of chamber and venturi I). However, little is known how these new spray nozzle designs affect spray coverage and weed control under field conditions. Several trials were conducted from 2008 - 2011 to evaluate drift-reducing spray nozzles and their effects on spray coverage and weed control when contact-type postemergent herbicides were used. Trials were conducted in a variety of settings, including orchards, vineyards, and open ground. Drift-reducing nozzles were compared to standard flat fan nozzles. Flat fan nozzles produced medium-sized spray droplets, while the drift-reducing nozzles produced droplet sizes from coarse to extremely coarse.

Although the number of spray droplets per in² and percent cover on water-sensitive paper increased with an increase in a spray volume of 20 to 40 gpa, it did not necessarily result in significantly better weed control. Turbo and Turbo TwinJet nozzles provided similar weed control to XRs or flat fans. Air induction nozzles gave the least amount of spray coverage and weed control. Although these nozzles gave comparable weed control to the other spray nozzle designs initially, overall control was reduced 10 to 20% later as weed regrowth occurred. A spray volume of at least 50 gpa was needed to help compensate for the larger size in droplets produced by air induction-type nozzles. It appears that drift-reducing nozzles can play an important role in postemergent weed control efforts, even where contact-type herbicides are used.

Benefits and Drawbacks of In-Row Cover Crops in Vineyards

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Cover crops in vineyards in the Monterey County low rainfall production district are typically grown in a narrow band in the row middles. The berms under the row vines are typically kept free of vegetation by a combination of herbicides and mechanical cultivation. Cover crops are an important component of a comprehensive vineyard floor management system. They provide multiple benefits to the soil plant system by increasing levels of soil organic matter, nutrient cycling and water infiltration. Cover crops can also reduce levels of nutrient and sediment loss during winter storms. In a five-year study conducted in Monterey County from 2001-2005 we observed significant improvements in soil health parameters in the row middles where the cover crops are grown. There were increased levels of soil organic matter and microbial activity where the cover crops are grown, but few of these benefits occurred under the adjacent vine row (Smith et al, 2008). In addition, we observed that the majority of the roots occurred under the vine row where the drip emitters were located (root systems are probably limited due to our dry climate). As a follow-up to this study we conducted two trials evaluating the use of cover crops under the vine row in order to bring the soil benefits of cover crops to the soil under the vine where most of the roots are located. However, a key concern of growing cover crops under the vine row was the competitive effect of the cover crops on the growth of the vines due to competition for nutrients and water. In a real way, a cover crop under the vine row would act like a weed. In a low rainfall area such as Monterey County, any water used by the cover crop would have to be replaced by irrigation, which could have negative economic consequences for crop production. As a result, two trials were conducted to evaluate management of vine row cover crops to minimize the detrimental aspects of the cover crops and maximize the benefits that they can provide crop production and vineyard management.

Methods: Two trials with vine row barley cover crops were conducted from 2006 to 2010: 1) A small plot kill-date timing trial with five treatments - cover crops killed with glyphosate at the following heights: 0, 6, 12, 18 and 24 inches tall. And 2) a large scale trial with three treatments – standard cover crop in row middles and strip sprayed vine row; bare row middles and strip sprayed vine row; and cover crop planted in row middles and vine row, and vine row cover crop allowed to grow to 12 inches tall and then killed with glyphosate. The treatments were evaluated for the effects on soil and plant nutrition, soil microbial biomass, levels of soil moisture throughout the year, and crop yield and berry composition.

Small plot trial: This trial allowed us to carefully examine the impact of allowing cover crops to grow in the vineyard for various periods of time. Allowing cover crops to grow to 24 inches tall was clearly detrimental to crop growth, and also reduced levels of nitrogen in the plants (Table 1). Interestingly, potassium levels in the plant were increased with cover crops allowed to grow for longer periods of time. Levels of soil moisture were reduced in the 24 inch treatment in the

late spring which may have accounted for the reduced growth observed in this treatment (Figure 1).

Large plot trial: The small plot trial showed that allowing the cover crop to grow to 12 inches tall did not adversely affect the growth or yield of the vines. As a result, in this trial we allowed the in-row cover crop to grow to 12 inches tall and then killed it with glyphosate. As was observed in the small plot trial, there was a significant reduction in nitrate-N in the petiole tissue at bloom (Table 2). The cover crops increased the levels of soil organic matter in the berm by the third year (2008). Also, there was an increase in potassium and phosphorus. There was no affect of the cover crop treatment on yield. The in-row cover crop did reduce the amount of soil moisture in 2007 in early spring (Figure 2), but increased the levels of soil moisture during the end of the growing season in 2007 and 2008. The increase in late season moisture in the in-row cover crop treatment may have been due to improved infiltration of applied drip irrigation water. We were not able to directly measure greater infiltration in the treatments, but did observe less runoff of water where in-row cover crops were present (Photos 1 & 2).

Conclusions: In-row cover crops have the potential to compete with the vines in low rainfall areas such as Monterey County. In this sense, they can act like a weed. However, if carefully managed, they can provide long-term benefits to the soil under the vines where most of the roots are located. In these studies, we observed that killing the cover crop when they are 12 inches tall safeguarded the yield of the vines and increased the levels of soil organic matter by the third year of the practice. In-row cover crops do reduce the levels of nitrogen in the crop and care must be taken to offset this negative impact. We are not sure why, but in-row cover crops increased the potassium and phosphorus levels in the crop at bloom. We have indirect evidence that the in-row cover crops improved irrigation water infiltration from drip emitters as we observed high levels of soil moisture in the in-row cover crop treatments during the summer irrigation season.

Table 1. Small plot trial: Tissue nutrient levels (at bloom) and vine growth parameters, 2008

Cover Crop Treatment	Petiole NO3-N ppm	Blade nitrogen percent	Petiole potassium percent	Blade potassium percent	Pruning weight kg/vine	Shoot weight grams
Standard - no cover	591 a	2.69 a	1.81 c	1.02 c	1.33 a	34 a
6 inches tall	504 a	2.66 a	1.94 bc	1.04 bc	1.28 a	31 ab
12 inches tall	456 a	2.70 a	1.96 bc	1.05 bc	1.28 a	31 ab
18 inches tall	608 a	2.70 a	2.15 ab	1.09 ab	1.33 a	34 a
24 inches tall	149 b	2.47 b	2.35 a	1.15 a	1.05 b	28 b

Letter followed by the same letter do not differ. Mean separation by Duncan's multiple range test, 5% level.

Figure 1. Small plot trial: Soil moisture during the winter and spring

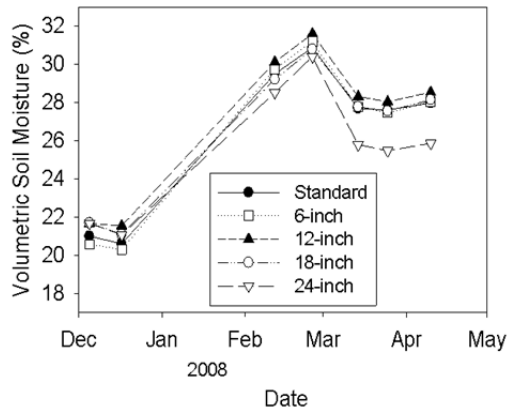


Table 2. Large plot trial: Tissue nutrient levels (at bloom) and vine growth , 2008

Cover Crop Treatment	Petiole nitrate ppm	Petiole potassium percent	Petiole phosphorus percent	Soil organic matter %	Pruning weight kg/vine
Standard Strip spray with cover crop in row middles	900 b	2.30 b	0.43 b	1.00 b	1.60 a
No vegetation Strip spray with bare row middles	1238 a	2.26 b	0.39 b	1.02 b	1.54 a
In-row cover crop Killed when 12" tall	435 c	2.66 a	0.52 a	1.12 a	1.46 a

Letter followed by the same letter do not differ. Mean separation by Duncan's multiple range test, 5% level.

Figure 2. Large plot trial: Soil moisture during the winter and spring and growing season

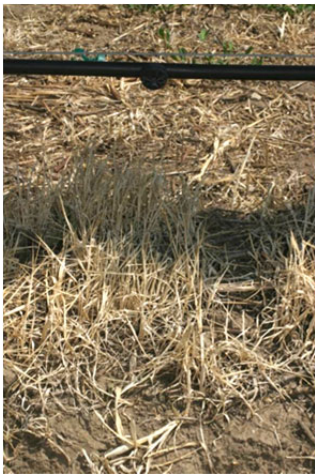
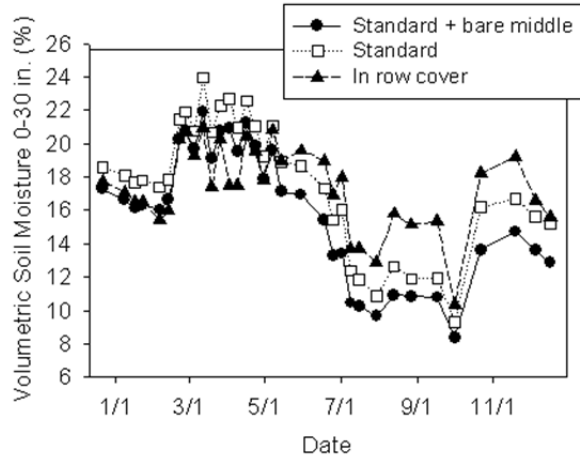


Photo 1. In-row cover crop



Photo 2. Standard bare berm
Note evidence of runoff below drip emitter

The Value of Residual Weed Control

Hank J. Mager, Bayer CropScience, Fountain Hills, AZ, hank.mager@bayer.com

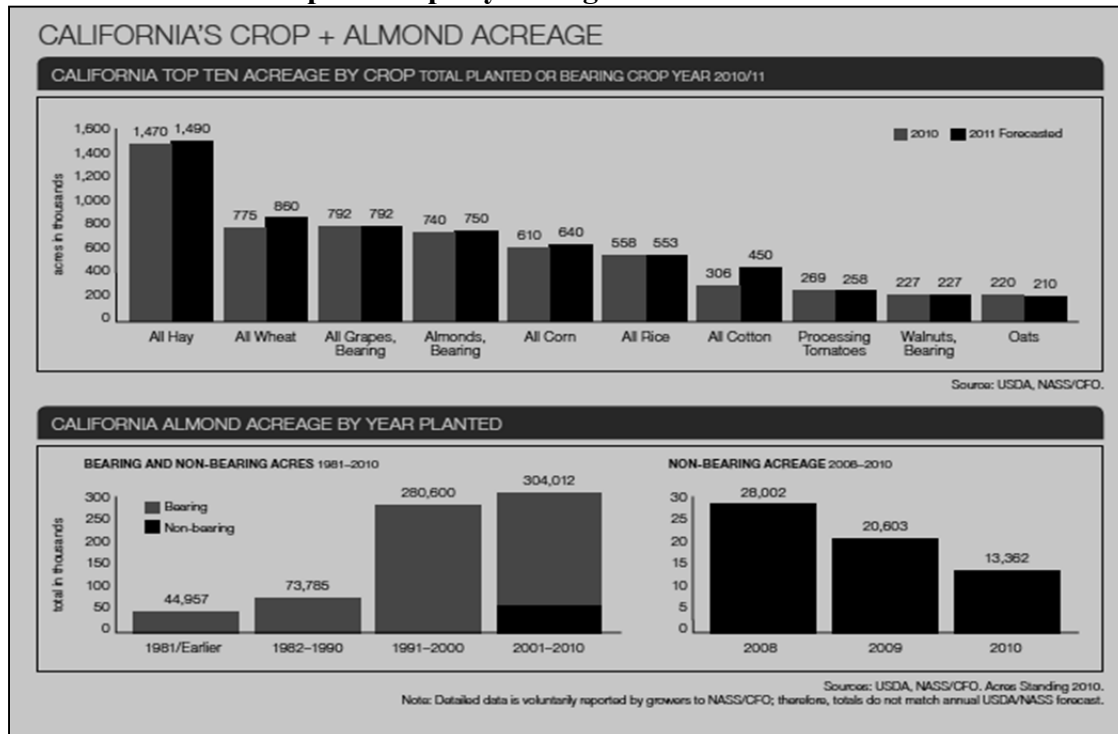
The true monetary value of residual weed control in tree and vine crops varies from one grower to the next as much as it does from one commodity to another. Residual weed control from preemergence herbicides can add value in many ways over mechanical and postemergent methods of weed control. Effective use of preemergent herbicides can reduce trips across the field providing substantial savings in time and labor as well as being beneficial to the environment. Preemergent herbicides play an important role in integrated pest management and can be a key component of an effective resistance management program. While weeds may effectively be controlled after emergence with postemergence herbicides, dead and decaying weeds can harbor pests and interfere with harvest operations. Picturesque weed-free groves and orchards may also add value to a grower's operation with regard to product marketing and agricultural tourism.

Weed control in nut crops

Mick Canevari UCCE San Joaquin Emeritus Farm Advisor, Stockton, California

The nut industry in California continues to grow in acreage, with almonds as the largest crop is estimated at 750,000 acres followed by walnuts, 227,000 and pistachios, 215,000 acres. The production areas occur in the San Joaquin and Sacramento valleys from Butte County in the north to Kern County in the south. Current acreage of major commodities in California is listed in Table 1.

Table 1. California top ten crops by acreage



Weed impacts on orchards

Weeds growing in newly planted orchards, specifically down the tree row compete for water and nutrients especially during the spring establishment period when roots begin to grow. Young orchards are more weed prone because of the smaller canopy that allows more light to reach the soil and stimulate weed germination and growth.

At this young stage, the impacts on tree growth can be most significant as roots are shallow occupying the same area as weed roots. Weeds also harbor rodent pest such as gophers, ground squirrels and voles feeding on roots and tender bark. During harvest, sweeping and pickup operations are hampered when weeds are growing in the tree row. Weeds can slow up the hulling process which increases time and cost.

Weed control techniques

Weed control must fit into an overall management system. Control programs depend upon grower practices, tree configuration and age, irrigation system, and soil type. Irrigation systems vary in design from drip, micro sprinklers, low volume impact sprinklers, furrow and flood. Each system has its own issues related to weed management from water distribution to plugging the orifices.

Soils with poor water penetration or surface seal may require frequent cultivation in row centers. Soil type and soil texture influence tillage practices, herbicide choices and applications rates. When planning your weed control program, consider the effects of herbicides on trees and environment and compare these with the effects of cultivation and weed competition, water penetration, water availability, ease of irrigation, soil structure and erosion, equipment needs, and fertilizer costs.

Chemical weed control

No single herbicide can control all vegetation. Chemical weed control does reduce mechanical trunk and root damage that can result from close cultivation especially on young trees. Combining (tank mixing) or alternating herbicides will enhance broad spectrum control of most weed species. Before selecting an herbicide or a combination of herbicides, consider the orchard weed history so you can choose the right type of herbicides.

New herbicides

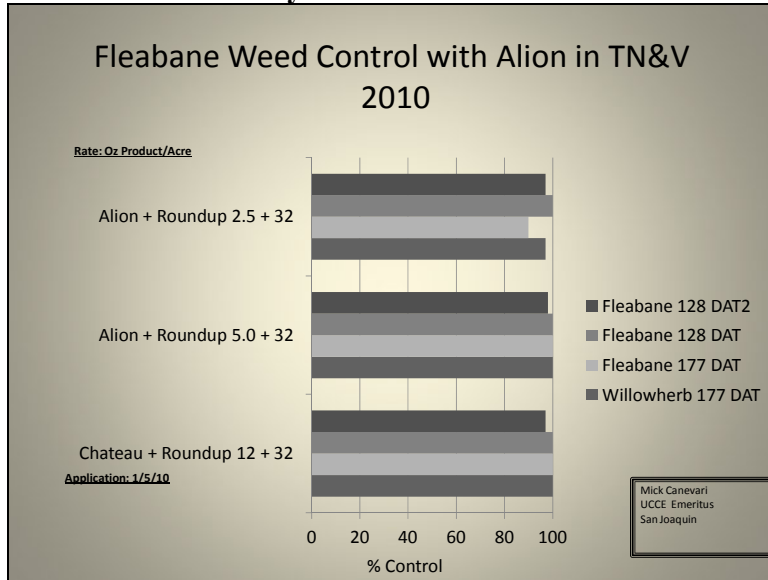
In recent years, several new herbicides have been registered for nut crops. These new active ingredient herbicides generally have reduced rates, many have activity pre and post emergent, and will control both grasses and broadleaf weeds. Most have an environmental profile that is safe to humans, wildlife and aquatic species, never the less, using best management practices are of paramount importance with all pesticides.

Shown below are several of the more recently registered herbicides for tree nuts with trial data. This list provides selected trials done by the author. Consult with the experts in your area to assist with specific conditions and recommendations.

Alion® Herbicide- Bayer

- *Indaziflam*- Preemergence herbicide
- Broadleaf and grasses
- Fruits & Nuts
- Mode of Action: Group 29 –Cellulose Biosynthesis Inhibitor

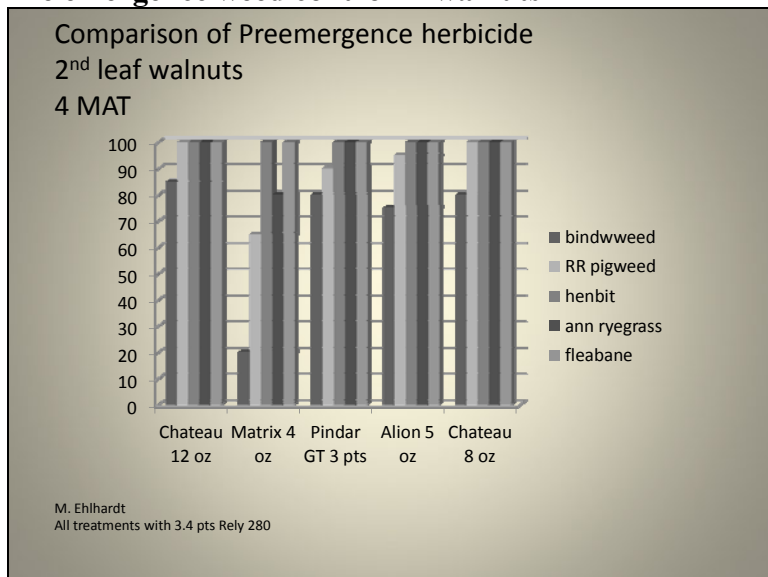
Alion control of hairy fleabane



Chateau® Herbicide- Valent

- *Flumioxazin* Fruits, nuts and vines
- Pre emergent herbicide for broadleaf and grasses
- Post emergent activity on small weeds
- Mode of Action: PPO inhibitor Group 14

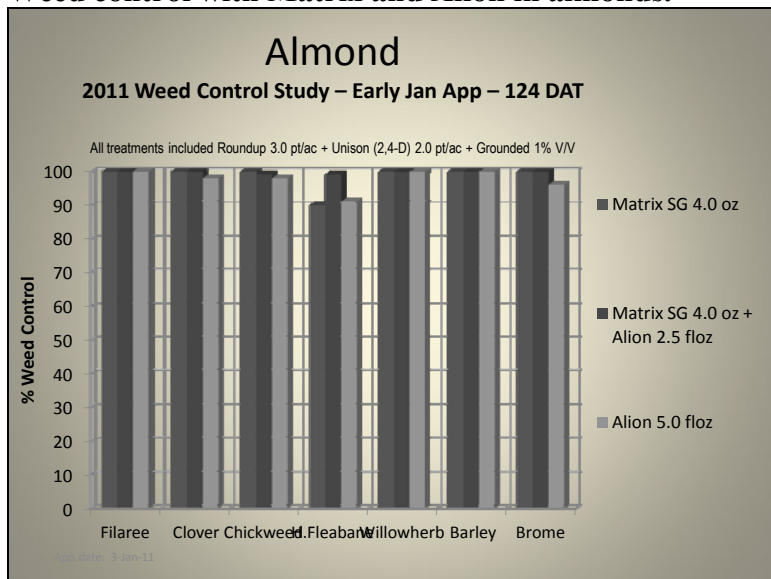
Pre emergence weed control in walnuts



Matrix® SG herbicide- Dupont

- Rimsulfuron (active ingredient)
- Mode of Action: Group 2 ALS inhibitor (sulfonylurea chemical class)
- Broadleaf weed and grass control, including fleabane and marestail
- Pre and Early Postemergence activity

Weed control with Matrix and Alion in almonds.

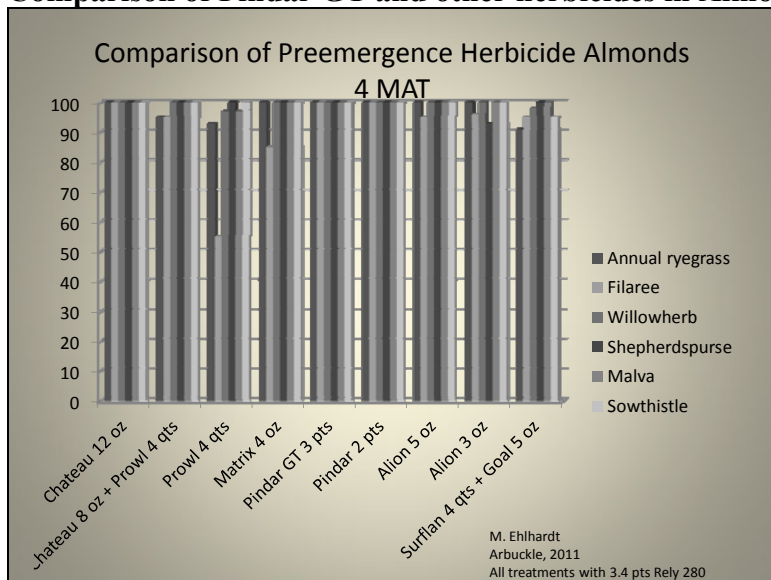


Pindar GT Herbicide- Dow AgriSciences

A premix of: *Penoxsulam*: ALS inhibitor active ingredient with broad spectrum weed control in tree nut crops and *Oxyfluorfen*: for broad spectrum residual and contact weed control.

- Burndown weed activity for many broadleaf and grass weeds
- Mode of Action- Group 2 & 14

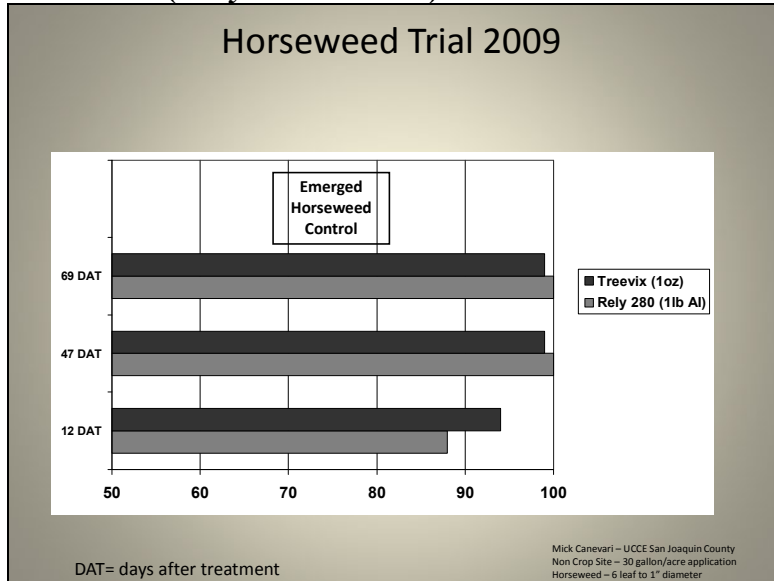
Comparison of Pindar GT and other herbicides in Almonds



Treevix™ BASF

- Saflufenacil – (active ingredient)
- Post Emergent burndown for Broadleaf Weeds
- Mode of Action - Group 14 PPO Inhibitor
- 1oz / Acre: PHI 7 Days for Tree Nuts
- Tank mix options: Glyphosate, Prowl® H₂O, Alion, Matrix®
- Rely® 280, Paraquat, Surflan, Chateau

Horseweed (*Conyza canadensis*) burn down trial with Treevix and Rely



Summary

Today there are many excellent residual herbicides available for growing nut crops.

- Matrix®, Alion™, Chateau®, Pindar™ GT “all” good products similar for residual weed control up to 150 days when applied in the winter months.
- Spring applications of residual herbicides Prowl & Surflan, can be tank mixed with new chemistries and better suited for summer weed spectrums and warmer temperatures.
- Newer post emergent herbicides include, Treevix®, Rely®, Shark® that are recommended with residual products. Glyphosate and Gramoxone can also be tank mixed to enhance weed spectrum control.
- With many different modes of action herbicides, a strategy for weed resistant’s becomes a manageable task.
- Generally newer pesticides are safer to humans, animals, and the environment however, caution should be made for crop safety and utilizing best management practices.

Determining the Yield Effect of Herbicide Drift on Dried Plum Trees

*L.M. Sosnoskie, M.J.M Abit, T. Lanini, and B.D. Hanson
University of California, Davis, Dept. of Plant Sciences*

Introduction:

Dried plums were first introduced to North America in 1856, when cuttings from France were planted in California (CA). In 2010, 63,000 acres in the US, almost 100% in CA, were devoted to dried plum production; 125,000 tons of prune-variety plums were harvested with an estimated crop value of \$153 million.

Recently, dried plum growers have observed instances of leaf spotting, mottling, poor tree growth and poor flower set that are suspected to be the result of off-target herbicide drift. In previous work conducted by the California Dried Plum Board, glyphosate and propanil were found in measureable amounts in dried plum leaf tissue. While the source of propanil was, most likely, aerial applications made to nearby rice fields, the origin of the glyphosate contaminant was not immediately evident. Glyphosate is a commonly applied herbicide in both non-crop and cropping systems, including prunes and other perennial production environments. Regardless of the source, it is not clear what effects sub-lethal rates of these, and other, herbicides are having on dried plum production. If one or both of these products are impacting dried plum productivity, it may be necessary to modify 1) the way they are applied or 2) the timing of the application.

In 2009, a research project, supported by the California Dried Plum Board (CDPB) was initiated to evaluate the effects of simulated propanil and glyphosate drift on the performance and fruit yield of established trees (~15 years old). An additional experiment was begun in 2011 to describe and compare injury symptomology and subsequent yield effects of sub-lethal doses of glyphosate, propanil, penoxsulam, glufosinate, and oxyfluorfen on newly established French prune trees over time.

Materials and Methods:

2009-2011 Wolfskill Farms Experiment

This experiment was conducted (2009 to 2011) in an established French prune orchard (Wolfskill Farms) near Winters, CA, to evaluate the cumulative effects of yearly, low-rate (simulated drift) applications of propanil (Stam 80 DF at 0.002, 0.01, and 0.1X labeled rate) and glyphosate (Roundup WeatherMax 0.01, 0.1, and 0.5X labeled rate) at three application timings (June, July, and August) on fruit set and fresh yield. The reference 1X herbicide rates are 1.5 lbs ae/A for glyphosate and 4.0 lbs ai/A for propanil. Both herbicides were applied to the tree canopies by researchers on an orchard ladder. Trees were sprayed with two-passes of a 3-nozzle spray boom from opposite sides of the tree resulting in approximately 80% of the upper canopy being treated. Applications were made using a CO₂-pressurized backpack sprayer, with 80015 nozzles, delivering 10 gal/A total spray volume. Individual plots consisted of a single tree, each; treatments were replicated up to three times. Visual observations of herbicide injury were recorded throughout the course of the study. Each year, two mid-canopy branches per tree were selected and the number of buds and fruit (set and harvested) per branch and fruit (set and harvested) per bud were counted. Fresh fruit weights were also recorded and the individual fruit weights determined. Several trees were left untreated at the site for the purpose of comparison.

2011-2013 Martinez Farms Experiment

With support of the CDPB and the cooperation of a local grower, a new field experiment was established at Martinez Orchards (Winters, CA) to evaluate the effects of several low-rate (simulated drift)

applications of glyphosate, propanil, penoxsulam, and oxyfluorfen on: canopy injury, flower and fruit set, fresh yield, and prune dry weight in a new French prune planting (1-leaf trees). Bare root French prune nursery stock was planted March 9, 2011 as “interplants” in a new commercial orchard planted by the cooperating grower; test trees will be removed when they are large enough to interfere with the commercial orchard trees. Herbicide treatments were applied above the tree canopies by research personnel using a CO₂-powered backpack sprayer, with 80015 nozzles, delivering 10 gal/A total spray volume. Glyphosate (Durango), propanil (Stam 80 EDF), penoxsulam (Tangent), glufosinate (Rely 280), and oxyfluorfen (Goal 2XL) will be applied at 0, 0.05, 0.1, and 0.2X of the herbicide use rates. The reference 1X herbicide rate is 1.5 lbs ae/A for glyphosate and 4.0, 0.03, 1.0, and 1.25 lbs ai/A for propanil, penoxsulam, glufosinate, and oxyfluorfen, respectively. Non-treated trees have been included in the study as negative controls. Individual plots consist of a single tree, each; all treatments are replicated five times. In 2011, treatments were applied on August 10 due to late planting and slow initial growth; however, treatments in 2012 and 2013 will be applied earlier in the spring. Data collection for the experiment includes: annual trunk diameter measurements, as well as visual estimates of foliar injury. Beginning in 2012, the number of flower buds will be counted on each tree (or representative portion thereof) prior to the first herbicide application and fruit set will be evaluated in mid-summer. Once fruit production begins, fruit on each tree will be counted and weighed and, if appropriate, a subsample will be dried and weighed to determine final prune yield and quality.

Results and Discussion:

2009-2011 Wolfskill Farms Experiment

When it occurred, visual injury was minor (7 to 18%) and transient, as well as consistent with the typical symptoms associated with each herbicide. Glyphosate is both translocated and slow to metabolize, and physical injury symptoms (yellowed tissues and shortened internodes or “witches brooms”) were often not observed until the season following the herbicide treatments. Leaves directly exposed to propanil, a photosynthesis inhibitor, exhibited interveinal chlorosis soon after treatments were applied. Over three fruiting years (2009, 2010, and 2011), no statistical differences were observed with respect to French prune bud and fruit set, as well as fresh fruit weight, in response to herbicide type, rate, or application timing (data not shown). Results from this trial suggest that visual injury from both propanil and glyphosate may not significantly affect fruit yield on established prune trees. If injury does occur, it may be difficult to measure given the variability among trees within an orchard, or among orchards, due to widely varying horticultural practices.

2011-2013 Martinez Farms Experiment

One month after application (MAA), slight to moderate canopy injury was observed for all herbicide treatments applied in 2011. The injury symptoms most often noted were chlorosis of newly emerged leaves (glyphosate), yellowing or dying leaves (propanil), necrotic spots of varying sizes (oxyfluorfen), and chlorosis and necrosis of new and old leaves (penoxsulam) (Figure 1). The greatest injury occurred in those treatments that received the highest rates of each herbicide (Figure 2). Injury ratings at 2 MAA were considerably less severe as compared to the 1 MAA observations, indicating plant recovery (data not shown); however, some degree of injury was still evident for the highest herbicide rates. Despite early season injury, final trunk measurements were not greatly affected by herbicide treatments, except those that were treated with propanil and oxyfluorfen (data not shown). Yield parameter data were not collected in 2011 because the trees were in their first growing season. The Martinez Farm site will be monitored in 2012 to evaluate the effects of simulated herbicide drift in 2011 on both bud and flower initiation. Treatments will be reapplied in 2012 and 2013 and similar data will be collected. The trial is expected to continue through the 2013 growing season before being terminated.

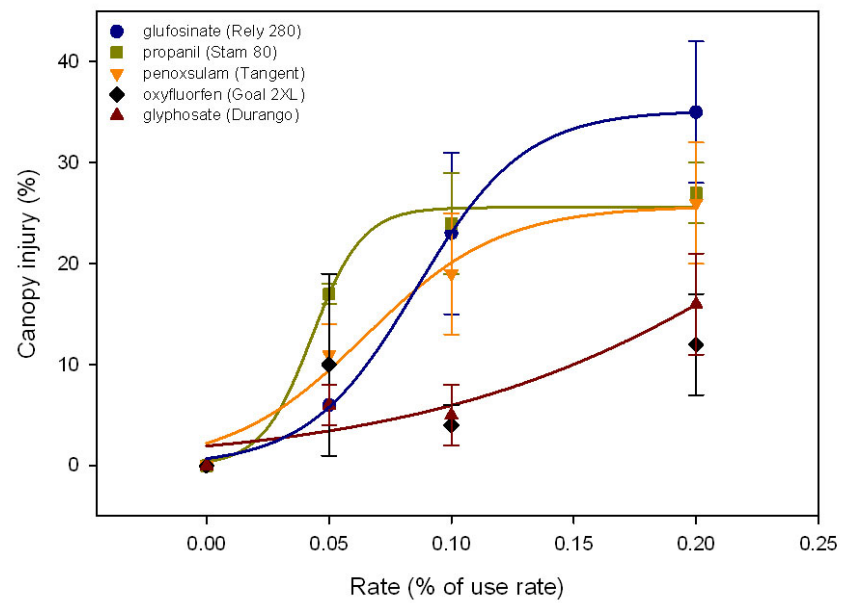
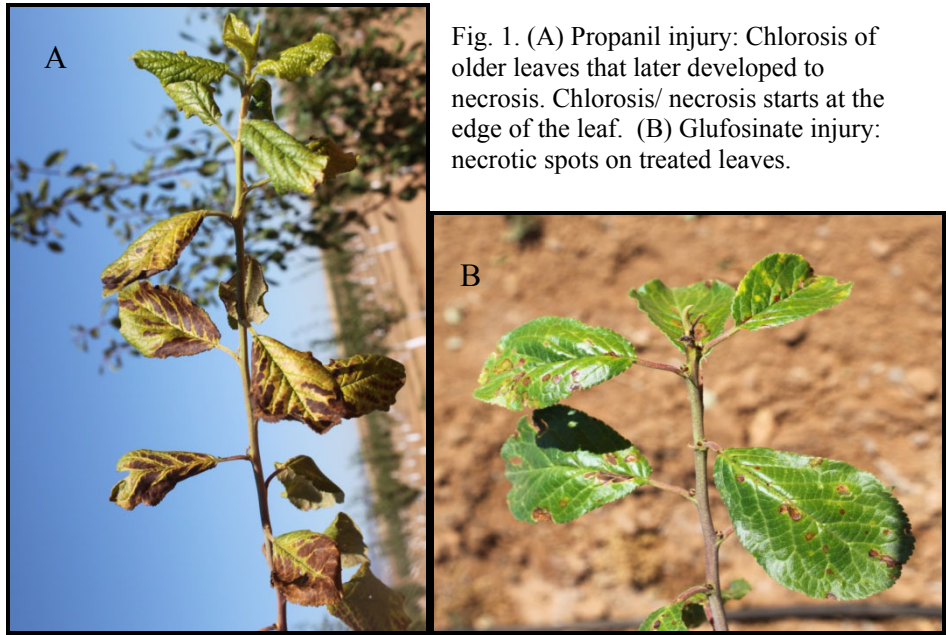


Fig. 2. Effect of simulated herbicide drift on young dried plum trees 1 MAA. Data are means (n=6) plus or minus standard error. A regression could not be fit to oxyfluorfen (Goal 2XL) data.

Partnering for Weed Removal on Santa Cruz Island

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Abstract

Santa Cruz Island is the largest and most biologically diverse of eight Channel Islands off the coast of southern California. The Nature Conservancy (TNC) owns and manages the western 76% of Santa Cruz Island (SCI), and the National Park Service (NPS) owns and manages the eastern 24% of the 95 sq. mi. island as part of the Channel Islands National Park. The weed management program on Santa Cruz Island has many components: scouting, mapping and reporting new infestations; accessing and treating weeds; assuring programmatic continuity for long-term treatment that will result in eradication; and securing funding to maintain the program over time. Managing the weed program on Santa Cruz Island is best accomplished by drawing on the diverse skills and knowledge of many groups and directing them towards a common goal. These groups include government agencies, private organizations and individuals. A variety of techniques and personnel are involved in treating weeds on the island. TNC's weed contractor uses a helicopter to transport weed technicians to rugged, difficult-to-reach locations to treat remote weeds; volunteers and Conservation Corps members under the direction of professionals remove weeds in watercourses and along roads; National Park weed technicians fell large invasive trees; and new invasive species are prevented from reaching the island through implementation of biosecurity protocols. The Nature Conservancy works closely with local, state and federal agencies to fund weed work on the Island and benefits from all these partnerships for an effective weed management program.

***Tamarix* Biocontrol and the Restoration of Riparian Ecosystems**

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Tamarix spp., occupy over one million acres in North America. *Tamarix* is the third most common woody plant in western U.S. riparian areas. *Tamarix* detrimentally impacts ecosystems and biodiversity. It displaces native riparian plants; transpires significant amounts of water; dessicates and salinates soils; increases erosion and sedimentation; increases risk of wildfire and lowers habitat quality for wildlife species.

Conventional control methods can be expensive and unsustainable. Control programs can actually promote secondary resurgence of other invasive weeds. Biocontrol of *Tamarix* is a more environmentally benign and cost-effective alternative.

Classical biocontrol research begins with looking for agents in a weed pest's native range, in this case in Asia, southern Europe and north Africa. Eventually three candidate insects, Chrysomelidae: *Diorhabda carinulata*, Curculionidae: *Coniatus tamarisci*, and Pseudococcidae: *Trabutina mannipara*, were approved for study by the Technical Advisory Group for the Biological Control of Weeds (TAG) with U.S. Fish and Wildlife Service concurrence. *Diorhabda carinulate*, also known as the tamarisk leaf beetle, from central Asia was approved for release in 1996.

A potential conflict emerged with the listing of the Southwestern Willow Flycatcher (*Empidonax traillii extimus*) as an endangered subspecies in 1995. The loss of its habitat, the typically cottonwood/willow riparian woodlands, enhanced by the invasion by *Tamarix*, are factors in the bird's decline. The flycatcher has been found to nest in *Tamarix*.

Ironically, the success of *Diorhabda* at defoliating *Tamarix* caused conflict with conservationists trying to protect the flycatcher. The biocontrol program was halted by the U.S. Fish and Wildlife Service for consultation under the Endangered Species Act. The premises were that defoliation caused by the beetle could expose flycatcher nests to excess heat; tamarisk may be eradicated too quickly before native plants could replace the lost habitat; the habitat would be too degraded for native plants and that the beetles may be toxic.

The beetle was studied in a number of sites throughout the western United States. *Diorhabda* did indeed prove to be successful at defoliating tamarisk in northern areas where the research was conducted. However, below the 38° parallel (San Francisco), the beetle's daylength-induced diapause caused it to enter into overwintering too early to allow survival until the following spring, and control at these sites failed. *Diorhabda carinulata* appears to be evolving a delayed

response to daylength cues to diapause and is establishing further south than the original releases.

Where successful, the initial impact of *Diorhabda* on *Tamarix* defoliation was rapid and dramatic. However, foliage re-growth occurred in a few weeks; die-back was gradual and mortality was slow. But even without mortality, benefits accrued. Canopy cover by *Tamarix* declined sooner and the subsequent season's cover and duration were reduced. Seasonal evapotranspiration was reduced by 65% in year one and by 90% in year two. The beetles even served as an additional food source, and bird diversity and abundance increased.

Well-intentioned but perhaps misguided conservationists are resisting the implementation of biocontrol of *Tamarix*, believing that *Tamarix* forests are needed for flycatcher survival. However, despite the flycatcher nesting in *Tamarix* in a few locations, over 90% of flycatcher nests are in native or mixed native/exotic vegetation. *Tamarix*'s trend is to create monocultures and flycatcher nests are absent in *Tamarix* monocultures. The data suggests that even as little as 30% native element sustains riparian birds but drops rapidly as *Tamarix* dominance goes over 80%. Additionally, flycatchers have responded well to native riparian recovery, showing increased fledgling success in restored habitats over *Tamarix* dominated sites. Fire may be the biggest factor promoting both *Tamarix* dominance and sensitive species decline.

Help to resolve the conflict by facilitating active restoration of native habitat in areas where the flycatcher is present is being provided by The Walton Family Foundation and coordinated by the Tamarisk Coalition, a non-profit alliance working to restore riparian lands.

Abstract for Proceedings, California Weed Science Society Meeting, Jan. 23-25, 2012

Nuance, Naysayers and twenty years of studying invasive species impacts. by Carla D'Antonio (presenter) and Nicole Molinari. Dept. of Ecology, Evolution & Marine Biology. University of California, Santa Barbara, CA. 93106.

Over the past twenty+ years, there has been an explosion of concern and study regarding the presence, control and impacts of non-native plants in wildland settings. Yet recently there has also been a backlash against this movement as well as a substantial reduction in funding allocated to the study and control of invasive plants. We argue that to curtail growth of the naysayer movement, and to enhance efforts at control, we need to, (1) use more careful terminology regarding who these species are that merit control, (2) conduct more targeted research on impacts and (3) embrace and communicate the nuances of species impacts. Since it is only a small (maybe 10%) of established, widespread non-native plant species that cause impacts that we care about, we need to communicate carefully about which species they are and be able to substantiate implications of their impacts. To better direct management efforts and avoid unscientific demonization of species, we need to study and communicate the nuances of species impacts.

Large Scale, Low Cost Restoration of Native Grasslands and Coastal Sage Scrub using Herbicides

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Restoring native habitat in southern California has not met with great success over the past few decades despite lots of effort. It is also expensive, with costs typically in the range of \$3,000 to \$40,000 per acre. Working with several colleagues, such as Edith Allen and Milt McGiffen at UC Riverside (and their students), John Eckhoff at CA Department of Fish and Game, and Marti Witter with the National Park Service, we have been exploring herbicide-based approaches as a low cost alternative.

These approaches concentrate on killing non-native annual grasses and forbs in order to eliminate competition with native plants. We are utilizing broadcast applications of low rates of herbicides; principally glyphosate, fluazifop-P-butyl, and triclopyr, as an efficient and inexpensive way to kill these weeds. We apply the herbicides in winter or early spring to kill the weeds early in the rainy season so the resident natives have access to the limited annual supply of precipitation. We repeat herbicide treatments annually for 3-5 years in order to eliminate the weedy plant seed bank so the problem does not re-occur.

In one site near Ramona in San Diego County, after a five-year regimen of glyphosate, weed whipping the inflorescences of persistent weeds, and seeding with natives; we have increased native cover to 50% compared to less than 5% for the untreated plots. We also have counted over 30 species of natives in the treated plots compared to 3-5 in the untreated plots. Our costs for the treatments for the five years of the study are about \$2000 per acre.

In another site near Jamul in San Diego County, we have been using herbicides to selectively remove non-native weeds in an area with a sparse native stand of purple needlegrass (*Stipa (Nasella) pulchra*, the CA State Grass). In this experiment, we are also applying herbicides broadcast in winter or early spring to kill the weeds. Our most successful treatment has been a combination of fluazifop and triclopyr, which is killing the weeds without visible damage to the native grass. After three years of treatment, our treated plots have purple needlegrass cover ranging from 20-60%, while cover in the untreated plots averages about 5%.

Where the Weeds Are: Prioritizing Regional Response to Invasive Plants Using CalWeedMapper

Doug Johnson, Elizabeth Brusati, Dana Morawitz, Falk Schuetzenmeister, Cynthia Powell, Suzanne Harmon, and Tony Morosco. California Invasive Plant Council, Berkeley, CA.*

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Abstract

Land managers need to devise strategic management plans in order to address invasive plants effectively with limited funding. The California Invasive Plant Council (Cal-IPC) interviewed experts throughout California on the abundance, spread and current management of 204 invasive plant species at the USGS 7.5' Quadrangle scale. These expert knowledge data are linked to existing online databases from Calflora and the Consortium of California Herbaria (CCH) and displayed in a new online mapping tool, CalWeedMapper. This website is designed to increase the effectiveness of invasive plant management by providing landscape scale maps that serve as the basis for setting regional priorities, tracking progress and justifying funding. Land managers can see management opportunities for their region divided into surveillance, eradication or containment targets. These reports are derived from maps of current distribution combined with projected suitable range for 2010 and 2050 climate conditions. Some species show likely range expansion with climate change, while others contract or shift their ranges. In other cases, the projected range does not change but the level of suitability does. In addition to providing recommendations for regional management opportunities, CalWeedMapper allows land managers to generate maps of individual species distribution and to explore and update USGS quadrangle data, through an update interface or by submitting occurrence information. We are working with stakeholder groups and agencies to apply CalWeedMapper to their invasive plant management. Check us out at calweedmapper.calflora.org!

Acknowledgments

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Weeds & Their Management in Vegetables: An Entomologist's Perspective

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Effective weed management is critical for the profitable production of vegetable crops for all the obvious reasons. However, weed management is also essential for another important, but often overlooked, reason. Several common weed species found in and around vegetable crops can serve as host plants to many insect pests that can later infest nearby crops. Additionally, when weeds are not controlled in the field, they can be an impediment to effective insect control. Although weeds can serve a beneficial role by harboring insect natural enemies and pollinators, the consequences resulting from weeds harboring insects as pests largely outweighs the benefits they potentially provide. This presentation will address the practical interactions between weeds and insect pests, and focus specifically on how poor weed management can contribute to insect pest problems in vegetable crops.

Weeds as Refuges for Beneficial Insects

There are numerous examples of how weeds can serve as a refuge for natural enemies of insect pests. Parasitic wasps and predatory insect species can build up to large numbers in weedy areas and subsequently migrate into adjacent vegetable fields where they can feed on damaging insect pests. Unfortunately, given the high cosmetic standards in many vegetable crops, these natural enemies are not generally capable of preventing economic damage to the harvested product. In contrast, flowering weed species can provide a source of nectar and pollen for a number of important insects such as honeybees and other native pollinators important for cucurbits and seed crop production. Of course, these same weedy refuges can serve as host sources for many key insect pests that cause economic damage to vegetable crops.

Weeds as Reservoirs for Insect Pests

Many of the common insect pests found in vegetable crops are polyphagous, capable of feeding and reproducing on crops and weeds in numerous plant families. For instance, a weed species such as Common lambsquarters, is known to serve as a host for a variety of economic insect pests in fresh-market vegetables and melons (Table 1). When found on field margins and ditch banks, weeds can provide insect pests with suitable resources needed for rapid population growth which subsequently can lead to insect infestations occurring in adjacent vegetable crops. For example, it is not uncommon for green peach aphids and false chinch bugs to build up to high numbers on cheeseweed and London rocket during the winter, only to invade nearby melon and seed crops later in the spring.

Many weed species can also be important for these economic insect pests by providing host plants that serve as a bridge between cropping seasons when vegetables crops are not in production (May-August). Since most of these key insect pests have the ability to move relatively long distances to find new food sources, weeds that are allowed to grow unchecked in fallow fields during the summer often serve as a key source of insect infestations for fall

vegetable and melon plantings. For example, pale-striped flea beetle and beet armyworm populations will annually develop on common purslane that has been allowed to grow in fallow fields prior to fall plantings.

Another host source for insect pests of vegetables are volunteer crops that are considered weeds ("a plant out of place") when allowed to grow in fallow fields, on field margins and within crops. Each summer, volunteer melons and cotton can be found germinating in fields being prepared for or planted in fall vegetable crops. If not removed in a timely manner, these weedy volunteer plants can sustain large numbers of insect pests that can eventually migrate into newly planted fields.

Table 1. Common weeds that are known to serve as hosts for the major insect pests of leafy vegetables and melon crops grown in the desert southwest.

	Beet armyworm	Corn earworm	Variegated cutworm	<i>Liriomyza</i> leafminers	Western flower thrips	Green peach aphid	Potato Aphid	Sweetpotato whitefly	Pale-striped flea beetle	False chinch bug	Bagrada bug
Sunflower											
Silverleaf nightshade											
Cheeseweed											
Lambsquarters											
Nettleleaf Goosefoot											
Jimsonweed											
Wright's groundcherry											
Common purslane											
Ragweed											
Pigweed											
Sheperd's purse											
Russian thistle											
London rocket											
Wild mustard											

Sources: Common names of weeds from Parker 1972; List of hosts for insects from Capinera 2001.

Weeds as Reservoirs for Insect-transmitted Viruses

Weeds can also serve as alternate host plants for a three important groups of viruses that affect vegetable and melons; tospoviruses, potyviruses and closteroviruses . These viruses utilize a number of important weeds as hosts, and are vectored by several of the key insect pests shown in Table 1. For example, one of the primary insect vectors of the tospovirus, *tomato spotted wilt virus*, is the western flower thrips. Not surprising, two common weed species (lambsquarters and cheeseweed) serve as hosts to both the vector and the virus. Similarly, these two weed species serve as a host reservoir for a number of potyviruses (e.g., *watermelon mosaic virus-2*) vectored by several aphid species, including green peach aphid. Most recently, a new closterovirus, *Cucurbit Yellow Stunting Disorder Virus*, which is vectored by the sweetpotato whitefly, has emerged as a major problem in fall melons. Initially it was believed that only cucurbits could host the virus, but has since been determined that several common weeds serve as reservoir hosts including: redroot pigweed, London rocket, lambsquarters, sowthistle, alkali mallow, Wright's groundcherry, and silverleaf nightshade.

Weeds as Impediments to Insect Control

Foliar Insecticide Sprays: Excessive weed densities during stand establishment can impede insect control by interfering with foliar insecticide sprays directed at small plants. Weeds infesting vegetable or melon fields can negatively influence insecticide deposition onto plant foliage, resulting in reduced insecticide efficacy. This may be especially important for broadleaf weeds such as Wright's groundcherry which are tall growing and capable of producing a canopy over seedling vegetable plants. Dense weed foliage can intercept insecticide spray droplets before reaching the target crop, resulting in less insecticide deposition and unacceptable plant damage from insect feeding on untreated foliage.

Soil Insecticides: A large number of acres planted to vegetable and melons crops each year are treated with soil systemic insecticides (i.e., imidacloprid , rynaxypyr) for early season control of whiteflies, aphids and beet armyworms. These insecticides are injected beneath the seedline just prior to- or at-planting and become systemically active in plants via root uptake during germination and seedling growth. Weeds are known to compete with plants for water and fertilizer during stand establishment, and they can also compete with crops for soil insecticides. Excessive weed densities can significantly intercept insecticides and reduce the amount available for uptake by the target crop.

Herbicide interactions: Anecdotally, it has been suggested that root injury in leafy vegetables resulting from applications of pre-emergent herbicides such as Kerb and Prefar could potentially reduce uptake of soil insecticides during stand establishment. Herbicide effects causing root pruning or clubbed roots could potentially impede normal uptake of the systemic insecticides until root growth resumed.

Relevant References

- Capinera, J.L. 2001. Handbook of Vegetable Pests. Academic Press, New York. 729 pp.
Parker, K.F. 1972. An Illustrated Guide to Arizona Weeds. Univ. of Arizona Press. Tucson.
Wintermantle W.H., L.L. Hladky, A. A. Cortez and E.T. Natwick, 2009. A New Expanded Host Range of *Cucurbit yellow stunting disorder virus*, Plant Dis. 93:685-690

Water Management Effects on Weeds in Vegetable Production

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Introduction: Water plays a central role for managing weeds in vegetable systems. Because moisture is needed for germinating weed seed, water is used in several cultural strategies to reduce weed seedbanks through germination before crop establishment. Irrigation method also affects weed populations in vegetables. Water can also increase weed populations when run-off from rain or irrigation carries and disperses weed seed in agricultural fields. The efficacy of herbicides and fumigants for weed control is often affected by soil moisture. Finally, water is used for non-chemical alternatives to fumigation such as soil solarization, aerobic soil disinfection, and soil steam sterilization.

Water use in cultural weed control strategies: At planting, a large proportion of weed seeds in the soil are in a non-dormant state and ready to germinate with the addition of moisture. Pre-irrigating is not only beneficial for giving the soil an optimal tilth before bed preparation, but also for germinating weed seed that could potentially compete with a young vegetable crop. Shem Tov and Fennimore (2006) reported that weed populations in lettuce were reduced by 50% by pre-irrigating and killing germinated weeds before planting. Similar to pre-irrigation, the *stale bed technique* of controlling weeds involves irrigating after bed shaping to germinate non-dormant weed seed near the soil surface. Newly emerged weeds are then killed using cultural means such as flaming or shallow tillage before planting.

After pre-irrigating and tilling soil for planting, some growers seed directly into soil moisture and avoid irrigating during germination to minimize further flushes of weeds. This technique is most often used with large seeded crops such as melons, squash and beans, which can be planted deeper than small seeded vegetables. In the past, some growers of processing tomatoes also seeded into existing soil moisture in the Sacramento Valley, but because tomato seed is small and planted shallowly, they use an implement on the planter to create a 2 to 3 inch mound of soil, known as a cap, over the seed line. Capillary action of the soil cap wicks moisture near to the surface where the seed is planted. The cap must be removed just before the seedlings emerge to prevent damage to the crop. Although the main objective of dry farming crops such as tomatoes and melons is to improve fruit flavor, another advantage is a reduction in weed numbers because the soil surface remains dry.

Irrigation method effects on weeds: Sprinkler and furrow irrigation tend to stimulate more weed germination than drip irrigation. These irrigation methods wet a greater surface area than drip. In addition, by eroding the soil and suspending shallowly buried seed, furrow irrigation can disperse weed seed within a field or transport weed seed to fields downstream that reuse the water for irrigation. Sojka et al. (2003) determined that the application of polyacrylamide polymer reduced weed seed numbers in furrow tail water by reducing soil erosion and improving water infiltration. Weeds growing along irrigation canals also disperse seed into surface water that is used to irrigate fields. Since drip systems must be filtered to prevent emitters from clogging, weed dispersal from surface water sources is less likely than with furrow and sprinkler.

Subsurface drip may offer the best advantage for reducing weed pressure. While surface placed drip tape will wet a portion of the top of a bed, subsurface drip can maintain a dry soil surface, especially if the tape is positioned at 12 or more inches below the soil surface. By transplanting vegetables into subsurface drip irrigated beds, growers can avoid wetting the soil surface with sprinklers and causing weeds to germinate (Shrestha et al 2007).

Role of water in activating herbicides and fumigants: Water is needed to solublize and transport herbicides to weed seed. Also, weed seed needs to be moist to absorb herbicides. One challenge of using drip alone for establishing a vegetable crop is to move and activate pre-emergent herbicides. Many pre-emergent herbicides used in vegetables are sprayed on the soil surface before planting and rely on overhead sprinkler water to move the herbicide into the soil and near weed seeds. Both pre-emergent herbicides oxyfluorfen and flumioxazin have been shown to be activated using surface drip in transplanted celery and cabbage providing levels of weed control comparable to sprinkler activation. (Table 1). In a study with seeded lettuce, pronamide sprayed on the bed tops did not provide significant weed control under either surface or shallowly buried drip (Fennimore et al. 2007). Injecting pronamide through the drip systems also did not control weeds.

Water also plays an important role in the transport of fumigants. Fumigants used as alternatives to methyl-bromide, such as 1,3 D cis and chloropicrin, have relatively lower vapor pressure and higher water solubility, and therefore require uniform soil moisture in beds to attain optimal weed control.

Water for non-chemical control methods Water can be used to create conditions that kill weed seed. Soil solarization takes advantage of the high heat capacity of water to sustain soil temperatures above 150 °F which is sufficient to kill many weed seed species. In locations too cool to use solarization, steam applications can also kill weed seed. Finally, saturating soil pores with water in carbon augmented soils with plastic mulch cover creates anaerobic conditions that have been shown to reduce weed densities (Daugovish et al. 2011)

References

- Daugovish, O., C Shennan., J. Muramoto and S. Koike. 2011. Anaerobic soil disinfestation for southern California strawberry. MBAO Proceedings. San Diego, CA, 2:1-4.
- Fennimore, S. A, R.F. Smith, and M. Cahn. 2007. Weed management systems for lettuce. Annual Report. California Lettuce Research Board. 137-146.
- Shem-Tov, S., S.A. Fennimore and W.T. Lanini. 2006. Weed management in lettuce (*Lactuca sativa*) with pre-plant irrigation. Weed Technology 20:1058-1065
- Shrestha A. J. Mitchel and W. Lanini. 2007. Subsurface drip irrigation as a weed management tool for conventional and conservation tillage tomato(*Lycopersicon esculentum* Mill.) production in semi-arid agroecosystems. J.Sust. Agric. 31:91-112

Sojka, R.E., D.W. Morishita, J.A. Foerster, and M.J. Wille. 2003 Weed seed transport and weed establishment as affected by polyacrylamide in furrow-irrigated corn. *Journal of Soil and Water Conservation*. 58(5):319-326.

Table 1. Drip and sprinkler activation of herbicides in Ventura County trials, 2005-2010*.

Crop and irrigation method ¹	Weed control ²	
	% (from untreated)	
	Oxyfluorfen ³	Flumioxazin ⁴
Cabbage, (green), transplanted into drip-only irrigated beds	96	88
Celery, transplanted into dry beds, drip-only irrigation	87	87
Celery, transplanted in drip-only pre-irrigated beds	90	79
Cabbage, sprinkler irrigation	92	80
Celery, sprinkler irrigation	75	94

* No significant crop injury or effects on yield were observed in any of the treatments.

¹ All crops were planted 1 day after herbicide applications. In drip-only irrigation, a single high flow line irrigated 2 rows of crop plants. In sprinkler irrigation, overhead water was applied for the first 2-3 weeks after planting and the fields were consequently drip irrigated.

² Major weeds present were: nettleleaf goosefoot, mustards, burnings nettle, shepherd's-purse and annual sowthistle. The weeds were counted at three and six weeks after emergence and the total number compared to untreated check to obtain percent control.

³ Goaltender (oxyfluorfen) was applied at 0.25 lb a. i. /acre (1 pint)

⁴ Chateau (flumioxazin) 0.063 lbs a. i. /acre (2 oz/acre of product)

Weed Control as Part of Soil Disinfestation with Fumigants and Nonfumigants

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INTRODUCTION

Strawberries and vegetable crops are highly susceptible to weed competition immediately after planting when the plants are small and frequent irrigation provides ideal conditions for weed germination. In coastal California, most weeds that invade strawberries and vegetable crops are annuals. Weeds such as little mallow (cheeseweed), burclover, sweet clover, and filaree invade during stand establishment and are common problems in strawberry fields because their seeds survive fumigation. After strawberry transplanting, weeds with windblown seeds, including sowthistle and common groundsel, may become problems. In conventional strawberry fields, effective weed management requires a combination of cultural practices, preplant soil fumigation, and additional herbicide applications when necessary. Proper field and bed preparation is essential for a good weed control program. Fumigation with a mixture of 1,3-dichloropropene/chloropicrin (Telone C35, Inline, Pic Clor 60) or chloropicrin alone for disease control, followed by an application of metam sodium or metam potassium, are among the best alternative disease & weed control treatments available for California strawberry producers. The use of impermeable films enhances weed control provided by Inline and Pic Clor 60, but the higher cost of these films has limited their adoption. For weeds that escape preplant controls, hand-weeding and/or selective herbicides are used.

Nonfumigant methods of soil disinfestation such as solarization or steam use a lethal dose of heat to kill soil pests including weed seed.

Crop Rotation. Rotational crops can be an important part of a weed control program. Rotations can be vegetable crops such as celery, lettuce or cole crops, or cover/ green manure crops such as barley, cereal rye, oats, or wheat. Where the cropping cycle permits, sudangrass may be included in the rotation cycle as a summer annual green manure crop. Intensive cultivation of a vegetable crop rotation such as lettuce or a cole crop helps control many problem weeds. A densely planted cereal rye cover crop or small grain crop is highly competitive with weeds and provides better weed control than a legume cover crop. In addition, alternative herbicides are available in rotational crops. Difficult to control perennial weeds such as field bindweed must be controlled in fallow ground with timely applications of glyphosate. No strawberry production should be attempted while a field is infested with field bindweed, because no fumigant or herbicide available for strawberry can control this weed. Instead field bindweed should be controlled with herbicides during fallow periods and during other crop cycles.

KILLING WEED SEEDBANKS WITH FUMIGANTS AND NONFUMIGANTS

Fumigation. Fumigation with methyl bromide, Telone C35, Inline, Pic Clor 60, chloropicrin, and metam sodium (Vapam, Sectagon 42) before bed preparation kills the seeds of most weeds

and the reproductive structures of some perennials. Nearly all fumigant applications are either immediately covered with plastic mulch or are injected through the drip irrigation system under plastic mulch. Drip injection of fumigants such as Inline or chloropicrin often improves the weed control compared to shank fumigation of these same fumigants. However, it is important to thoroughly wet the planting bed during drip fumigant injection to ensure weed control on the edges of the bed. Where drip fumigation is used, only the bed is treated, and the row middles are not fumigated. Soil-applied herbicides such as flumioxazin, napropamide or pendimethalin can be used to control weeds in the row middles. Soil fumigants control weeds by killing both germinating seedlings and dormant/quiescent seeds. Methyl bromide, Inline, Telone C35, and metam sodium kill weed seedlings and seeds by respiration inhibition. However, to kill weed seeds, fumigants must be able to penetrate the seed coat and kill the seed embryo. It is more effective to kill moistened seed, because the seed tissues swell with water and allow the fumigant to penetrate more thoroughly. Moist seeds also have higher respiration rates and are more susceptible to fumigants than dry seed with low respiration rates. The need for adequate soil moisture to wet weed seed means that proper irrigation before fumigation is one of the keys to effective weeds control with all fumigants.

Heat. Heat treatment can be used for soil sterilization or pasteurization. Studies have shown that most plant pathogens, insects and weeds will die when moist soils are heated to temperatures of 150°F for 30 min. (Baker and Roistacher, 1957). Most annual weeds can be controlled by solarization (Hartz et al., 1993). Annual sowthistle, barnyardgrass, London rocket, black nightshade, common purslane and tumble pigweed were all susceptible to temperatures above 122°F (Dahlquist et al., 2007). Perennial and bulbous weeds are, however, hard to control via solarization (Linke, 1994). Those in the legume family with hard seed coat are also not controlled well with solarization (Linke, 1994). Weeds such as nutsedge can also sprout under solarization treatments and the resulting shoots are generally trapped under the clear tarp (Chase et al., 1998).

Seedbanks. Weed seeds in the soil are called the weed seedbank. Most weeds in the soil are dormant and only a fraction of the seeds are available to germinate under good conditions. Preemergence herbicides kill germinating seedlings, and therefore act on only a small fraction of the weed seedbank. Similarly, postemergence herbicides, cultivators and hoes only kill emerged weeds. Therefore, most of our weed control tools do not affect the dormant weed seedbank. Soil fumigants such as methyl bromide, and metam sodium are an exception and can kill dormant and nondormant weed seeds. Methyl bromide and other fumigants are respiration inhibitors. Dormant, nondormant, and germinating weed seeds are living organisms that respire, and therefore most can be killed with fumigants such as methyl bromide. However, not all weed species are susceptible to fumigants. Among those species that are tolerant to fumigants are: California burclover, sweet clover, little mallow and filaree. Those weed species are tolerant due to the presence of hard seed coats that prevent penetration of the fumigant through the seed coat (Figure 1). The hard seed coat also means that water cannot penetrate and the embryo is dry.

Wetting of seeds with water is necessary to make them swell and respire. Weed seeds that are dry are highly resistant to fumigants. Plant cells in the embryos of dry seed are tightly compacted and the fumigants can only move slowly through dry seed. In contrast, the wet weed seed has cells that are fully expanded and full of free water that allows the fumigant molecule to move more freely. Many people state that before fumigation you need to irrigate the field to “germinate weed seeds”. While it is true that fumigants do a good job of killing weed seedlings, fumigants can also kill ungerminated weed seeds with soft seed coats such as common chickweed. For hard coated seed such as clover, the only seed that will be killed are those that germinate. In summary, if you can get a lethal dose of

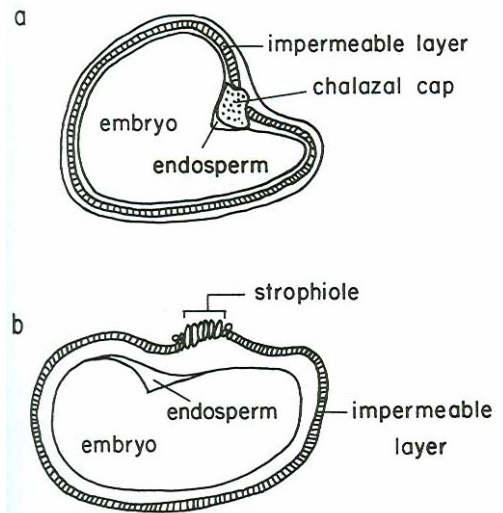


Figure 1. Hard-coated seeds that are difficult to kill with fumigants: a) little mallow, b) clover.

fumigant through the seed coat and into the embryo of a wet seed, then you can kill soft-coat weed seed whether it is germinating or not, but most hard coated seeds can only be killed if they germinate.

WHERE WEEDS MUST BE CONTROLLED

Weeds must be controlled on the top and shoulders of raised beds and in the furrow bottoms. Weed control on the bed top and shoulders are controlled by 1. fumigants, 2. herbicides, 3. mulches, 4. hand weeding.

Table 1. The optimum and maximum depths of emergence for several weeds (Radosevich and Holt 1984).

Weed	Optimum emergence depth (inches)	Maximum emergence depth (inches)
Annual bluegrass	0.4	0.8
Calif. burclover	0.5	--
Common chickweed	0.4	0.8
Common lambsquarters	0.2	1.9
Little mallow (cheeseweed)	0.5	--
Shepherd's-purse	0.2	0.8

Most weed seeds are small and emerge from shallow layers in the soil (Table 1). Because of this, the most critical zone for controlling weeds is the surface soil layer. To kill weed seeds in the surface layer, the fumigant concentration or temperature in the case of heat must reach the critical dose required to kill the weed seed.

Lethal fumigant doses. The objective of using a fumigant is to temporarily create conditions that are lethal for pests, and by doing so to disinfest the soil of pathogens and weed seed. Lethal conditions are created by maintaining the fumigant concentration above a critical level for a sufficient amount of time to kill the weed seed. The lethal conditions are usually described as the lethal dose required to kill 50 or 90 percent of a pest population (LD₅₀'s or LD₉₀'s). For example, Inline maintained at or above 130 lbs/A for 72 hours will kill 90 out of 100 chickweed seeds (Table 2).

Table 2. Inline dose (lbs/A) required to control 90% (LD₉₀) of weed seeds.

Weed species	LD ₉₀ lab (24 hour)	LD ₉₀ field (72 hour)
	----- Lbs/A -----	
Knotweed	340	180
Common chickweed	162	130
Common purslane	121	80
Little mallow (cheeseweed)	>4005	>400
Filaree	>4005	>400

Because weed seeds can emerge from shallow layers anywhere on the bedtop and bed shoulders, good lateral distribution of the fumigants within the bed is necessary. Fumigants applied by drip irrigation must be applied in sufficient water to move them to the edge of the bed at a high enough concentration to kill weed seeds. The edge of the bed is a particularly difficult area for the fumigant to penetrate at concentrations necessary to kill weed seeds there because of the longer distance from the drip tape that the fumigant must travel (see arrow in Figure 2). Proper soil moisture conditions are required to get the lateral distribution necessary for effective weed control at the edge of the bed.

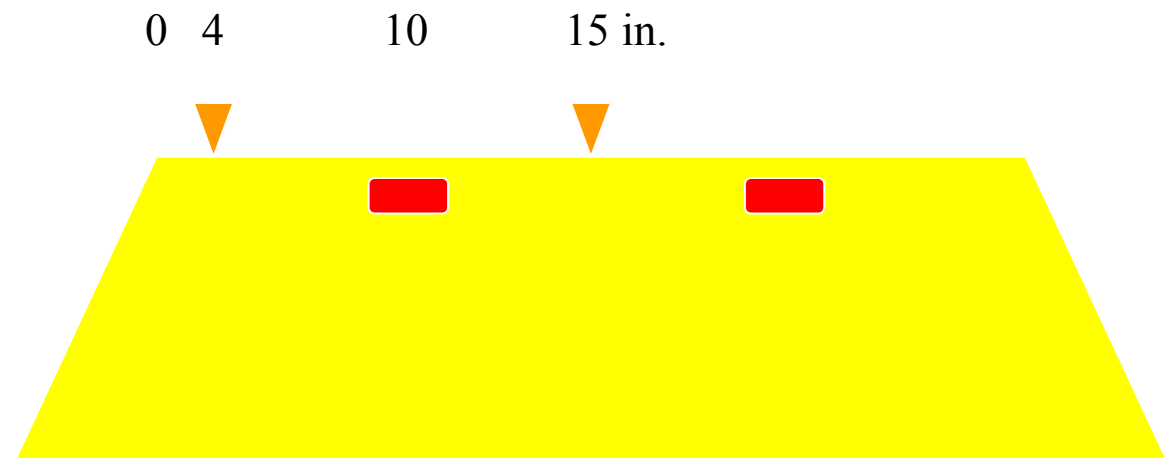


Figure 2. A strawberry bed fumigated by drip irrigation. The arrows show the locations in the center and edge of the bed (distance in inches from the edge) where it is more difficult to get the fumigant at concentrations needed to kill weed seeds.

Sequential applications of metam sodium. With the phase out of methyl bromide, the most effective soil fumigation treatments are a sequential application of chloropicrin or Inline followed 5 to 7 days later by metam sodium or metam potassium. This use of sequential application of complementary fumigants can provide effective control of weeds as well as soilborne pathogens, soil insects and nematodes.

Chloropicrin is effective on soilborne diseases, but less effective on weeds. Inline (1,3-dichloropropene plus chloropicrin) tends to provide better weed control than pure chloropicrin, but generally Inline provides less effective weed control than methyl bromide. One way to improve weed control with chloropicrin and Inline is to use a sequential application of metam sodium or metam potassium.

Metam sodium (Sectagon 42, Vapam HL and others) or metam potassium (Kpam) are used as sequential fumigants following drip applications of chloropicrin or Inline. In this procedure, chloropicrin or Inline can be applied through the drip irrigation system followed 5 to 7 days later by metam sodium/potassium applied through the drip irrigation system. It is necessary to have a 5 to 7 day interval between the chloropicrin or Inline application and the metam application due to chemical incompatibility between the products. Critical aspects to be aware of when using a sequential application of metam sodium/potassium are that: 1) soil must be in seed bed condition with clods no larger than 0.5 inches in diameter, 2) beds must be shaped and ready for planting, and 3) soil moisture must be 50 to 80% of field capacity at time of application. These factors are important to ensure good fumigant distribution throughout the soil profile and to ensure that viable weed seed are moist and easier to kill. It is important to avoid soil disturbance after treatment to avoid movement of viable weed seeds from deeper layers to the soil surface.

USE OF IMPERMEABLE FILMS WITH FUMIGANTS

Impermeable films are designed to reduce fumigant emissions to near zero (Figure 3). Researchers have found that, if impermeable films can be installed intact with minimal stretching or tearing, then fumigant emission is reduced. Reduction of fumigant emissions by impermeable film causes an increase in the fumigant concentration under the tarp. Because fumigant concentrations are higher under impermeable film, more weed seeds are killed and weed control is improved.



Figure 3. Impermeable film consists of at least three layers. In the three layer film shown above, the top and bottom layers consist of normal polyethylene tarp, and the middle layer consists of an impermeable layer.

SUMMARY

The keys to effective weed control with fumigants and heat in strawberry and vegetables are:

1. Careful field selection to avoid difficult to control perennial weeds and severe annual weed populations.
2. Ensure proper soil moisture at time of fumigation so that weed seeds either germinate, or that dormant seed can absorb fumigants.
3. Ensure good lateral distribution of fumigant in the planting bed to control weeds throughout the bed.
4. Sequential applications of metam sodium or metam potassium following chloropicrin or Inline can improve weed control.
5. Increased retention of fumigants with impermeable film can improve weed control.
6. The activity of heat for soil disinfestation with steam or solarization is similar to the activity of fumigants that kill weed seed. Fumigants kill weed seed by reaching lethal concentrations, and heat kills weed seed by reaching lethal temperatures.

References

- Baker, K.F. and C.N. Roistacher. 1957. In: Baker, K.F. The U.C. system for producing healthy container-grown plants. Calif. Agric. Exper. Sta. Ext. Serv. Manual 23.
- Chase, C.A., T.R. Sinclair, D.G. Shilling, J.P. Gilreath, and S.J. Locascio. 1998. Light effects on rhizome morphogenesis in nutsedges (*Cyperus* spp.): implications for control by soil solarization. *Weed Sci.* 46:575-580.
- Dahlquist, R.M., T.S. Prather, and J.J. Stapleton. 2007. Time and temperature requirements for weed seed thermal death. *Weed Sci.* 55:619-625.
- Hartz, T.K., J.E. DeVay, and C.L. Elmore. 1993. Solarization is an effective soil disinfestation technique for strawberry production. *HortScience* 28:104-106.
- Linke, K.H. 1994. Effects of soil solarization on arable weeds under Mediterranean conditions: control, lack of response or stimulation. *Crop Protection* 13:115-120.

A PCA's Perspective on Weed Control in Vegetables

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Introduction:

Started as a PCA for Coastal Ag-Chemical in 1976.

Listened intently to the older PCAs for their wise experiences.

Went independent in 1980.

Celery has been my main crop over the years, but I have also walked a wide array of other vegetable crops and some strawberries.

What has changed over the years:

Celery

36 years ago we were using Caparol and Lorox. Our main herbicides now are Caparol and Lorox. We use them overall or over the drip hose at a reduced rate. We have used them pre-transplant during the seeder period, but control was weak and weeding was expensive. When was the last time you heard a chemical rep say "We have this new selective herbicide for celery that is unbelievable"?

For grasses we were using Treflan. Efficacy was poor. Progressed to Treflan pre-plant, Poast plus Lorox post-emergent. Results were much better for most grasses. Changed to Prism, Shadow or Select Max (Clethodim). Results were excellent. We have been using the Shadow w/ Lorox for nut sedge suppression. Have been seeing synergy activity. It is the only selective herbicide registered for celery since becoming a PCA.

I have been using surfactants with Lorox for years. Just recently started using a MSO surfactant (Dynamic). I haven't seen any extra phytotoxic effects at all. I have been able to pick up more of the groundsel, larger and the entire burning nettle and knot weed which use to come through the Lorox before.

I had a look at Dual Magnum on nutsedge. At the high rate we got pretty good suppression, but in one trial we had some definite stunting while the other trial looked fine. Nutsedge isn't as bad in Ventura without onions being grown.

The only thing changed in celery for me is the use of Select Max and the use of surfactants over the years.

Cole Crops

How many people remember Tok herbicide? Active ingredient is nitrofen. Tok was banned in the late 70's or early 80's as a mutagen I think. It was the herbicide of choice then: a selective herbicide with no phytotoxic effects at all for both transplants and direct seeded Cole crops. After all these years we still haven't replace it as a truly selective herbicide.

We have some selective herbicides we are using now. Goaltender and Prefar are the two we are using in Ventura County. We use Goaltender on Cabbage and Broccoli and Prefar on the bunched coles like Mustard Greens, Kale and Collards. We also used some Dacthal pre-emergent and AN-20 post-emergent in the past.

Goaltender works really well on transplant crops. You can't use Goaltender on seeded Cole Crops because of the phytotoxins on the cotyledon leaves. It's a good thing that most of the Cole Crops in the county are transplanted because of the lack of a good pre-emergent herbicide. We also can't get it to work during the warmer months of the summer in Ventura County. For some reason we lose almost all activity when the temperature reaches around 90. We have tried timing, surfactants, encapsulating, higher rates etc. We are still looking for an answer to this temperature problem.

Prefar is one of those herbicides that are a better than nothing product. We don't have the correct weed spectrum that it works well on. That's why I call it a better than nothing product. You are still going to weed the field if you use Prefar.

Leaf Lettuce

Started using Kerb in 1976. Kerb is still the best herbicide on leaf lettuce now, if you can get it. We really need re-registration on this product. Any other product is a better than nothing product. Prefar is the only other choice. Another reason that we need the registration of Caparol on Cilantro is the only product registered is the ineffective Prefar.

With the lack of effective herbicides we my growers are more aware of keeping their fields cleaner through weeding. One dirty crop and you are paying for that problem for the next 5 years. We are also looking at the neighboring areas for volunteer weeds that may blow in such as groundsel, thistle and ragweed. We've had problems with manure spread on our ground, which was stored next to weedy surroundings. You have to make sure anything spread on your field is clean.

What can we do in the future? Try different things and keep an open mind. Think outside the box. You never know what is going to work.

Industry Update on New Developments in Weed Control in Vegetables

*Jesse M. Richardson, Dow AgroSciences, 9330 10th Ave., Hesperia, CA 92345,
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Two new developments in weed control have been introduced to lettuce producers in California and Arizona. The first is Kerb[®] SC, a new formulation from Dow AgroSciences. This formulation is easier to use than Kerb[®] 50-W. Field research conducted in California and Arizona demonstrated that the new formulation provides weed control and crop safety that is similar to the original formulation.

The second new development is a Kerb[®] SC split chemigation application label, which allows part of the maximum allowable application rate to be initially applied to head lettuce, endive, escarole or radicchio greens, and the balance of the maximum allowable application rate can be applied up to 10 days later. Field research conducted in Bard, CA demonstrated that a split chemigation application of Kerb[®] SC gave better control of nettleleaf goosefoot than a single chemigation application of Kerb[®] SC at 0.5 or 0.63 lb a.i./acre. However, no advantage was seen to the split chemigation application in common purslane and sowthistle control.

[®]Trademark of Dow AgroSciences LLC. KERB SC is not registered for sale or use in all states. Contact your state pesticide regulatory agency to determine if a product is registered for sale or use in your state. Kerb is a federally Restricted Use Pesticide. Always read and follow label directions.

Personal Protective Equipment For Pesticide Applicators

Robert Krieger, Ph. D.

Cooperative Extension Specialist, Toxicology

Department of Entomology, University of California, Riverside

Pesticide label requirements, company policy, or your own judgment may result in use of Personal Protective Equipment (PPE) during pesticide handling to minimize exposure. The overall goal is to reduce risk by minimizing the pesticide exposure factor from the handling of pesticides based on the general expression, $Risk = Hazard \times Exposure$. Handling includes mixing, loading, and applying pesticides and other work tasks in which concentrates or formulations are used. Basic worker protection standard (WPS) clothing includes long sleeved shirt, long pants, socks and shoes. These clothes are important protection against pesticide particles or liquids that may contact the skin, the most important route of exposure during normal work activities. Skin contact, inhalation, and incidental oral contact with pesticides are exposures with the potential for absorption. Risk is the likelihood of harm resulting from contact with a hazardous substance (pesticide) and the amount of exposure. Guidelines for the use of WPS clothing and PPE are intended to reduce the likelihood of exposure and as a result, reduce risk.

Laws and Regulations Jeopardy

David Chang, County of Santa Barbara Agricultural Commissioner's Office, 263 Camino del Remedio, Santa Barbara CA 93110, dchang@co.santa-barbara.ca.us

While many pesticides being used and developed today are safer than ever to use, pesticides must nevertheless be applied according to the laws and regulations of the California Food and Agricultural Code and California Code of Regulations. Compliance with the regulations protects not only the applicator, customer, and the environment, but also protects the pest control company, farmer, and any pesticide user from potential lawsuits by the public, by disgruntled employees, and from enforcement actions by the local agricultural commissioner, because non-compliance immediately places the employer and employee in an untenable position.

Employers must properly train their employees and provide them with appropriate safety gear. Employers should make it easy for their employees to comply by providing properly maintained and comfortable safety gear, treating their employees fairly, and stressing the importance of professionalism in their work ethic by being professional in their own attention to compliance with the regulations.

The regulations promote professionalism and responsible application by licensed and certified application companies. Documentation of compliance through licensing, training records, written safety programs, and pesticide use reports is mandated by the regulations.

The county agricultural commissioners and the California Department of Pesticide Regulation would prefer to catch you applying pesticides properly rather than forcing you to correct your procedures with disciplinary enforcement.

The laws, as promulgated by the state legislature, governing pesticide applications in California are contained in the California Food and Agriculture Code; primarily in Division 6. Pest Control Operations with some laws contained in Division 2. Local Administration; Division 7. Agricultural Chemicals, Livestock Remedies, and Commercial Feeds; and Division 13. Bee Management and Honey Production. The California Department of Pesticide Regulation, and the agricultural commissioners further govern pesticide application by also enforcing Title 3. Food and Agriculture, Division 6. Pesticides and Pest Control Operations of the California Code of Regulations; and Division 3. Professions and Vocations Generally, of the California Business and Profession Code as enacted by the Structural Pest Control Act.

Pesticide Laws and Regulations Jeopardy emulates the Jeopardy television game show, and was developed as an engaging way to present the sometimes mundane details of the laws and regulations. Rather than attempt a summary of the proceedings, here, it is perhaps more useful to direct the audience to these three internet websites for more information:

- California Food and Agriculture Code:
www.leginfo.ca.gov/cgi-bin/calawquery?codesection=fac&codebody=&hits=20
- California Code of Regulations:
www.calregs.com/linkedslice/default.asp?SP=CCR-1000&Action=Welcome
- California Department of Pesticide Regulation – Laws and Legislation:
www.cdpr.ca.gov/docs/legbills/opramenu.htm

Pesticide Labeling Interpretation

Victor B. Acosta, Staff Environmental Scientist, Pesticide Enforcement Branch, Department of Pesticide Regulation, California Environmental Protection Agency, vacosta@cdpr.ca.gov

The role of regulating pesticides in California is a joint responsibility of the Director of the Department of Pesticide Regulation (DPR) and county agricultural commissioners (CACs). Food and Agricultural Code (FAC) section 2281 provides that DPR is responsible for overall statewide enforcement and for issuing instructions and making recommendations to the CACs.

The CACs are responsible for local administration of the pesticide use enforcement program. Several other FAC sections (11501.5, 12977, 12982, 14004.5, and 15201) state that CACs conduct pesticide work under the direction and supervision of the Director. The *Pesticide Use Enforcement Program Standards Compendium* (Referred to as the Compendium) is the vehicle used by DPR to deliver DPR's guidance to the CAC's in the form of instructions and recommendations.

The Compendium is a series of eight manuals that contain pesticide use enforcement directives, interpretations, recommendations, and expectations. The Compendium represents the Pesticide Use Enforcement Program's "standard operating procedures." Contents of the Compendium supersede any position or direction on these subjects contained in previous letters to CACs or earlier manuals.

Guidelines for interpreting pesticide product labeling is found in Volume 8 of DPR's compendium. The link is (<http://www.cdpr.ca.gov/docs/enforce/compend.htm>). Volume 8 – Guidelines for Interpreting Laws, Regulations and Labeling includes DPR interpretations of various sections of law and regulations, and guidance on interpreting pesticide labeling, including interpretations of some general and specific labeling statements. It is cross-indexed by subject and section of the law or regulation addressed. Volume 8 is divided into 8 chapters. The guidelines for interpreting pesticide product labeling are found in Chapters 1 through 4 that address General Interpretation Guidelines, Pesticide Product Labeling Interpretations, Specific Labeling Statement Interpretations and DPR Specific Use Site Interpretations respectively. Chapters five through eight address guidance relating to Supplemental labeling, Worker Safety, Pesticide Product Registration, and Research Authorizations respectively.

This presentation will cover the first four chapters in Volume 8. From each chapter, I have selected specific guidelines established by U.S. EPA and DPR that are essential in interpreting pesticide product label and labeling as follows:

- Starting with “General interpretation guidelines” it is very important for you to understand definitions and examples given for: Agricultural use and Non-agricultural use; and production and non-production uses.
- As it relates to interpreting “Pesticide product labeling”, there are established guidance For understanding the definitions of: Label and labeling, Mandatory vs. Advisory, Conflict with labeling exemptions (2ee), and Site listing – Inclusive vs. Exclusive.
- Specific labeling Statement interpretations include: “Avoid breathing spray mists or dusts”, Bee protection statements, Feed restrictions statements, Harvest date, physically present (Certified Applicator), Plant back restrictions and Professional applicator statements.
- DPR Specific Use Site Interpretations include: Cropland/field crops, Non-crop land areas, Fallow land, and Bee protection statements.

Available tools and resources that is available for interpreting pesticide labeling:

- Food and Agricultural Code
- California Code of Regulations.
- Pesticide Use Enforcement Program Standards Compendium
- Internet Resources via Registration Branch Home Page
<http://www.cdpr.ca.gov/docs/label/abelque.htm>
 - Pesticide Registration Branch (Query DPR Databases)
 - Product/label
 - Section 24 labeling
 - Section 18 Exemptions
 - National Pesticide Information Retrieval System (NPIRS)
Maintained by Purdue University
 - U. S. EPA’s Pesticide Information Retrieval System (PR Notices)
 - U. S. EPA’s State Label Issue Tracking System (SLITS)
- U.S. EPA label Review Manual 3rd Edition
<http://www.epa.gov/oppfead1/labeling/lrm/>
- Title 40 Code of Federal Regulations
http://www.access.gpo.gov/nara/cfr/waisidx_02/40cfrv20_02.html.
- American Society of Agricultural and Biological Engineers (ASABE) Standards.

California Pesticide Issues Update
Renee Pinel, Western Plant Health Association
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California 2011 Legislation

2011 was a busy year legislatively despite the fact that the state continued to be broke.

- AB 88 – Assemblyman Huffman: Bill would require all GMO salmon to be labeled. Would set precedent that would be applied to all forms of GMO commodities.
- AB 553 – Would require that permissible exposure limits (PEL's) set by OSHA must correspond with health based exposure limits set by OEHHA. Since OEHHA exposure limits would undoubtedly be much lower, worker exposure limits would be dramatically lowered impacting ability of workers to utilize pesticides particularly fumigants.
- AB 1176 – Assemblymember Williams. Would require pesticides designated by DPR as toxic air contaminants (TAC's) to be reviewed by other agencies including ARB, OEHHA, local air districts in determining appropriate control measures. This would dramatically extend the registration process for pesticides, beginning with fumigants with mitigation controls set well below current standards and ongoing litigation.

California 2011 Legislation

- SB 394 – Senator DeSaulier. Originally would have banned most pesticides/herbicides from use in or around schools. Would have required every school to have an “IPM specialist” on site to authorize the use of any product. Registrants of the products banned from use at schools would have funded the IPM specialist position through a fee. Bill was amended due to cost removing language prohibiting most products and only requiring each district or school to have a designated staff person undergo mandatory IPM training. Bill was re-amended this year back to banning most products not contained in bait stations or gels.

- SB 900 - Senator Steinberg . Originally designed to address the problematic conflict of interest requirements that impact regional water boards. Currently requirements disallow agricultural or local government participation. Legislation would have set water board standards to be reflective of the legislature. Bill was held in committee until gutted, by environmental groups. Governor is indicating he wants to use this bill as a vehicle for his re-alignment of regional water boards.
- California 2012 Legislation
- All of the legislation described earlier for 2011 was held in committees. However, due to the two year California legislative session, all of these bills were eligible to be continued in 2012.
- Good news, all of these bills (except the Governor’s water board re-alignment which was out of its house of origin) were held in committee last week and so died. Bad news, they will all likely be re-introduced in 2012. However, due to California’s ongoing economic issues it will be difficult to move these bills beyond Appropriations.
- The continuing activism surrounding the registration of a new fumigant will result in the introduction of more legislation aimed at making it more difficult to register a product in California or set control measure impractical for industry.
- Environmental Justice
- Environmental Justice is defined as the “fair treatment for people of all races, cultures, and incomes, regarding the development of environmental laws, regulations, and policies.”
- Cal-EPA adopted this concept through regulations, and all boards, departments, and agencies must comply.

Environmental Justice & Air Quality

- Mendota Air Monitoring Project
 - DPR will be partnering with UC Davis to monitor approximately 30 pesticides in and around homes of 100 farm worker families in Mendota.

- Goal is to compare exposure of pesticides used in the home vs. agricultural pesticides
- Air Monitoring Network
 - DPR is looking to do air monitoring studies of 3 communities for the next 5 years.
 - Will be looking to compare exposures to pesticides used in the home and agricultural pesticides.
 - Will be monitoring approximately 21 – 25 pesticides.
- Environmental Justice & Air Quality
- List of Communities for Monitoring
 - Linden/Ripon: San Joaquin Co.
 - Shafter/Wasco: Kern
 - Greenfield/Salinas/Castroville: Monterey

Air Quality Issues

- List of Pesticides for Monitoring

<ul style="list-style-type: none"> - Chlorothalonil (Bravo) - Chlorpyrifos (Lorsban) - Cypermethrin - Diazinon - Dicofol (Kelthane) - Dimethoate (Cygon) - Diuron (Karmex) - Endosulfan (Thiodan) - EPTC (Eptam) - Malathion - Baked as dichiovos (DDVP) - 1,3-Dichloropropene (Telone, Incline) - Sodium tetrathiocarbonate (Enzone) 	<ul style="list-style-type: none"> - Norfluazon (Solicam) - Oryzalin (Surflan) - Oxyfluorfen (Goal) - Permethrin - Phosmet (Imidan) - Propargite (Omite) - S,S,S-tributyl - phosphorotrithioate (DEF) - Simazine (Princep) - S-metolachlor (Dual) - Trifluralin (Treflan) - Acrolein (Magnacide) - Methyl Bromide
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- Also under consideration but with less sampling is: Chloropicrin, Metam-sodium, Metam-potassium & dazomet (Vapam) as methyl isothiocyanate (MITC)

Air Quality Issues

Non-Fumigant Pesticide VOC's

- DPR focused on 4 AIs:
 - Abamectin
 - Chlorpyrifos
 - Gibberellins
 - Oxyfluorfen
- These 4 AI's are the largest use chemicals, so rather than trying to regulate dozens of chemicals in use for small reductions, focus on a few and try to obtain larger reductions.
- If enforcement is necessary DPR is looking at options including having these AI's become restricted use (Ag commissioner approval), retailers authorize sale of higher emitting products, or having PCA's authorize sale of higher emitting products.

DPR planning on releasing proposal this spring with a final rule by spring 2013.

Surface Water Regulations

DPR is submitting surface water quality regulations impacting the urban use of approximately 70 products. When they are finalized the regulations will impact:

- Non-Ag Agriculture
- Industrial Weed Control
- Professional Applications
- Home use via labels
- Focus of regulations are aimed at:
 - Sensitive aquatic sites
 - Runoff likely to enter storm water systems

DPR developing its water quality criteria and methodology that will be extremely important as they move toward developing regulations for agricultural products.

Water Quality Issues

Pyrethroid Re-Evaluation

DPR has undertaken the largest re-evaluation in the history of the department. Currently 1,300 products are under review, excluding natural pyrethrins.

Much of the concern is driven by Water Agencies afraid of being sued by environmental groups over pyrethroid levels.

It is now considered much more likely that urban users are responsible via pet products, outdoor wear laundering, etc., for the levels.

Water agencies will now have to monitor before and after treatment.

WPHA has been working with the Pyrethroid Working Group (PWG), made up of registrants, and who are providing DPR with most of the scientific data on actual contributions and mitigation processes.

The PWG conducted a study in 2009 which establishes that pyrethroids are the largest classes being purchased by consumers.

Pyrethroid Re-Evaluation

- DPR is now shifting the focus to a smaller group of pyrethroids dependant on use rather than chemistry.
- Focus is now on:
 - Pyrethroids used outdoors in residential, industrial, and institutional settings.
 - Possibly may address diazinon & chlorpyrifos in agriculture.

The focused approach should provide a more detailed analysis of the problem.

Should incrementally address surface water contamination.

California Budget Deficit Impacts

- Major Impacts to CDFA
 - General fund reduction of \$18 million in 2011 and another \$12 million this year.
 - Ag Commissioners could have impacts through re-distribution of uncollected gas tax.
 - Counties will have to backfill programs like Med fly Preventive Release Program through other funds.
 - Industry will have to fund programs like Pierce's Disease Program.
 - Elimination of eradication efforts within the Red Imported Fire Ant Program.
 - Programs will have to become self-supporting through registration or packaging fees.

California Weed Science Society
Custom Summary Report
July 1, 2011 through May 23, 2012

Ordinary Income/Expense

Income

4000 · Registration Income	85,073.00
4001 · Membership Income	420.00
4010 · Proceedings Income	2,376.54
4020 · Exhibit Income	19,161.00
4030 · Sponsor Income	10,750.00
4065 · Orchid Fundraiser	875.00
4070 · Football Reception Fundraiser	1,400.00
4290 · Refunds	-2,070.00

Total Income 117,985.54

Expense

4300 · Conference Accreditation	145.00
4320 · Conference Catering Expense	48,234.73
4360 · Student Awards/Poster Expense	1,500.00
4361 · Awards-Board/Special Recog.	145.43
4362 · Fundraiser Supply Expense	1,226.46
4370 · Scholarship Expense	10,000.00
4380 · Conference Supplies	550.10
6090 · Advertising	1,462.50
6120 · Bank Service Charges	2,591.68
6130 · Board Meeting Expenses	1,209.06
6240 · Insurance - General	3,065.00
6270 · Legal & Accounting	1,800.50
6280 · Mail Box Rental Expense	33.37
6307 · Outside Services - PAPA	39,097.33
6340 · Postage/Shipping Expense	1,602.87
6345 · Printing Expense - Newsletter	2,467.91
6355 · Website Expense	1,500.00
6360 · Storage Rental Expense	264.00
6390 · CWSS Textbook	1,500.00
6440 · Supplies Expense	434.55
6500 · Taxes - Other	10.00
6520 · Telephone/Internet Expense	588.57
6530 · Travel - Transport/Lodging	1,068.72
6540 · Travel - Meals/Entertainment	1,139.23
6545 · Student Travel - Transport/Lodg	789.10
6550 · Student Travel - Meals	146.59

Total Expense 122,572.70

Net Ordinary Income -4,587.16

Net Income -4,587.16

RBC Wealth Management Acct

Balance as of 4/30/12
\$257,319.29
27% Cash & money market
5% US equities
67% Taxable fixed income
1% Other assets

CWSS HONORARY MEMBERS LISTING

Harry Agamalian (1983)
Norman Akesson (1998)
Floyd Ashton (1990)
Alvin Baber (1995)
Walter Ball *
Dave Bayer (1986)
Carl E. Bell (2010)
Lester Berry
Tim Butler (2008)
Mick Canevari (2008)
Don Colbert (2002)
Floyd Colbert (1987)
Stephen Colbert (2012)
Alden Crafts *
Marcus Cravens *
Dave Cudney (1998)
Richard Dana
Boysie Day *
Nate Dechoretz (2003)
Jim Dewlen (1979)*
Paul Dresher *
Ken Dunster (1993)*
Matt Elhardt (2005)
Clyde Elmore (1994)
Bill Fischer *
Dick Fosse *
Tad Gantenbein (2004)
Rick Geddes (2006)
George Gowgani
Bill Harvey *
David Haskell (2009)
F. Dan Hess (2001)*
Floyd Holmes (1979)
Nelroy Jackson (1997)
Warren Johnson (1977)*
Bruce Kidd (2009)
Jim Koehler
Harold Kempen (1988)
Don Koehler (2003)*

Butch Kreps (1987)
Edward Kurtz (1992)
Art Lange (1986)
Wayne T. Lanini (2011)
J. Robert C. Leavitt (2010)
Oliver Leonard *
Jim McHenry
Bob Meeks
Bob Mullen (1996)
Robert Norris (2002)
Ralph Offutt
Jack Orr (1999)
Ruben Pahl (1990)
Martin Pruett
Murray Pryor *
Richard Raynor
Howard Rhoads *
Jesse Richardson (2000)
Ed Rose (1991)
Conrad Schilling *
Jack Schlesselman (1999)
Vince Schweers (2003)
Deb Shatley (2009)
Conrad Skimina (2003)
Leslie Sonder *
Stan Strew
Huey Sykes (1989)
Tom Thomson (1999)
Robert Underhill
Lee VanDeren (1983) *
Ron Vargas (2001)
Stan Walton (1988) *
Bryant Washburn (1988)
Steve Wright (2007)

*Deceased

CWSS AWARD OF EXCELLENCE MEMBERS LISTING

- 1985 June McCaskell, Jack Schlesselman & Tom Yutani
- 1986 Harry Agamalian, Floyd Colbert & Ed Rose
- 1987 Bruce Ames, Pam Jones, & Steve Orloff
- 1988 Bill Clark & Linda Romander
- 1989 Earl Suber
- 1990 Ron Hanson & Phil Larson
- 1991 John Arvik & Elin Miller
- 1992 Don Colbert & Ron Kelley
- 1993 Ron Vargas
- 1994 Jim Cook & Robert Norris
- 1995 Mick Canevari & Rich Waegner
- 1996 Galen Hiatt & Bill Tidwell
- 1997 David Haskell & Louis Hearn
- 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
- 2008 Dan Bryant & Will Crites
- 2008 Ken Dunster* & Ron Vargas*
- 2009 Ellen Dean & Wayne T. Lanini
- 2010 Lars W.J. Anderson & Stephen F. Colbert
- 2011 Jennifer Malcolm & Hugo Ramirez
- 2012 Rob Wilson

*President's Award for Lifetime Achievement in Weed Science

64TH ANNUAL CALIFORNIA WEED SCIENCE MEETING
JANUARY 23, 2012 - JANUARY 25, 2012

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64TH ANNUAL CALIFORNIA WEED SCIENCE MEETING
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64TH ANNUAL CALIFORNIA WEED SCIENCE MEETING
JANUARY 23, 2012 - JANUARY 25, 2012

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64TH ANNUAL CALIFORNIA WEED SCIENCE MEETING

JANUARY 23, 2012 - JANUARY 25, 2012

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64TH ANNUAL CALIFORNIA WEED SCIENCE MEETING
JANUARY 23, 2012 - JANUARY 25, 2012

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64TH ANNUAL CALIFORNIA WEED SCIENCE MEETING
JANUARY 23, 2012 - JANUARY 25, 2012

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64TH ANNUAL CALIFORNIA WEED SCIENCE MEETING
JANUARY 23, 2012 - JANUARY 25, 2012

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64TH ANNUAL CALIFORNIA WEED SCIENCE MEETING
JANUARY 23, 2012 - JANUARY 25, 2012

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64TH ANNUAL CALIFORNIA WEED SCIENCE MEETING
JANUARY 23, 2012 - JANUARY 25, 2012

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64TH ANNUAL CALIFORNIA WEED SCIENCE MEETING
JANUARY 23, 2012 - JANUARY 25, 2012

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64TH ANNUAL CALIFORNIA WEED SCIENCE MEETING
JANUARY 23, 2012 - JANUARY 25, 2012

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64TH ANNUAL CALIFORNIA WEED SCIENCE MEETING
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California's Growing Marijuana Business Impacting Agriculture

Article written by Harry Cline, Western Farm Press, February 8, 2012 (reprinted with permission)

California prides itself on feeding America.

It also has the dubious distinction of being America's biggest dope supplier.

Approximately 75 percent of the marijuana sold in the U.S. is grown in California — not Mexico, according to Sgt. Mike Horne of the Ventura County (Calif.) Sheriff's Department narcotics bureau. Horne heads a six-man commando-like unit that uses helicopters and rugged all-terrain vehicles to search and destroy marijuana growing operations in the national forest of his county.

This is not the typical article you find in an agricultural publication. However, Horne made his comments in a very typical agricultural setting, the recent California Weed Science Society annual meeting in Santa Barbara, Calif. The weed Horne was talking about has likely never been the topic of the society's annual meeting in its 64-year history, where the presentations center around controlling unwanted weeds like horseweed, morningglory and Johnsongrass — not pot.

Horne was invited to speak on marijuana cultivation as the tentacles of these illegal operations pervade the rural, agricultural areas of the state. Marijuana cultivation has grown to the point where it is making it dangerous for government employees like University of California Cooperative Extension farm advisors to do their jobs.

Michelle Le Strange, UCCE farm advisor in Tulare County and immediate past president of CWSS, said she has been warned by county officials and law enforcement officers that she should be alert in driving a county vehicle in rural areas because marijuana plantation tenders might think she is a law enforcement officer, and she could be in danger.

Horne said Le Strange and any government officials driving vehicles with government plates should be concerned because these marijuana plantations are operated by Mexican drug cartels, the same lawless gangs who are responsible for thousands of murders each year in Mexico. These cartels actually scour the U.S. Forrest Service lands in search of ideal growing sites, often adjacent to running streams. The cartels stock these plantations with people, drip irrigation tubing and chemicals to farm the illegal weed.

Horne showed a video and photos of what his men have uncovered in the national forests. As

expected, there were neatly planted marijuana rows with drip irrigation tubing, the same as used by farmers. More chilling to the CWSS audience were the photos of not only automatic weapons confiscated in a raid, but pictures of chemicals and fertilizers used in these growing operations. The logos of many very prominent ag chem and fertilizer companies were clearly visible. There were also photos of ag chem products manufactured in Mexico, brought in by the cartels. Horne said many of those chemicals are not legal in the U.S.

Le Strange pointed out that chemicals and fertilizers used in these growing operations could well find their way in to streams and lakes. The unsuspecting public is likely to put the blame on agriculture for any contamination from these illegal chemicals or misuse of U.S. registered products.

The national forest marijuana problem is not new, but it is growing, becoming more sophisticated and more dangerous with the cartel involvement. Workers in these plantations are armed with automatic assault rifles.

In recent years, marijuana growing has flourished in California's rich agricultural valleys. This has been precipitated by California's new medical marijuana laws. Illegal drug dealers are operating under the guise of growing medical marijuana. One large-scale growing operation raided by county sheriff's officials just east of Fresno was in an area of small vegetable farms. On the fence surrounding the pot farm letters were posted professing that it was a medical marijuana operation. Many of the letters were duplicated and tacked on the fence of the raided farm. Sheriff's deputies had traced the marijuana grown there to illegal drug sales on the East Coast.

Horne said Asian gangs are leasing agricultural land for these marijuana operations.

Horne cited official statements that only 15 percent of marijuana growing operations on federal land are detected and destroyed each year. He disagrees with that, at least in his county, where he said his task force takes out 50 percent to 70 percent of the operations.

What he did not dispute is the size of the problem statewide. Horne said it has been estimated that there are 71,000 acres of marijuana under cultivation each year in California. That represents 121 square miles or an area equivalent to the size of Sacramento.

Horne said they are so plentiful, it is common for hunters and hikers to stumble across marijuana plantations.

These operations have also been linked to wildlife deaths from drinking polluted water and several have been linked to starting forest fires.

Off-Site Movement of Herbicides

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The fate of herbicides or other pesticides in the environment can be grouped broadly into “degradation processes” and “transfer processes”. *Degradation* implies one or more changes in chemical structure that alters the potency or activity of the compound. Usually this means reduced phytotoxic activity but there are cases where intermediate degradation products also have some level of activity. Generally speaking, all herbicides degrade in the environment but the rate of degradation can vary widely among specific herbicides and environments. *Transfer* processes, on the other hand, refer to changes in the location or availability of the herbicide not associated with changes in the chemical structure. There are four primary ways that herbicides can move off-site: volatilization, physical particle movement, water (leaching or runoff), and through uptake and removal in plants or animals. The potential for any type of off-site herbicide movement is greatly affected by the chemistry of the specific herbicide and the environmental conditions.

Off-target vs off-site:

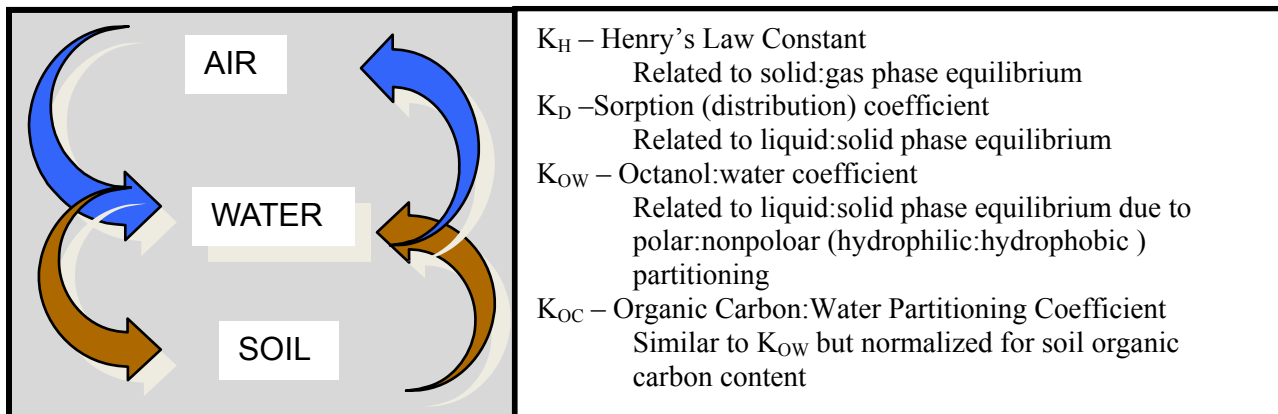
Two similar sounding terms have very different meanings in the context of herbicide applications. Off-target applications are those that miss the target site or zone. For example, the target of a post emergence herbicide is weed foliage. Thus, a post emergence herbicide that misses the plant and hits the soil technically is “off target”. Similarly, a soil-applied herbicide is usually targeted to the surface of the soil or a shallow three dimensional layer of soil to ensure that germinating seedling are exposed to the herbicide. Herbicides incorporated too deeply or not deep enough are not on target. While obviously these are not ideal situations, off target applications usually result simple cases of reduced weed control efficacy and wasted money. Of greater concern for the environments are cases of off-site herbicide movement. Off-site movement refers to herbicides that misses or moves from the treated zone. The intended treatment zone could include whole fields or portions of a field such as blocks, strips, berms, furrows. The intended site could also be defined areas such as road shoulders, fence rows, lawns, or landscape areas or even individual plants. Herbicides that move off site also reduce efficiency and economics of weed control but can also result in non-target plant injury, environmental contamination, legal issues, and negative public perceptions of weed management operations and agriculture in general.

Herbicide Chemistry:

The chemical structure and formulation of an herbicide can have a large impact on the potential for off-site herbicide movement and the most likely routes of movement. The chemistry of the herbicide directly impacts the solubility, volatility, stability, and phase equilibrium of the product in the soil and water environment. With any pesticide in a relatively stable environment, the

active ingredient will reach an equilibrium (not necessarily equality) among the solid, water, and gas phases of the soil or water environment. There can also be significant interaction between specific herbicides and the environment, especially soil type, texture, pH, organic matter content, and moisture.

Figure: generalized herbicide partitioning diagram and coefficients.



Information on the phase partitioning of many herbicides is available online or in resources such as the WSSA Herbicide Handbook. In general, herbicides with relatively lower Henry’s Law Constant (K_H) tend to partition into the liquid or solid phase while higher K_H values are associated with greater partitioning into the gas phase (more volatile). Compounds with high sorption coefficients (either K_d or K_{oc}) tend to be more tightly bound to soil particles or soil organic matter while products with low sorption are less tightly bound and tend towards the liquid phase. Lipophilic herbicides (those with high K_{ow}) tend to bind to lipids, especially those in organic matter while low K_{ow} compounds are much more likely to be found in the water phase. It is important to remember that these are “rules of thumb” and behavior of any herbicide depends simultaneously on all of these coefficients and other factors.

Volatilization

Movement of volatile herbicides generally is due to herbicide active ingredients that “evaporate” from leaf or soil surfaces after deposition on the intended site. Herbicide movement in the gas phase is somewhat affected by air temperature, wind speed, and soil moisture (e.g. high temp, high wind, and high moisture tend to increase volatilization). However, vapor pressure, which is related to the chemical structure and formulation of the herbicide, is the most important factor affecting potential for off-site movement due to volatilization. In certain cases, formulation technology is used to change the volatility of herbicides. For example, the 2,4-D ester is considerably more volatile than the amine formulation. Relatively speaking, most herbicides are not especially volatile (Table) but we do tend to require incorporation of herbicides that are more volatile than 1×10^{-6} mm Hg to minimize losses due to volatilization. Proper herbicide selection

and understanding of factors influencing volatility, and timely incorporation can minimize the potential for off-site movement of volatile herbicides

Table. Vapor pressures for some herbicides and example compounds.

■ methyl bromide	vp	1640 mm Hg @25C
■ rubbing alcohol	vp	60
■ water	vp	20
■ EPTC	vp	3.4 x 10 ⁻²
■ clomazone	vp	1.4 x 10 ⁻⁴
■ trifluralin	vp	1.1 x 10 ⁻⁴
■ oxyflourfen	vp	2.0 x 10 ⁻⁶
■ simazine	vp	2.2 x 10 ⁻⁸
■ glyphosate	vp	4.3 x 10 ⁻¹⁰
■ sulfonylureas	vp	~ x 10 ⁻¹⁵

Physical Drift

Herbicide drift generally refers to the off-site movement of herbicide droplets before they are deposited on the target surface. This type of off-site movement is a common cause of problems if sensitive plants are growing near a treated area and is most subject to equipment setup and decisions made by the applicator in the field. Environmental conditions contribute to potential for drift; the effect to high wind speed should be fairly obvious but high temperature and low humidity can also lead to drift conditions because of rapid evaporation of the water droplets – small droplets are lighter and can move off-site more easily than large droplets. Occasionally, temperature inversion conditions can lead to very still air and very slow settling of fine spray droplets; these can also be prone to drift. Equipment setup and application decisions strongly affect the potential for drift. Nozzle type, orifice size, spray pressure, and nozzle orientation can all affect the size distribution of spray droplets. Similarly, boom height (whether ground or aerial) can affect drift because greater distances between nozzle and target allow more time for evaporation and lateral movement due to winds. The consequences of herbicide drift can vary depending on the level of drift, the activity of the herbicide, and the sensitivity of nearby plants. Physical drift can best be managed by setting up equipment to apply fewer fine droplets, leaving appropriate buffers to sensitive areas, and monitoring environmental conditions at the applications site. Above all, physical drift potential can be reduced by adequately training sprayer operators and avoiding applications during adverse weather conditions.

Off-site movement on soil particles:

Herbicides bound to soil particles can move off site along with soil eroded by wind or water. When significant off site herbicide movement occurs due to wind erosion, it is usually associated with dry soil conditions, very little vegetation cover, and high wind speeds. Injury is more common with herbicides that are persistent and active at very low concentrations and the

presence of highly sensitive non target plant species. Herbicides bound to soil particles can also be moved off site with surface water runoff – either irrigation tail waters or heavy rainfall conditions that surpass the infiltration rate of the soil. These herbicides tend to end up in the bottom of water courses or holding areas. Off-site movement of herbicides on soil particles is primarily managed by minimizing soil erosion through water and vegetation management, increasing water infiltration, and decreasing the total amount of surface water leaving the field.

Herbicide leaching or percolation losses.

Herbicides that move too deeply in the soil profile to be active on the target weeds are also “off site”. The usual target zone for soil-applied herbicides is the top inch or two of soil where most weed seeds germinate. Herbicides that are poorly soluble in water and strongly absorbed to soil tend to have low potential for leaching. Conversely, water soluble herbicides with weak binding properties can move to a greater extent in soil. Leaching potential is also affected by the timing and amount of irrigation or rainfall that occurs after the herbicide application. Large amounts of water on the soil surface shortly after the herbicide application is more likely to lead to leaching compared to delayed irrigation or precipitation because of time-dependant binding. Soil texture and structure also can affect leaching potential; coarse texture soils, channels, and cracks can lead to greater losses into the profile due to leaching or mass flow. Once herbicide moves beyond the root zone, they tend to be relatively more persistent in the soil environment due to more anerobic conditions, less microbial activity, and greater temperature stability. Leaching is best minimized through proper herbicide selection, effective and timely irrigation management, and soil management that minimizes channeling and cracks.

Plant and animal uptake and removal.

Off-site movement of herbicides due to plant or animal uptake and removal from a treated field is usually only a very small portion of the herbicide applied to a site. However, this route of herbicide movement can be economically important due to the potential illegal residues in the harvested commodity which is the primary reason for preharvest intervals (PHI), grazing, and crop residue use restrictions. Specific examples include very specific limitations on when and where certain herbicides can be used because of their persistence in plant tissue (even through the composting process) and potential damage to highly susceptible species.

There are many economic and environmental reasons to minimize off-site movement of herbicides. Increased weed control efficacy, economic efficiency, avoiding legal claims and disputes, stewarding soil and water resources, and protecting the environment. The potential for off-site herbicide movement can be greatly reduced through proper equipment setup, operator training, and weather and environmental monitoring. A basic level of understanding of the chemical, soil, and environmental factors that affect herbicide availability and potential routes of movement can lead to better herbicide recommendations, better applications, and more effective weed control treatments with fewer adverse effects on the environment.

Herbicide Translocation and Metabolism

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Barriers to herbicide absorption

Herbicides are applied to an appropriate site of entry into the plant from where they must move to the appropriate site of action. Sites of entry for soil applied herbicides are young root tissues especially root hairs on dicots (broadleaf) and the crown or coleoptilar nodes on monocots (grasses). The leaves and, to a lesser extent, stems are the sites of entry for above ground herbicide applications. Young root tissues do not have a cuticle so as to not impede water and mineral nutrient absorption. However, mature roots will have suberized tissues that prevent entry (and exit). The first significant barrier to entry for foliar applied herbicides is the cuticle, which is designed for protection and to prevent water loss from the plant. It is comprised primarily of epicuticular wax and cutin with pockets of embedded wax. Nonpolar (oil-like) lipophilic herbicides move more quickly through the waxy portions of the cuticle than the cutin. Polar (water-like) hydrophilic herbicides move more quickly through the cutin than waxy portions. Pectin strands and cellulose extending from the cell wall are the next significant barriers for lipophilic herbicides but pose a relatively easy conduit for hydrophilic herbicides. Once past the cuticle, herbicides can move further into the plant along the cell walls and not enter cells through the plasma membrane. Movement outside the plasma membrane is called apoplastic (i.e. the “dead” portion). Movement within the plasma membranes of living cells is called symplastic movement (i.e. “living” portion). Herbicides and other molecules can move from living cell to living cell remaining within the symplasm through plasmadesmata. Entering the symplasm is a significant barrier to herbicide entry, which is determined primarily by the herbicide’s partition coefficient, K_{ow} . The K_{ow} of an herbicide is the ratio of herbicide dissolved in octanol to herbicide dissolved in water. A high K_{ow} is indicative of low polarity and relative ease in passing through the plasma membrane (e.g. atrazine, oxyfluorfen, fluazifop-p-butyl). Herbicides such as glyphosate and paraquat have low K_{ow} ’s and thus have difficulty with this barrier.

Herbicide Movement inside Plants

There are three processes by which herbicides move inside the plant: diffusion, active transport, and bulk transport. Most herbicides enter plant cells from the apoplasm to the symplasm by simple diffusion: a passive process of random movement from high concentration to low. Sometimes protein channels in the plasma membrane provide a path of lesser resistance to herbicides and similar molecules than moving directly through the plasma membrane. Active transport requires an expenditure of ATP to drive a proton pump (e.g. ATP synthase) which ultimately establishes an electrical as well as chemical gradient on one side of a membrane relative to the other. Protein carriers imbedded in the plasma membrane then facilitate

transport of molecules including herbicides into the symplasm. A phosphate carrier is probably bringing glyphosate into the cell. An auxin efflux carrier transports the herbicide 2,4-D, whereas glufosinate is probably utilizing an amino acid carrier. Bulk transport is the process responsible for most long distance transport inside plants. This passive process (not counting the ATP expended for sugar loading and unloading) occurs apoplastically in the xylem or symplastically in the phloem.

The site of action for contact herbicides is the same as the site of entry because they do not move well within the plant. Systemic herbicides usually must move some distance inside the plant to the appropriate site of action. These herbicides use either the transpiration (water) stream of the xylem or translocation (sugar) in the phloem to travel long distances. All herbicides must eventually get to living cells to achieve herbicidal action. Systemic herbicides move in both the symplasm and apoplast but preferentially in one. Polar (hydrophilic) herbicides tend to move better in the apoplast because they move through cell walls easily. Nonpolar (lipophilic) herbicides tend to move better in the symplasm because they move easily through plasma membranes. Some herbicides such as paraquat and trifluralin do not move much at all in either symplasm or apoplast whereas dicamba can move equally well in both. Symplastically (phloem) mobile herbicides are typically applied to the leaves (glyphosate, 2,4-D, sulfonylureas) whereas apoplastically (xylem) mobile herbicides are soil applied (triazines, phenylureas). Bulk transport in the symplasm (phloem) moves from photosynthetic sources primarily mature leaves to growth and storage sinks such as flowers, roots, or young leaves. Directionality of transport is from nearest source to nearest sink. Thus upper source leaves tend to feed upper sinks and vice versa. Top to bottom (i.e. polar) transport is achieved for certain weak acids such as auxin according to the weak acid hypothesis (also called the chemiosmotic model or ion trapping). Essentially, protonated (un-dissociated) weak acids in low pH conditions such as occurs in the cell walls can pass into the symplasm with relative ease compared to the deprotonated

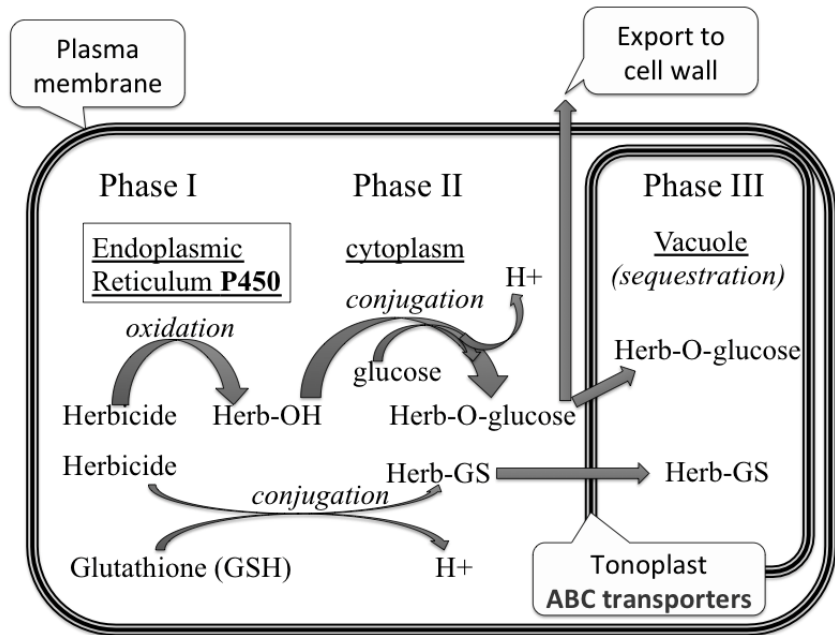


Figure 1. Summary of the three main phases of herbicide metabolism.

weak acid in high pH conditions such as the cytoplasm. An ATP-expending proton pump maintains low pH in the cell walls. Auxin efflux proteins (PIN and PGP) preferentially transport auxins and other weak acids such as 2,4-D from shoot tips toward the roots.

Metabolism

Herbicide metabolism describes the processes by which herbicides are detoxified or activated inside plants. That certain species are better or worse able to metabolize herbicides results in the selective activity of herbicides. Some herbicides such as glyphosate is not readily metabolized inside most plants which explains its broad spectrum activity. Herbicides such as atrazine can be degraded rapidly inside plants where some species are better able than others to detoxify it making it a selective herbicide. Though not common there are several examples of differential herbicide *activation* inside plants that can provide selectivity such as the use of 2,4-DB in legumes where sensitive weeds will beta oxidize 2, 4-DB to form 2,4-D. Differential breakdown is more common and can be divided into three phases summarized in Figure 1.

Phase I

A significant detoxifying mechanism in plants and animals are a family of proteins, which comprise the mixed function oxidases called cytochrome P450 in the endoplasmic reticulum. These enzymes are normally involved in biosynthesis of structural compounds such as lignin but can also oxidize herbicides. Figure 2 summarizes the main oxidation steps performed by these enzymes. Other phase I reactions include reduction by N-deamination (removal of an amino group).

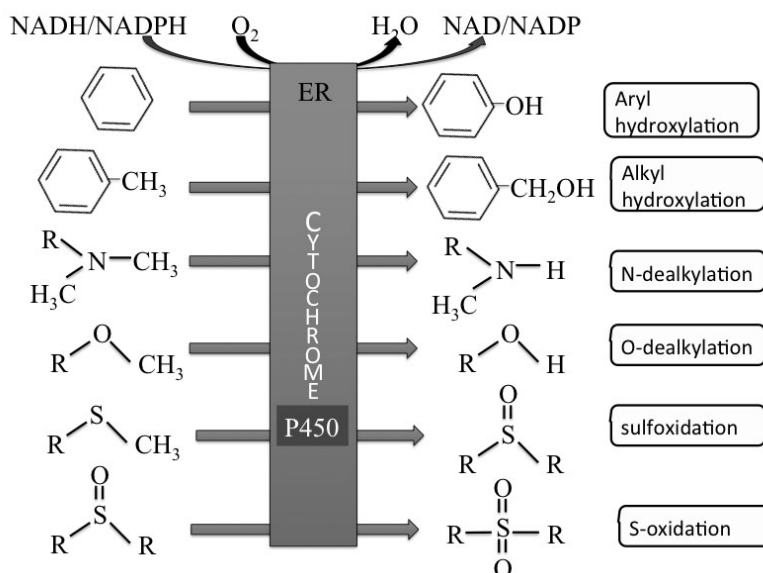


Figure 2. Summary of oxidation reactions that occur in the endoplasmic reticulum by the cytochrome P450 enzymes.

Phase II

Conjugation of oxidized herbicides to sugars, amino acids, glutathione or homogluthathione are examples of phase II reactions in plants. Some plant species can conjugate herbicides without them being oxidized where glutathione or homogluthathione are substrates and glutathione-S-transferase is the enzyme that works on the electrophilic centers of herbicides. Examples of herbicides that are conjugated in this way are the arylophenoxypropionates (-fops), triazines,

thiocarbamate (EPTC), and the chloroacetamides (e.g. metolachlor and alachlor). Triazine detoxification occurs readily in plants by one or a combination of three mechanisms: N-dealkylation (minor but may explain cotton and soybean tolerance), DIMBOA-mediated hydrolysis, and glutathione conjugation. Corn possesses all three of the mechanisms, which explains its tolerance of atrazine.

Phase III

Glucosylated herbicides (attached glucose) and glutathione-herbicide conjugates are moved to the extracellular matrix or transported to the vacuole for further processing or storage. The ATP binding cassette (ABC) transporters are responsible for conjugated herbicide transport. Often the final processing step is the attachment of a malonyl group to the conjugate before final transport outside the cell or into the vacuole.

Safeners

The idea to use chemical safeners as “antidotes” to herbicides was developed by Otto Hofman in the 1940’s. Most often safeners enhance glutathione conjugation or enhance cytochrome P450 enzymes for plants exposed to these chemicals. Perhaps increased activity of ABC transports is another mechanism of safening. Flurazole, dichlorid, benoxacor, and fenclorim are examples of safeners used in grass crops. They may be applied to the crop seed before planting or can be premixed with the primary herbicide. The reduced activity of herbicide mixtures associated with antagonism may be due to a safening effect whereby the herbicides in mixture may be enhancing herbicide metabolism inside plants. Conversely, synergism of herbicide mixtures may be due a decrease in metabolism as occurs in strawberries where teracil damage increases in the presence of fluazifop-p-butyl.

References:

California Weed Science Society. 2002. Principles of Weed Control 3rd Edition. Thomson Publications, Fresno, CA 630 pp.

Radosevich, SR, JS Holt, CM Ghera. 2007. Ecology of Weeds and Invasive Plants: Relationship to Agriculture and Natural Resource Management. 3rd Edition. John Wiley and Sons. Hoboken NJ 445 ppg.

Ross, MA and CA Lembi. 2009. Applied Weed Science: Including the Ecology and Management of Invasive Plants. Pearson Prentice Hall, Upper Saddle River, NJ 568 ppg.

Weed Population Dynamics in Overhead and Sub-surface Drip Irrigated Conservation Tillage Cropping Systems

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As resources such as water and fuel become more limited and expensive for agriculture in the San Joaquin Valley (SJV), farmers look towards technology for improved efficiency. Subsurface drip has become an increasingly popular irrigation method in row crops in the SJV. This technology conserves water, reduces runoff, and works well in minimum tillage operations. Further, it has been shown to reduce weed populations compared to furrow irrigation. This is because the soil surface and the top few inches of the soil profile where most weed seedlings emerge from is relatively dry with sub-surface drip. However, overhead irrigation systems (linear move and central pivot) are regaining popularity in the SJV for economic reasons. The possibility of combining overhead irrigation systems with conservation tillage (CT) has sparked a renewed interest in the technology. Water movement down furrows was often cited as an impediment to the adoption of CT systems in surface-irrigated row crop systems in the SJV. However, this problem may no longer be a concern in overhead irrigation systems. Therefore, the introduction of overhead irrigation in CT systems may enable the combination of water and soil conserving techniques and contribute to the development of sustainable cropping systems in the SJV.

Any change, however, in the prevalent cropping system may bring about changes in pest population dynamics, especially weeds. Pest population dynamics and management are important components of any cropping system that have not been adequately explored in overhead/sub-surface drip irrigated CT systems. Therefore, a study was initiated at the University of California West Side Research and Extension Center in Five Points, CA in 2008 to look at various components of different cropping systems. Initially, the system comparisons included no-till (NT) and standard tillage (ST) under overhead linear move or furrow irrigation in a corn-wheat rotation. In 2011, furrow irrigated treatments was replaced with sub-surface drip irrigation and all the plots were converted to strip-tillage and acala cotton was also introduced to the crop rotation. Therefore, the crop rotation over the years has essentially been wheat (silage) – Roundup Ready (RR) corn – wheat (silage) – RR corn – wheat (silage) – RR cotton. The only herbicides used in the rotation so far have been 2,4-D in wheat and glyphosate in RR corn and cotton. Although various components of these cropping systems were evaluated, this paper will only focus on weed population dynamics during the course of the study. Data on weed densities

by species were collected in each phase of the rotation and analyzed and statistical differences between the treatments were evaluated at a 0.05 level of significance.

Weed densities in the wheat phase of the rotation were similar between the irrigation and tillage systems. Similarly, no differences in weed densities were observed in the corn phase of the rotation in 2009 and 2010. The most prevalent weed species in the experiment were redroot pigweed (*Amaranthus retroflexus*), shepherd's purse (*Capsella bursa-pastoris*), London rocket (*Sisymbrium irio*) and field bindweed (*Convolvulus arvensis*). Weed densities at the onset of the experiment were fairly high as the wheat plots had up to 112 weeds/m² in mid-winter. However, the weed density has decreased over the years. This in part is due to the strategic rotation of the crops and the deliberate reduction in tillage. The broadleaf weeds were controlled by 2,4-D in the wheat phase and the wheat itself outcompeted many weeds. The remaining weeds, both broadleaves and grasses, were controlled with glyphosate in the RR corn phase.

In 2011, cotton was planted in the rotation after the furrow-irrigated plots were converted to sub-surface drip irrigation with the tape buried 12 inches beneath the soil surface. Once again, the crop rotation and weed management led to very few weeds in the cotton plots. However, there was a significant difference ($p < 0.05$) between the treatments. The sub-surface drip plots had an average of 1 weed/m² compared to 10 weeds/m² in the overhead irrigation plots. The most prevalent weeds were sowthistle (*Sonchus* spp) and field bindweed. However, volunteer corn emerged evenly in all the plots in cotton as it was a RR variety in RR cotton and glyphosate was unable to control them. Thus, the volunteer corn had to be removed by hand pulling. Cotton was harvested in October and wheat was planted in all the plots in November 2011. Cotton will be planted again in spring 2012 after green-chopping the wheat. In conclusion, weed densities in the experiment so far have diminished over the years due to the strategic rotation of crops and herbicides. Tillage and irrigation systems initially had no effect on weed densities but with the recent introduction of sub-surface drip irrigation, differences were observed between the irrigation systems. The CT system used in the experiment has not shown an increase in weed densities. The weed seedbank is currently being monitored to assess the belowground weed population dynamics.

Poster Title: Development of a method to evaluate mortality of black mustard (*Brassica nigra*) seeds exposed to volatile compounds from composted greenwaste.

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Abstract:

Disposal of municipal greenwaste is an increasingly important issue in California. Composting of plant residues could be manipulated to provide enhanced weed control when incorporated into soil. Compost can increase the efficacy of soil solarization, and one possible mechanism is the evolution and enhanced retention of biotoxic volatile constituents during decomposition. The goal of this study was to develop a method to evaluate the effect of volatile compounds from greenwaste compost on mortality of seeds of black mustard (*Brassica nigra* (L.) W. D. J. Koch) during heat treatment. We conducted three preliminary experiments to modify existing methods used in laboratory studies of weed seed thermal death. In all experiments, seed samples were placed in organo bags and loaded into replicated jars half-filled with the material being tested (sand, field soil, field soil amended with wheat bran, or field soil amended with compost and wheat bran). Jars were heated at a constant temperature of 42°C in a water bath. Each jar contained one bag of seeds suspended in the headspace of the jar above the material to estimate the effect of volatile compounds, and one bag of seeds filled with the same material as the jar and buried within the material to provide direct contact. After removal from jars, seeds were incubated for 14 days in a growth chamber to determine germination percentages. Experiment 1 evaluated the effect of compost maturity on seed mortality by comparing compost-amended soil incubated at two different temperatures. Field soil was amended with greenwaste compost and wheat bran and incubated for two days at either room temperature or in a refrigerator at 4°C. Seed mortality was significantly higher in compost-amended soil that matured at room temperature (60% in headspace seeds, 83% in buried seeds), compared to refrigerated compost-amended soil (20% in headspace seeds, 27% in buried seeds). There was no significant difference in mortality between seeds suspended in the headspace and buried seeds, indicating that volatiles contributed to mortality. Experiment 2 compared two materials for comparing seed mortality in compost-amended soil to a control material without compost. Jars were filled with field soil, field soil amended with wheat bran, or field soil amended with greenwaste compost and wheat bran. There were no significant differences in seed mortality between soil and soil amended with bran, indicating that non-amended field soil was an appropriate control. Experiment 3 obtained a preliminary estimate of the effect of volatiles from compost on seed mortality, using compost-amended soil incubated at room temperature (Experiment 1), versus non-amended field soil (Experiment 2) and sand as controls. Jars were filled with sand, field soil, or compost-amended soil. Seed mortality was highest in seeds buried in the compost-amended soil (47%) and lowest in seeds in the headspace of soil (14%) and sand (15%).

Poster Title: A Field Trial to Evaluate Deleterious Effects of Composted Municipal Greenwaste and Soil Solarization on Black Mustard Seeds

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Composting of municipal greenwaste provides products that may be combined with existing pest management techniques, such as soil solarization, for enhanced herbicidal efficacy. By itself, solarization can be a useful alternative to chemical herbicides for weed management in many areas of California. A replicated field trial was conducted in July 2011 to evaluate the effect of amending soil with greenwaste compost on mortality of seeds of black mustard (*Brassica nigra* (L.) W. D. J. Koch) during solarization. Organdy bags were filled with seeds and field soil, either alone or amended with 8% greenwaste compost and 2% wheat bran (dry basis). Bags were then buried in plastic, 1 gallon nursery plant bags containing the same mixture. The nursery bags were then buried at the experimental field site at KAC in Parlier, and the plots were irrigated and covered with clear plastic. Seed bags were sampled at intervals of 2, 3, 3.5, 4, and 22 days after the beginning of the field trial. Seed mortality, as determined by germination tests and tetrazolium staining, was much higher in the compost-amended, solarized soil, with an average of 78% mortality on the first sampling date and 100% mortality for all subsequent samples. Seed mortality in non-amended, solarized soil was relatively low (14-29%) for the first four sampling dates, and 100% mortality was not reached in soil by the 22 day sample. The higher seed mortality observed in greenwaste-amended soil could be due to increased heat from decomposition of the organic fraction of the mixture, or to seed exposure to toxic constituents of the compost. These preliminary results suggest that composted greenwaste may be useful in agricultural weed management, especially when combined with solarization.

Solar Tents for On-Site Sanitation and Eradication of Rogued, Weedy Plant Propagative Materials

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Solar tents, which are inexpensive, disposable, and nonpesticidal, can be used to inactivate unwanted weed plant propagative materials, on-site. Previous studies with imbibed weed seeds have shown effectiveness, but proof of efficacy on vegetatively propagative material has been lacking. During two field trials in Stanislaus County, in September 2010, solar tents produced diurnal temperature maxima within closed sample bags of 146-172 °F. The mean maximum temperatures within the sample bags were 91-108 °F higher than those of ambient air, and temperatures ≥ 140 °F were maintained for 3-6 hours each afternoon during the field trials. Rhizome segments, excavated and excised from a local infestation of johnsongrass (*Sorghum halepense*), were used for treatment evaluation. The rhizomes were completely destroyed following confinement within tents containing a moisture reservoir for three days. Solar tent construction used locally-available materials, similar to those which could be scavenged in many California ecoregions. In sufficiently warm climatic areas and weather conditions of California and elsewhere, similar tents, which employ passive solar energy, can provide a useful alternative for inactivating weed propagative materials. Potential uses include destruction of quarantined, propagative materials following regulatory roguing in remote locations, or routine roguing of limited scale areas to remove invasive weeds.

The Global Value of Herbicides

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When it comes to herbicides, the world can be divided into three groups of countries—developed countries that treat 90% of their acres with herbicides and have used herbicides for fifty years, rapidly developing countries, such as India and China, that treat 30-50% of their cropland with herbicides, and countries in sub-Saharan Africa, where herbicides are used on only 5% of cropland. Developed countries rapidly adopted herbicides in the 1960s due to shortages of farm labor for hand-weeding and the desire for increased food production. American cotton workers in the South migrated to the North for factory jobs. In California, the *Bracero* Program ended in the 1960s and the short-handled hoe used for weeding was banned in the 1970s. In Japan, Germany and other Western European countries, rebuilding industrial sectors after World War II required millions of new workers. In Italy, hand-weeding of rice became a social justice issue. The survival of agriculture in these countries depended on the timely arrival of herbicides. Concurrently, herbicides proved more effective than tillage for weed control in field crops (maize, rice, wheat) and yields increased dramatically.

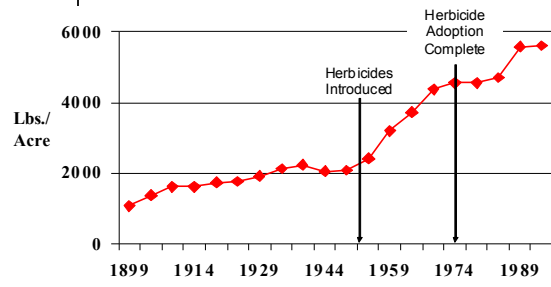
The same phenomena are driving rapid adoption of herbicides today in India and China, contributing to significant increases in crop yields in these and similar countries. Shortages of rural workers are occurring due to rapid industrialization. In the 1980s, China had an estimated 43 million hectares heavily infested with weeds, resulting in a loss of 18 million tons of grain annually. With herbicide use, wheat and maize yields have doubled since the 1980s.



It has been well known for many years that herbicide use by African farmers would dramatically increase yields. Yields on smallholder farms are one tenth that of African research farms where weeding is done at the right time. Subsistence farmers are only able to do half of the weeding required for optimal yields; poorly timed and suboptimal weeding results in yield losses of 20-100%. Despite years of trials demonstrating the benefits, herbicide use remains low due to several factors. First, weeding is seen as women's work and not taken seriously by governments. Additionally, international aid organizations have not made weed control a priority and generally do not support herbicide use in sub-Saharan Africa. As a result, weed science and extension support and spray services for weed control are not available to most African farmers.



U.S. Rice Yields



Assessing the Return to Weed Control Expenses in California Agriculture

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Weed control plays a vital role in California's diverse and vibrant agricultural sector. In 2009 the value of production was \$34.8 billion. Expenditures on inputs to agriculture totaled \$29.6 billion (Table 1). The net returns to California agriculture were \$8.8 billion. The factors of production include labor, capital and management. Some labor is hired labor or custom labor where cash payments for services transpire. Other labor includes unpaid family and operator labor. Similarly, capital inputs are comprised of owner's equity and borrowed capital which requires interest charges. Management is defined as the knowledge for planning, directing, evaluating, and bearing risk. Management may be a paid position or unpaid operator contribution to the farm business. The net return to farming is a return to the unpaid factors of production including unpaid family labor, unpaid operator labor, operator's capital (equity), and operator management including risk.

Annual production inputs such as seed, feed, pesticides, and fuel vary by crop. In order to maximize profit, theory dictates that each input should be used to the point where the value of one more unit of input measured as an increase in revenue equals the cost of that unit of input. Beyond that point, the added income resulting from adding more of the input is less than the cost of the input and the impact is to actually decrease profit. Therefore, the expenditure on inputs is equal to the return to the input if the input is used efficiently. Specifically, the value of weed control can be estimated by the expenditure on weed control.

An estimation of the expenditure on weed control in California is complicated by a number of considerations. In many cases, operations serve dual purposes. The most significant is soil fumigation used to control disease and nematodes while also acting as pre-emergent weed control. Other examples include ground preparation before planting, and cover crops that also provide habitat for beneficial insects, biomass, and nitrogen. Often herbicides are applied during the same operation as planting and/or disease control. What part of the equipment and labor for this operation should be allocated to weed control?

Based on cost and return studies from the University of California Cooperative Extension (available at <http://coststudies.ucdavis.edu>) the costs of weed control was estimated for a range of crops on a per acre basis. Not surprisingly, hand weeding is only used for the high value crops – processing tomatoes, broccoli, lettuce, and strawberries. Herbicide is used in all conventional crops except strawberries where weeds are controlled with fumigation and hand weeding (Table 2). The costs per acre range from a low of \$44 per acre for alfalfa to a high of \$760 in hand weeding for strawberries.

These costs were then divided into materials, labor, and depreciation on equipment to match the categories of expenses used in the CDFA farm expenditure values in Table 1. The expenditures for weed control were calculated as a percentage of all expenses for each crop. Then the expenditures were weighted by the income generated by each commodity group. From these values the expenditures on weed control were estimated. The total is \$901 million for 2009. This can be interpreted as the value of weed control in California agriculture.

Weed control also boosts the returns to other inputs in several ways. Most notably, weed control increases irrigation efficiency and fertilizer efficiency by reducing weed competition with crops for water and nutrients. Weed control also aids in the uniform distribution of water by allowing water to flow evenly through furrows and keeping weeds from interfering with sprinkler irrigation. With hay crops weed control increases quality and price received. These returns are captured by these complementary inputs in cost savings and should not be double counted, however in estimating the value of weed control.

Interestingly, the same crops that utilize hand weeding on a commercial scale for conventional agriculture are the only crops that use hand weeding for organic production. In other words, organic production does not substitute hand weeding for herbicides in crops where the revenue does not warrant such high labor costs. However, for organically produced crops relying on hand weeding, hand weeding is higher than for conventional crops. Most commonly, mechanical control substitutes for herbicide use in organic production (Table 4).

Table 1. CA Farm Income and Expenses – 2009 (\$Billion)

	Income	Expenses
Value of Crop Production	\$27.10	
Value of Livestock Production	7.7	
Revenue from services	2.9	
Government payments	0.6	
Feed and livestock		\$5.70
Purchased inputs - manufactured		4.2
Repairs, custom, marketing, misc.		9.2
Hired labor		6.1
Rent and real estate interest		2
Property taxes and DMV		0.9
Depreciation		1.6
Total	\$38.40	\$29.60
Net Farm Income	\$8.80	

Source: CDFA. California Agricultural Resource Directory 2010 – 2011

Table 2. Weed Control Costs for Selected Crops (\$ per acre)

	Mow	Cultivate	Hand Weed	Herbicide	Total
Tomatoes		34	67	113	215
Alfalfa				44	44
Corn		15		69	84
Broccoli		16	94	51	161
Lettuce		8	80	141	229
Strawberry *			760		760*
Raisins		16		102	118
Almonds	35			153	188
Walnuts	29			47	76

*Weeds controlled with preplant fumigation. Cost not included.

Source: various cost and return studies, www.coststudies.ucdavis.edu

Table 3. Estimated Expenditure on Weed Control in California (Million \$)

	Manufactured Inputs	Labor	Depreciation and Interest	Total
Field crops	5	94	31	170
Nursery	415	34	23	8
Fruits and Nuts	195	205	35	436
Vegetables	61	129	25	216
All Crops	342	464	93	901

Table 4. Weed Control Practices for Organic and Conventional Systems

	Mow	Disc	Hand Weed	Flame	Herbicide
Tomatoes		O C	O C		C
Alfalfa		O			C
Corn		O C			C
Broccoli		O C	O C		C
Lettuce		O C	O C		C
Strawberry *		O	O C		
Raisins	O C	O C			C
Almonds	O C			O	C
Walnuts	O C		O		C

New Herbicides for Small Grains

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jmrichardson@dow.com.*

Three new herbicides for small grains include Axial (pinoxaden), Express (tribenuron-methyl), and Simplicity[™] (pyroxsulam). Axial is a postemergence graminicide for wheat and barley, controlling weeds such as wild oat, foxtails, Italian ryegrass, barnyardgrass and canarygrass. Express provides postemergence control of broadleaf weeds such as common chickweed, common groundsel, coast fiddleneck, common lambsquarters, London rocket, redroot pigweed and shepherd's-purse. Simplicity provides postemergence grass and broadleaf weed control in wheat, including wild oat, Italian ryegrass, bromes, foxtails, canarygrass (suppression), mustards, pigweeds, common lambsquarters, nettleleaf goosefoot, shepherd's-purse, coast fiddleneck, common chickweed, burning nettle and groundsel. All three herbicides provide acceptable crop safety and excellent crop rotation flexibility.

[™]Simplicity is a trademark of Dow AgroSciences. Simplicity is not presently registered for sale or use in California.

Weed Control Challenges in Desert Areas of Southern California

Tim Hays, Wilbur-Ellis Co.

Lancaster, California

In the beginning, there were weeds. When I began my career in the mid nineteen seventies, there were many surprises awaiting me. The Primary Crop was Alfalfa for hay production. It occupies the most acres of irrigated land. Small grains for hay, sudangrass, onions, carrots, potatoes, stone fruits, pears and apples are also grown here.

Visiting alfalfa producers, I found several items that were troubling. Many growers had difficulty establishing good fields, many older fields had problems with serious perennial weeds. Control of summer and winter annual weeds was erratic. Many fields were being overtaken by dodder. There were weeds that people couldn't identify or control. Several steps would be needed to address these issues. First identify the weeds. Get help if needed, but that is the first step. Second, learn why these weeds are there. Third, come up with a plan to control these weeds if possible, using an integrated, agronomically sound system.

Weed identification was done mostly from academic training and resource books, at that time the Growers Weed Handbook was still coming out. The older Weeds of California was useful. Some local weeds required help from the County Ag commissioners and UC Extension to identify. The most important and common weeds were:

Annual Foxtail Barley, Downy Brome, Rescuegrass, Annual Bluegrass, Schismus Sps., Volunteer grains, London Rocket, Tansy mustard (flixweed), Red-stem filaree, Malva, Shepardspurse, Common Groundsel, Fiddleneck, tumbling mustard, Russian thistle, prickly lettuce, Annual Sowthistle, Thyme-leaved speedwell, Buckhorn Plantain, Dandelion, Lambsquarter, Pigweeds, Crabgrass, Setaria foxtails (millets), Watergrass, Dodder, Bermudagrass, Johnsongrass, and a mixture of strange, exotic and domesticated species.

Common Groundsel was present in abundance in several fields in the Antelope Valley area. Further analysis revealed that these growers had been using Diuron herbicides at low doses for many years. The groundsel thrived in this competition-free environment. Many of these growers were not aware that groundsel was toxic to animals. Some of this hay was sold to feed stores catering to horse owners. Several years later I was called as a weed expert to identify weeds in hay at a feed store. The concern was that about 20 horses had developed severe jaundice and were dying. Poison weeds were suspected. The analysis of the hay showed some marehail but no toxic weeds. The problem was that the damage was done months earlier when these horses had been fed groundsel-infested alfalfa. The symptoms can take months to show up, at which time it

is too late to save the animals. There was no way to track where the hay that really caused the problem came from. This incident became a major incentive to solve this problem. Another grower made “Premium Horse pellets” with groundsel infested hay. In subsequent years, the growers began to use Paraquat and then Velpar, with Diuron. This was a very effective treatment for groundsel. These mixtures are still our primary treatments for winter weeds. The Goundsel case is an example of weed selection by eliminating its competition.

Annual Foxtail Barley was the other major problem occurring virtually every year. Many fields had to have the first cutting sent to the hay grinders to be milled into pellets, at a substantial loss of income to the growers. The introduction of Paraquat and Velpar also greatly aided in control of this weed. Foxtail would germinate early in some years and become well enough established to survive diuron treatment, adding Paraquat or Velpar would control these tough weeds.

Control of the regular winter annuals has been generally good with the existing tools, but we are seeing reduced effectiveness and selection pressure in favor of perennials over time. It has been many years since we have used new materials in this market. Chateau is being used a little in our area, but is very expensive and not as effective as our standard treatments.

Dodder has been a constant problem, although today many people forget how bad it was. The main reasons it was so bad were that most High desert hay was grown in long rotations, patches were allowed to go to seed and there was no effective preemergent control for many years. Growers blamed birds, sheep, their neighbors and a host of other reasons. The real main culprit was cheapskates who bought homegrown seed from their neighbors that was infested with dodder seed. Some farmers tried deep plowing, but this usually was not effective. Burning was the main method used to control attached dodder. This was not fun on a 110 degree desert day. Later, Dow General was used mixed with oil as a contact killer. This was easier than burning, but required repeat treatments and was eventually banned by the EPA. Fail mowing was found to be effective if done all the way to the ground, and is still the best non-chemical treatment. In the early 1980's Treflan herbicide was made as a 10% Granule. This product was very interesting because it offered a way to pre-emergently control grassy weeds like Setaria sps. that were infesting a lot of alfalfa in California. We applied some for grass control and found it also worked quite well on dodder. Steve Orloff got hold of this information and ran with it. He did research on when dodder germinated, when treatments should be applied and what materials were most effective. To this day, that is the gold standard on dodder recommendations. Prowl was shown to be even better than Treflan. Today we apply Prowl H2O at 2 to 4 quarts per acre per year and get excellent results. Results are much better on newly planted fields than older fields with many dead spots. The development of Roundup Ready Alfalfa will also help, as this treatment will control attached dodder. My personal opinion is that we should still control dodder with pre-emergent materials and follow up with Roundup-ready where this is an option. Previous attempts to go with a post emergent only program have not been very successful. The contaminated seed problem continues to this day. Some growers have achieved very good

control for many years, then rotated out of alfalfa, and planted back after 3 years and been badly infested again. When they did tillage, they brought up buried seed that came from the earlier years of heavy infestation. This problem will be with us for a long time.

Many of the weed problems come from less than optimum farming practices. In the earlier days, we stressed cultural practices and the effect they had on weeds. Many people have gotten used to good herbicide results and tried to get by with shortcuts. A thick stand of healthy, well fertilized vigorous Alfalfa is still the best weed control we have. Poor stand establishment was a problem for many growers. Some tried to compensate by increasing seeding rates, but this was not effective, because Alfalfa self-thins to the same population density. Weed competition in newly planted Alfalfa is very harmful to stand life and overall profitability. This has been one of the most difficult aspects of Alfalfa production.

Early practices focused on 2 materials post emergent: 2,4-DB and IPC(chem.-hoe). These were effective but had many problems: timing was critical, irrigation management was very complicated and they could adversely affect the growth of the alfalfa. Balan and Eptam were used as pre-plant treatments, but were poor choices for fall planted hay in our area. Kerb was developed and used for several years as a replacement for IPC. Finally Poast was approved and this was a big step ahead, a safe and selective effective post-emergent material. Poast has declined in use and today Selectmax (or generic forms) dominate this use. Pursuit and Buctril were developed to replace 2,4-DB. They are outstanding on many weeds, especially mustards, malva and filaree. But they miss Prickly lettuce and Sowthistle, so if these weeds are a problem, Buctril or 2,4-DB can be tank mixed. Many growers are using low rates of all 3 together. Raptor is the follow up to Pursuit. It adds grass control and less carryover. Pursuit is still popular because it gives longer residual control than Raptor. Some people are combing low rates of these two products to get broad spectrum and long residual. We also use Selectmax, even with Raptor, to go after seedling Bermudagrass. Often volunteer grain emerges early and in abundance, so we will apply Selectmax early and come back with a second application for the other weeds.

Time of seeding has been a critical issue in the High Desert. The optimum time is late August or early September. If planting is delayed, seedling growth is slowed significantly. 2 weeks can make all the difference. The competitiveness of the Alfalfa is reduced and the danger of severe wind damage is greatly increased. Unfortunately, we have seen many fields literally blow away in the winds of October and November. Spring planting usually is a disaster. Cover cropping is a good insurance measure on sandy soils. Typically, small grains are used for this and controlled by herbicides before they can damage the stand. In some years, we will see low temperatures of 0-10 degrees. Some fields have been winter-killed. Variety selection is also important in this regard. Other important cultural controls used in this area are: Time of cutting management, Good weed control in rotational crops(use 2,4-D when you can), avoidance of nitrogen fertilizers if possible, plowing down manure applications instead of top-dressing and planting clean seed.

Roundup-Ready Alfalfa is being planted on a limited basis. Some growers export hay and they want to avoid it. Many growers feel that their existing practices are working fine and don't like the added expense. The advantages in seedling establishment, spot control of dodder and effectiveness on perennial weeds will make RR more popular in the future. Our experiences so far show us great results on seedling weed control, although follow up treatment will be needed. I believe an approach of using RR Alfalfa and residual Herbicides will be the future direction we need to go in.

It is very important that we retain our older products also. 2,4-DB has come and gone a couple of times. We keep finding uses for it, even though it is 50 years old. The cost of development of new herbicides is ridiculous. The chicken little-activists will keep going after our essential products because their paranoid fear is greater than our ability to explain the truth to them.

Application practices have changed over time. Today many products are applied by chemigation, where approved. Center Pivots have enabled this to be quite effective, although very good management and skill are needed to make it safe and effective. Most products are applied by ground-rigs. Air application has virtually ceased in this area. Weed control results have generally been better by ground. The high winds and low humidity can be very challenging at times. The desert water sources, mostly ground water, can have very high pH and mineral contents. Adjuvant use is essential with many products.

We have made some major steps ahead in the quest for high quality hay in our region. This is a good legacy to pass on to future farmers and those that work with and advise them.

Weed Control Options for Corn Production

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Introduction

In California, 640,000 acres of corn was grown in 2011, two-thirds of it planted for silage. The acreage grown for grain is very price dependent. The majority of the corn was planted in the Central Valley. No single weed control regime is effective for all growing conditions. An integrated weed management program utilizes a combination of cultural, mechanical, and chemical methods for consistent, effective weed control. It also helps prevent the development of weed resistance to herbicides and the emergence of a few dominant weeds. Some of the major weeds include pigweeds, tall and Wrights annual morningglory, common and horse purslane, barnyardgrass, and purple and yellow nutsedge. The major grass weeds include barnyardgrass, sprangletop, Johnsongrass, and volunteer wheat. Purple and yellow nutsedge are controlled using halosulfuron or glyphosate in combination with sweep type cultivators. Accent gives excellent control on Johnsongrass and small barnyardgrass when applied to up to 20 inch tall corn, then after that using drop nozzles to 36 inches.

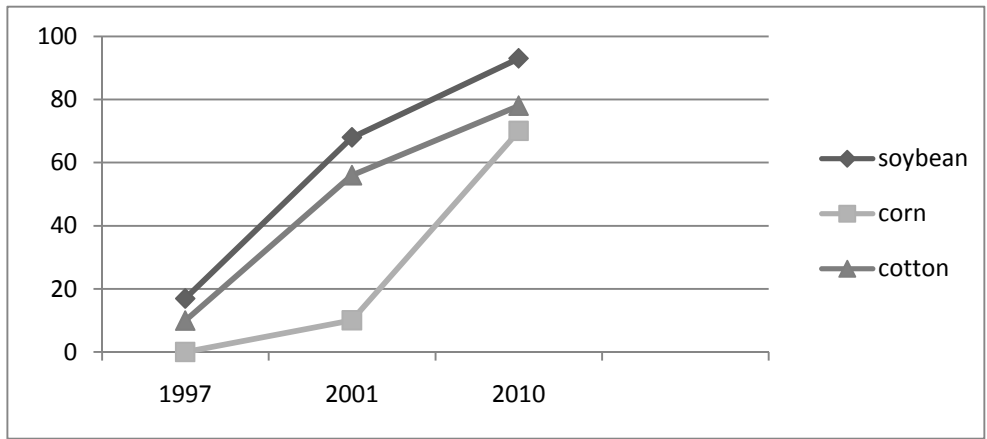
Cultural practices play an important role in corn weed management. In California, a well-managed corn crop is extremely competitive with most weeds. Good cultural practices, including timely cultivations, often control weeds sufficiently to maximize yields and profit.

Growing corn under no-till or reduced tillage may reduce weeds because the soil is not disturbed, thus reducing the number of seeds that germinate. Preirrigation prior to planting and controlling volunteer cereals and emerged weeds will get the crop off to a good start, although this practice delays planting. For weeds that do emerge, postemergent herbicides can be applied. In practice though much of the reduced tillage corn has uncomposted manure spread on the fields, fields are irrigated up, and often a single mode of action (glyphosate) is used, leaving fields very weedy by the end of the growing season.

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

Transgenic Corn. Herbicide-tolerant varieties represent approximately 60% of corn grown in California and provide additional options for weed control. The Roundup Ready technology has provided growers with an excellent tool for managing many annual and perennial grasses. Glyphosate can be applied post emergence so growers can wait and see the weeds present. There are no plant back restrictions nor is it listed as a restricted material like several other corn herbicides. There is substantial fuel savings, as tillage operations are reduced. In Roundup Ready varieties, glyphosate can be applied over the top to corn up to the V8 stage of corn or 24 inches. Drop nozzles are recommended for corn taller than 24 inches. Keep spray out of whorls after corn is 30 inches tall. Rates depend on formulation and weed type and size.

Fig. 1. Percent of soybean, corn and cotton acreage planted with glyphosate resistant crops in the United States



Kassim Al-Khatib

The following herbicides are used in corn:

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

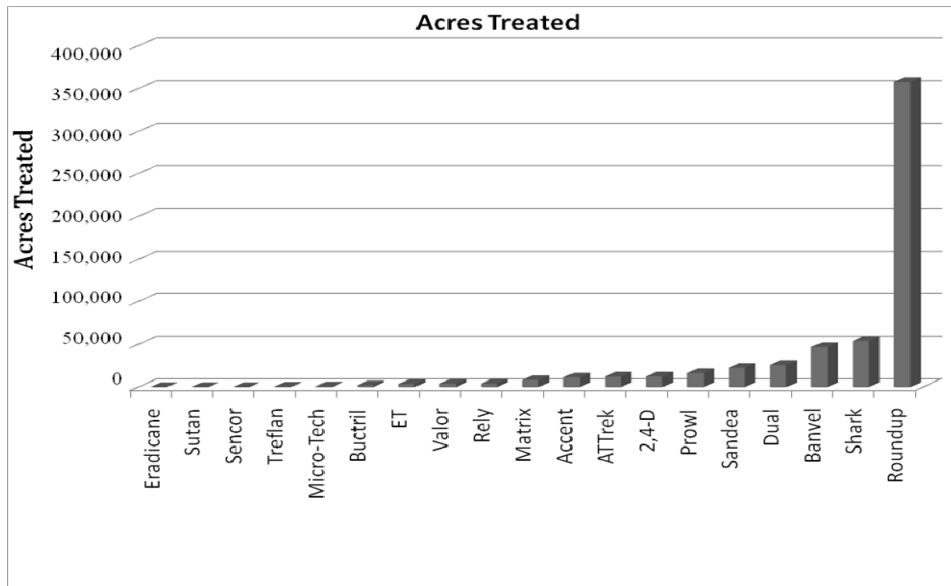
At Planting: Micro-Tech, Aatrex, Atrazine, Dual Magnum, Roundup, Gramoxone Inteon, Eradicane

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

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

An over-the-top application can be used, but some products or tank mixes require a directed spray on corn larger than 8 to 12 inches in height to keep the herbicide out of the whorl and to minimize the risk of corn injury. Postemergent herbicides commonly used in corn include 2,4-D, bromoxynil (Buctril), carfentrazone (Shark), dicamba (Clarity), dicamba/halosulfuron (Yukon), diflufenzopyr (Distinct), halosulfuron (Sandea), metribuzin (Sencor), nicosulfuron (Accent), and foramsulfuron (Option). It is important, however, to pay close attention to application guidelines on the labels to avoid phytotoxicity to the crop, especially with carfentrazone (Shark). Fig. 2 demonstrates the acreage of various herbicides used in California. Even though there are many herbicide options to use in corn, the chart demonstrates the dominance of a one mode of action approach. Research conducted in 2011 with Matrix (rimsulfuron) as a post plant but either preemergent or postemergent to the weed demonstrated excellent weed control. Hopefully this herbicide will be registered and add to the options available for corn growers.

Fig. 2. 2010 Herbicide Usage in California Corn



Summary

Weed management in corn should incorporate resistance management strategies that include crop rotation, herbicide rotation, and control of weed escapes by tillage or hand. In Roundup Ready crop systems in other states, weed shifts and weed resistance occurs. Weed shifts occurred when an herbicide program was used repeatedly, resulting in the survival of only weeds that are tolerant of the herbicide. Weed shifts were associated with reduced tillage systems and not rotating herbicides nor including tillage even when that was the most appropriate weed control tool.

A major concern is the development of resistance to glyphosate (Roundup) in lambsquarter, pigweed species, horseweed, fleabane, and Italian ryegrass in California. Rotating glyphosate-resistant corn with another glyphosate-resistant crop such as cotton or alfalfa will only increase this problem. To help prevent the development of herbicide-resistant weeds and prevent weed shifts from occurring, it is important to incorporate tillage into your weed management practices, as well as alternating herbicides that have a different chemical mode of action. The use of residual herbicides should be considered. Manage field edges as many of these weed seeds can blow into neighboring fields.

References:

- Wright, S., D. Munier, M. Canaveri, 2010. Weed Control in Corn. University of California IPM Pest Management Guidelines in Corn Publication.
- Wright, Steve, 2010. Integrating Weed Control in Cotton and Corn. California Weed Science Society.
- Wright, Steve, R. Vargas. 2008. Integrating Weed Control in Cotton and Corn. California Weed Science Society.

Recent Developments in Alfalfa Weed Control

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Weed control practices in alfalfa are continually evolving to develop more effective weed management systems. Recent developments in alfalfa weed control include the reintroduction of Roundup Ready (RR) alfalfa, research on the control of summer annual broadleaf weeds such as pigweed, and research on the use of Sharpen (saflufenacil) in established alfalfa.

Roundup Ready Alfalfa Survey Responses

The release of Roundup Ready alfalfa has been more contentious and disputed than the other RR crops. After its initial release and the subsequent injunction prohibiting further plantings, RR alfalfa was just released again in February of 2011. Alfalfa growers now have a full production cycle (3-6 years) of experience with the initial plantings and a season or partial season's worth of experience with the new plantings that have occurred in 2011. A survey was conducted in the fall of 2011 to better understand alfalfa-grower attitudes and perceptions regarding RR alfalfa. The full survey responses and background information can be found at: <http://alfalfa.ucdavis.edu/+symposium/proceedings/2011/11-332.pdf>.

Of the 381 people who completed the survey, 113 of them had grown RR alfalfa. The results indicated that a large majority (90%) were either satisfied, very pleased, or felt that the technology far exceeded expectations. Eight responded that they were disappointed, and two extremely disappointed. A majority (71%) said that they would plant it again, while 20% said maybe, and 9% said no. Better weed control, simplicity, and flexibility of weed management were the key advantages cited by respondents. Cost of seed was cited by 80% of all respondents as the major negative. This response was more than four times more popular than any of the other choices which included weed control was not effective, Roundup resistant weeds, don't like the technology use agreement, and varieties don't seem to yield well. The least popular response was difficulties in marketing RR alfalfa, indicating that this has not been a significant problem for those who have grown RR alfalfa.

It appears that alfalfa growers are becoming convinced of the risks of herbicide-resistant weeds. Forty-one percent of respondents indicated a concern for Roundup-resistant weeds as a consequence of the use of the technology, while only 25% indicated that it is not a concern. The rest indicated that they were not sure but that maybe resistant weeds are a concern.

The RR alfalfa system greatly simplifies weed management in alfalfa. Depending on the grower's philosophy toward GE crops, their market, and the weed pressure encountered, the RR system has been shown to have significant benefits for many producers. It has

proved to offer some important environmental benefits for those areas where traditional herbicides are problematic.

Pigweed Control in Established Alfalfa

Summer grasses, such as green and yellow foxtail and barnyardgrass, have been the most troublesome summer annual weeds in alfalfa fields. These weeds are still a major problem but there appears to be an increase in some broadleaf weeds as well, primarily pigweeds (both redroot and Palmer amaranth) and to a lesser degree lambsquarters. Winter dormant soil-residual herbicides generally do not persist long enough to adequately control these weeds. With center pivot irrigation some fields stay wetter between cuttings than they would with wheel-line or flood irrigation, allowing these broadleaf weeds to emerge and get a foothold between cuttings. For the same reason, rain between cuttings also encourages pigweed and lambsquarters infestations. Another major contributing factor is the use of manures. There are weed seeds in the manure and nitrogen in manure encourages weed growth.

A trial was conducted in the High Desert by UC Farm Advisor Andre Biscaro to evaluate pre- and post-emergence control of pigweed in established alfalfa. The most effective pre-emergence treatments were a split application of Prowl H₂O, a tank mix of Prowl and Chateau, and the longest lasting treatment was the herbicide prodiamine (not registered for alfalfa), which provided near perfect control for the entire season (Figure 1).

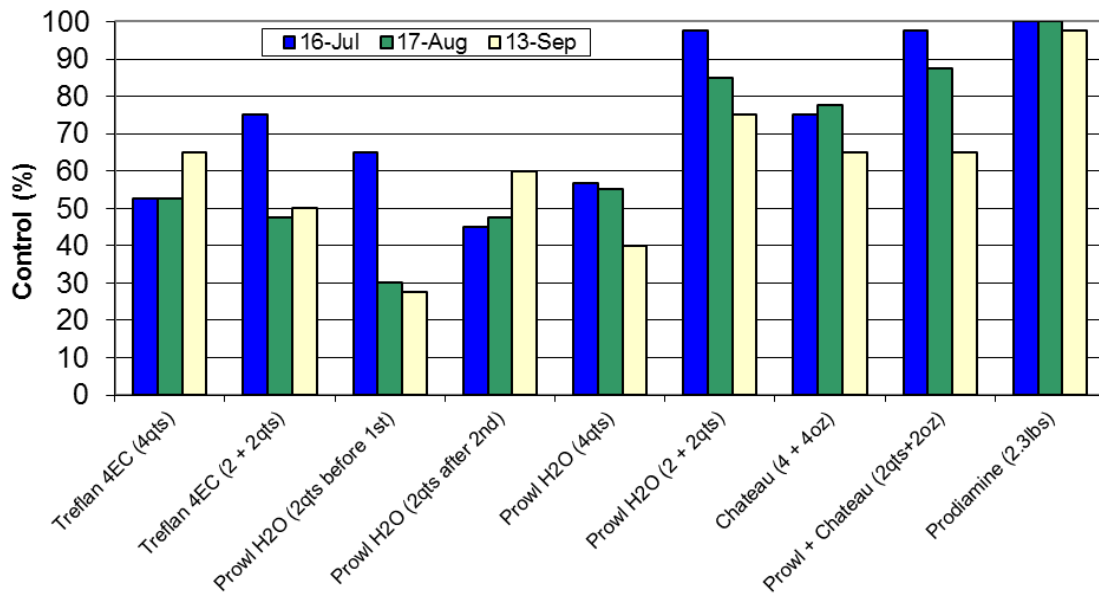


Figure 1. Pre-emergence control of pigweed in established alfalfa in Hinkley, CA. Andre Biscaro. 2010.

None of the post-emergence treatments were highly effective. Pursuit initially provided 80 percent control but as the season progressed, control fell to less than 40 percent. The best control, 90 percent early season and 80 percent mid- and late-season, was achieved with a tank mix of Raptor and Pursuit with each being applied at 3 oz. per acre.

Winter Weed Control in Established Alfalfa

There are few effective post-emergence herbicides to use in established alfalfa for broadleaf weed control. Paraquat (Gramoxone) is the primary herbicide, but oftentimes it does not adequately control some problem weeds, common groundsel being a prime example. Research was conducted by Mick Canevari, Farm Advisor Emeritus in San Joaquin County, to evaluate the use of Sharpen and standard dormant-season herbicides for controlling common groundsel and other problem weeds. Sharpen caused a high degree of initial necrosis and stunting, more than that observed with paraquat. These effects lasted longer than with paraquat or the other winter dormant herbicides, but the alfalfa recovered by harvest time. Sharpen was much more effective than Gramoxone for controlling common groundsel (Figure 2). Combinations of Sharpen with Chateau or Velpar were especially effective providing perfect control at all evaluation dates.

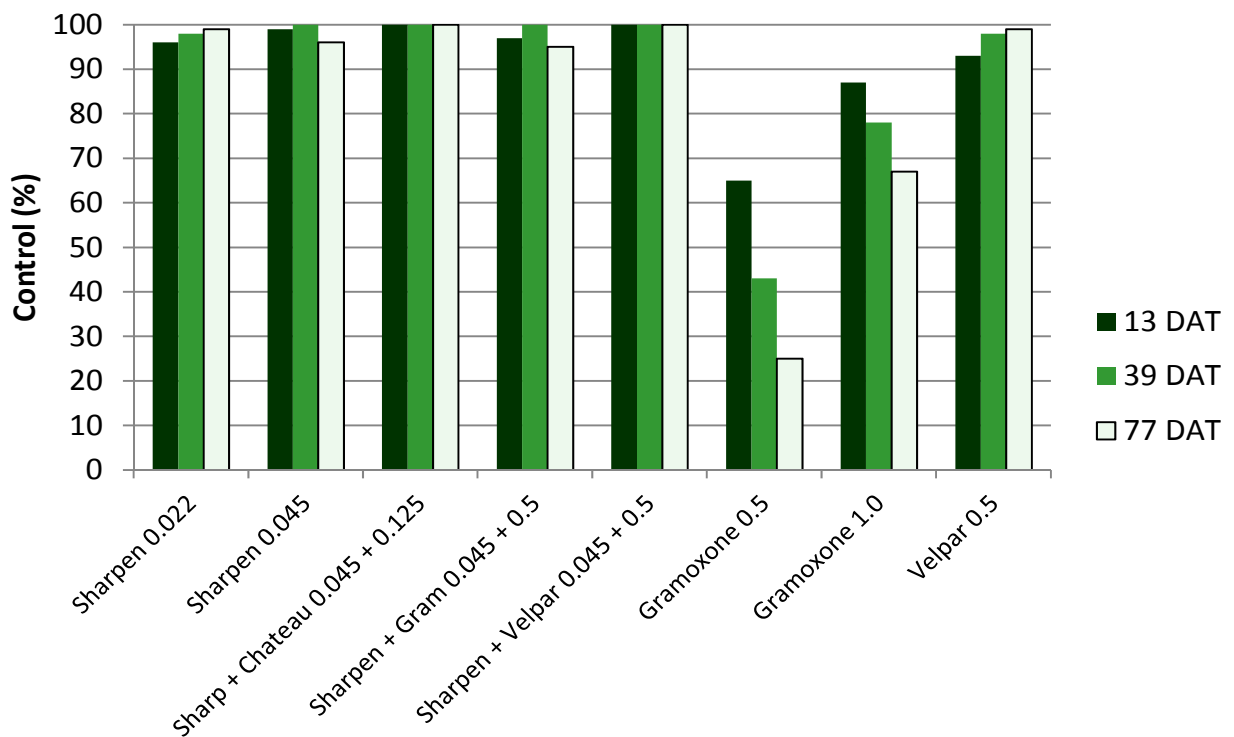


Figure 2. Common groundsel control in alfalfa in established alfalfa. San Joaquin County. Treated on 12/10/2010. Mick Canevari. 2011.

Sharpen was also effective for controlling annual sowthistle and hairy fleabane, however, late emerging plants escaped control. Sharpen alone did not adequately control shepherd's purse. A Sharpen plus Gramoxone tank mix was similar to Sharpen alone for groundsel control, but shepherd's purse control was improved. Sharpen, especially when combined with soil-active herbicides, shows potential for controlling groundsel and other problematic weeds in alfalfa.

Innovations in Cotton Weed Management

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The development of herbicide resistant weeds in southeastern U.S. cotton fields presents serious challenges to cotton producers across the country. The number of herbicide resistant weed populations has steadily increased for over the last 40 years and the number of glyphosate resistant weed populations has increased dramatically since 1996 to 21 resistant weed biotypes in early 2012 (11 grass and 10 dicot species). The current status of herbicide resistant weed populations worldwide can be found at www.weedscience.org. Palmer amaranth (carelessweed, pigweed, *Amaranthus Palmeri*) resistant to glyphosate, the active ingredient in Roundup products, is the most widespread and difficult to manage in cotton due to its fast growth rate and prolific seed production. This weed can increase production costs as much as \$100 to \$200 per acre through increased costs for chemical, hand labor, fuel and equipment.

Common cotton production practices in western states such as tillage, furrow irrigation, in-season cultivation and diverse crop rotation sequences have delayed the development of herbicide resistant weeds in the west. Western farmers have the opportunity to be proactive and adopt management practices that can avoid or delay the development of herbicide resistant weeds. The concept of diversity is the key to managing herbicide resistance in weeds. No-till cotton farmers that used only postemergence glyphosate (e.g., Roundup) sprays for weed control were the first to develop glyphosate resistant Palmer Amaranth populations.

Diversity means using a combination of tactics to reduce the selection pressure imposed by any single weed control practice. Diversity means using mechanical, cultural and biological practices in addition to herbicides. Diversity in herbicide use is achieved by applying several herbicides in a season that have different mechanisms of action but will control the same target weed or weeds. The development of herbicide resistance can be delayed and perhaps avoided by using a few or several of the tactics listed in **Table 1**. One of the best ways for western cotton producers to increase their diversity of herbicide use is to apply preplant-incorporated residual herbicides such as trifluralin or pendimethalin at the beginning of the season. Another is to continue to use tillage; both preseason tillage for field preparation and in-season cultivation for weed control.

Preemergence herbicide experiments conducted in 2004 to 2008 at the University of Arizona Maricopa and Safford Agricultural Centers (MAC and SAC) investigated the early season weed suppression of Palmer Amaranth (AMAPA) and ivyleaf morningglory (IPOHE) resulting from different methods of applying pendimethalin and trifluralin in RR Flex cotton and Liberty Link cotton. The herbicides were simultaneously applied to flat ground (i.e., broadcast)

and incorporated with a field cultivator or were applied with a roto-mulcher following listing (i.e., bed formation). When applying the herbicides with the mulcher, TeeJet XR8001VS or XR8015VS 80 degree flat fan nozzles were mounted to spray a band that was 50% of the row spacing centered on the listed bed and the rate in the sprayed band was double the broadcast rate of the treatments applied with the field cultivator. Thus, after the mulcher incorporated the herbicides and redistributed the soil, the herbicide rates were comparable on a broadcast area basis.

The preplant incorporated (PPI) application of pendimethalin with a field cultivator prior to bed formation provided excellent control of Palmer amaranth (AMAPA) and suppression of ivyleaf morningglory (IPOHE) in terms of both reduced weed density and slower growing weeds. These two effects resulted in a longer early season topical glyphosate or glufosinate application window and improved weed control later in the season. For example at MAC in 2005 at 34 DAP (days after planting), AMAPA plants were 6.8 cm tall with 8.8 leaves per plant and there were 205 plants m^{-2} in the absence of pendimethalin compared to plants that were 2.5 cm tall with 6 leaves per plant with a density of 5.2 plants m^{-2} in the presence of pendimethalin (1.06 kg/ha). Similarly, at 34 DAP, IPOHE plants were 4.8 cm tall with 4 leaves per plant and there were 48 plants m^{-2} in the absence of pendimethalin compared to plants that were 2.0 cm tall with 2 leaves per plant and a density of 13.3 plants m^{-2} in the presence of pendimethalin. The effects of pendimethalin on weed size resulted superior Palmer amaranth control after early season topical herbicide applications and in greater suppression of ivyleaf morningglory after two sequential postemergence herbicide applications (either glyphosate or glufosinate).

In a dry-plant experiment at MAC in 2008, the control treatment not treated with a dinitroaniline herbicide contained 85 and 79 AMAPA and IPOHE plants m^{-2} , respectively, 40 DAP (i.e., after the germinating irrigation). Treatments that had pendimethalin (0.92 kg/ha) or trifluralin (0.7 kg/ha) applied with the field cultivator had 0.2 and 0.2 AMAPA plants m^{-2} and 37 and 18 IPOHE plants m^{-2} at 40 DAP, respectively. Similarly, treatments that had pendimethalin (0.92 kg/ha) or trifluralin (0.7 kg/ha) applied with the roto-mulcher after bed listing had 0.8 and 1.3 AMAPA plants m^{-2} , respectively, and 27 and 35 IPOHE plants m^{-2} at 40 DAP, respectively. The herbicide treatments had significantly fewer weeds compared to the control but the differences in AMAPA and IPOHE densities as a function of herbicide application method (field cultivator versus roto-mulcher) were not significantly different. Thus, in furrow-irrigated cotton production systems, growers can eliminate a preplant pass across cotton fields by combining preemergence herbicide applications with roto-mulching that is necessary as a part of bed formation thereby reducing crop production costs.

Another tactic that can be used to reduce the risk of developing or selecting for herbicide resistant weeds is secondary tillage or in-season cultivation for weed control. Previous precision

tillage research conducted in Arizona cotton in the 1990s prior to development of GPS-RTK systems determined the equipment needed (e.g., articulated electro-hydraulic quick-hitch and wands that sensed location of cotton plants/seed-line) and documented the benefits in terms of improved weed control, faster operating speeds, reduced operator fatigue and reduced costs. However, the system had limitations including that it could not be used until cotton stems could withstand the force applied by the wands (i.e., about 1 foot tall) and that equipment maintenance and training workers proved to be too difficult for most adopters of the system.

The maturation of GPS-RTK tractor auto-steer technology and widespread availability provide growers with an opportunity to increase the use of steel and reduce the reliance on postemergence herbicides. When this technology is used for all field operations (i.e., listing, roto-mulching, bed-shaping and planting) growers have precise knowledge of the location of the cotton seed-line (i.e., the A-B line) and this information can be used to conduct precision in-season tillage for weed control. In small cotton (2 to 4 leaf) a rigid, 3-tool-bar cultivator frame with two disk-stabilizers mounted on the rear bar can be used with the following tools (front to back): disc openers, banana knives (facing away from the crop row and mounted on the front of the middle bar) and Alabama sweeps. The disk openers should cut a shallow slot that the banana knives run in to avoid moving surface soil around the cotton seedlings and damaging their stems. Typically the uncultivated band around the seed line in coarse textured soils is 5 to 6 inches.

Precision tillage and in-row weeding can be conducted with tools such as Bezzerides Spring Hoe weeders or Torsion Bar weeders in bigger cotton with several inches (>3”) of woody bark at the base of the stem (normally cotton > 1 foot tall). A rigid 3-bar cultivator frame with two disk-stabilizers can be used with the following tools (front to back): disk openers, beet knives (mounted on the front of the middle tool bar) with the points facing the crop row and the vertical shank away from the crop row, Bezzerides Torsion Bar Weeders mounted on the back of the middle bar) with Alabama sweeps on the rear bar. A typical gap between the ends of the beet knives is 3 to 4 inches and they should run about 2 inches deep to undercut the roots of weeds. The torsion bar weeders are set to slightly overlap the cotton seed line and run about 1 to 2 inches deep. Fertilizer injection knives can also be mounted on the front of the rear tool bar and a tank and pump system mounted on the cultivator to simultaneously cultivate and side-dress nitrogen fertilizer in one pass through the field. Special clamps may be needed in the latter situation to provide enough room for the tools on the rear bar.

Precision tillage can be combined with the use of postemergence herbicides sprayed in narrow bands to reduce the amount of herbicide used and the consequent selection for herbicide resistant weeds since steel is non-selective. Keys to making precision tillage work are an understanding of the GPS-RTK system and the use of disk stabilizers on the cultivator so that the soil engaging tools do not twist the tractor on its radial tires and cause “cultivator blight”. The 3-

point hitch sway blocks must be used to lock the cultivator into position directly behind the tractor so there is no sideways motion and yet allow the cultivator to be lowered to the appropriate working depth. The beet knives and torsion bar weeders should be running about two inches below the soil surface during operation. Stable depth control is best achieved with gauge wheels.

Additional tactics that can reduce the selection for herbicide resistant weeds is to choose and use herbicides with different mechanisms of action and to use the full labeled dose of herbicide when spraying. (A ***herbicide mechanism of action is the biochemical site within a plant with which a herbicide directly interacts.***) The Weed Science Society of America (WSSA), the EPA and primary herbicide manufacturers have collaborated to develop a mechanism of action group numbering system for herbicides (see the WSSA website; <http://www.wssa.net/Weeds/Resistance/index.htm> and click on the link for “[WSSA Classification of Herbicide Mechanism of Action](#)”). These group numbers are on most major manufacturer labels but not yet on all generic herbicide labels. Using herbicides with different trade names but the same group number is NOT using herbicides with different mechanisms of action and will not reduce the risk of developing herbicide resistant weeds. The development of Liberty Link Cotton which is resistant to glufosinate (Liberty) and GlyTol cotton that has resistance traits for both glyphosate and glufosinate provide growers with an alternative to continuously using glyphosate herbicides in cotton production.

When spraying weeds the full label rate specified on the label should be used. As defined by the Weed Science Society of America the “***full labeled rate***” is the rate or range of rates set by a manufacturer that consistently provides effective control of a weed species across growth stages and site conditions. Using low herbicide rates repeatedly over time can lead to the evolution of a herbicide-resistant weed population by allowing some treated plants to survive, reproduce and disperse seed. As defined by the WSSA, a “***low rate***” is a rate applied below the labeled rate that may provide effective control at an individual location, but will not provide consistent control over a wide range of conditions. Weeds may be exposed to low rates due to: 1) the intended use of low rates, 2) spraying plants larger than those recommended on the label, 3) inadequate spray coverage of weeds because of size, density and/or crop cover, and 4) errors in sprayer calibration, faulty equipment, or mixing errors.

Table 1. Weed management tactics that can delay the development of herbicide resistance.

Tactic	Strategy	Action
Herbicide	Use multiple herbicides with different mechanisms of action	MIX: tank mix herbicides with different mechanisms of action and spray them together. For example, mix prometryn with glyphosate when making post-directed sprays midseason.
		SEQUENCE: use a sequence of herbicides with different mechanisms of action. For example, use a residual “yellow” herbicide (trifluralin or pendimethalin) preplant incorporated followed by postemergence herbicides or use a residual herbicide at layby.
		ACROSS SEASONS: use different herbicide mechanisms of action across seasons. For example, grow Liberty Link Cotton one year followed by Roundup Ready Flex Cotton the next year.
Mechanical	Use steel to kill weeds; steel kills both herbicide susceptible and resistant weeds (<i>clean implements between fields</i>)	PRE-PLANT: use primary tillage to prepare fields for planting and start the season with a clean field.
		IN-CROP CULTIVATION: use steel to kill weeds that may have escaped chemical treatment and maintain a clean furrow.
		IN-ROW WEEDING: when cotton has several inches of bark at the base of the stem, consider using precision guidance and in-row weeding tools such as Bezzersides Spring Hoe Weeders or Torsion Bar Weeders.
		POST-HARVEST: use tillage at the end of the season to kill surviving weeds.
Cultural and Biological	Maximize crop growth and competition against weeds; minimize pollen and seed movement	CROP ROTATION: rotating crops exploits differences in tillage practices, crop competitiveness and herbicide choices for controlling weeds.
		PLANT POPULATION: an optimum crop plant population maximizes competition against weeds.
		ROW SPACING: Narrower rows result in more rapid shading of the furrows; wider rows require longer periods of weed control.
		COVER CROPS: cover crops planted before the primary crop may suppress weed growth through physical presence or release of allelochemicals that affect weed germination and growth.
		SANTITATION: remove weeds growing around field margins or borders to prevent pollen movement between resistant and susceptible plants. Prevent movement of weed seeds and vegetative propagules (e.g., tubers and rhizomes) between fields by cleaning equipment.

California NPDES Aquatic Pesticide Permit Update: What's New?

*Michael S. Blankinship,
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Aquatic weed specialists working for drinking water, flood control, restoration and the irrigation community manage algae and a variety of aquatic weeds including submersed, floating, emergent and riparian species. These weeds can create flow restrictions in irrigation canals and flood control structures and pose taste, odor and aesthetic problems in drinking water storage and conveyance facilities. Intentional introduction of pesticides into Waters of the US to control these weeds requires a permit. Details of permit requirements will be presented with examples.

Ditch Bank Weed Control

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Managing vegetation along irrigation ditch banks and roadways can be extremely challenging. If weeds are allowed to grow unchecked, problems arise inside the canal by restricting the flow of water and causing water levels to rise. Weed seeds could easily spread with the water flow to nearby fields and re-germinate.

Vegetation that grows at the waterline inside the canal has been controlled by glyphosate for many years and are now showing resistance to this material.

In recent years this has been an increasing problem because of the lack of registered chemicals that will effectively control these waterline weeds. Fleabane, Marestail and Mexican Sprangletop are weeds that are well known to anyone who manages vegetation for a living.

Management of these weeds truly takes a new approach to your spray program. Products that will effectively control them are difficult to use around irrigation canals. Many of these sites are too close to agricultural crops for safe use, and not registered for use on flowing water structures.

This presentation will discuss the importance of managing vegetation along irrigation canals and the practices involved. Additional topics will include how to develop a good weed control program, management of resistant weeds in hard to control areas, and common products used in vegetation management.

References:

SePro Corporation, *Clearcast product label* www.sepro.com

Target Specialty Products materials list www.target-specialty.com

South American Spongeplant is Invading California

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South American spongeplant (*Limnobium laevigatum*) is a water hyacinth wannabe that may have the potential to be even more persistent and widespread in California than hyacinth itself. Unlike hyacinth, it produces many seeds and very small seedlings, so it moves more easily than hyacinth. The seeds can also lay dormant for at least four years, so it returns quickly after control measures if a seed bank has been established.

In the last several years, South American spongeplant has advanced its establishment in California, especially in the Central Valley.

Spongeplant first appeared in 2003 in a single 5-acre pond in Redding. The plant was easily controlled with diquat, but this initial infestation still requires treatment after six years.

Beginning in 2007, spongeplant began to pop up in well-separated locations in the San Joaquin Valley, centered in the Fresno area including the San Joaquin River. Infestations in any one location are relatively easy to eradicate if they are caught early, but the plant's mobility and ready recovery from seeds present challenges to eradicating it from the state.

This talk will describe the spread of the plant and some of the control efforts.

***EGERIA DENSA* CONTROL IN THE SACRAMENTO-SAN JOAQUIN DELTA**

Terri Ely and Ken Yelle, California Department of Boating and Waterways
Lars Anderson, United States Department of Agriculture – Agricultural Research Service
Scott Shuler and Dave Blodget, SePRO Corporation

The California Department of Boating and Waterways (DBW) has been treating *Egeria densa* throughout the Sacramento-San Joaquin Delta (Delta) since 2001. The herbicide of choice for Egeria control in the Delta is fluridone (Sonar Aquatic Herbicide) based upon numerous environmental impact studies completed to meet Endangered Species Act requirements. Fluridone requires a contact time of six to twelve weeks for control of Egeria making treatment in a riverine delta system challenging. In the early years of the program, mainly small scattered sites were treated and with permit restrictions these treatments did not start until July. In 2006, permit modifications allowed treatment in some areas to begin in April. Treatment effectiveness improved dramatically. In 2007, armed with early start dates the program decided to try large regional type treatments. The area chosen was Franks Tract State Recreation Area in the Central Delta. The treated area was approximately 3000 acres. This was done over two consecutive seasons and was very successful. The Egeria control program has overcome many challenges related to endangered species, flow within the delta, agricultural irrigation intakes and understanding how to apply fluridone to sustain concentrations that will provide control. In the 2011 season we were again in Franks Tract and surrounding sloughs as well as the western portion of Discovery Bay. Preliminary results indicate a successful treatment. The Egeria program is poised for success and further progress once the Federal Permits are renewed this year.

Weed Management Practices in Nurseries

Bruce Kidd, PCA, Dow AgroSciences (Retired), Murrieta, CA

Weeds are persistent problems in the production of ornamental plants and in the landscapes where these plants are sold. A relatively small number of species account for the most common weeds encountered in nursery culture. For instance, a report on weeds in container nursery stock in the UK cited Hairy bittercress (*Cardamine hirsuta*), Willowherb (*Epilobium sp*), Pearlwort (*Sagina recumbens*), Groundsel (*Senecio vulgaris*), and Chickweed (*Stellaria media*) as among the most common weeds found. This report could just as easily have been written to describe the most common weed problems in California, with the addition of a few local favorites such as Prostrate spurge (*Euphorbia supina*), Common woodsorrel (*Oxalis corniculata*) and Sowthistle (*Sonchus arvensis*). The occurrence of similar weeds in nursery production from widely differing geographies suggests that similar cultural practices play a major role in determining nursery weed survival and proliferation.

Plant growth requirements such as water, fertilizer, light and favorable temperatures are rarely lacking in the nursery environment. Conditions designed to promote rapid ornamental growth are ideal for weeds that tend to germinate, grow and reproduce faster than the crop, which is often more delicate and less competitive than the weeds. Weed competition is constant and transferable to the next crop, the next year and beyond. A nursery manager frustrated by weed problems knows that the weeds he's seeing have been selected by his cultural practices, which are designed to grow perfect plants. For that reason, weed control in nurseries is addressed through a combination of manual and chemical operations throughout the life cycle of the crop.

When it comes to preventing or removing weeds, crop safety is paramount. Hand weeding seems like an easy and obvious solution except that the high cost of repeated hand labor for stubborn weeds like spurge, oxalis and sowthistle may exceed the value of the crop. On the other hand, some weeds such as willowherb are relatively easy to pull due to their height and small root systems, but difficult to control with herbicides. The real challenge may be as simple as getting a crew to do it before the weeds proliferate and scatter new, windblown seed. Prostrate spurge is almost impossible to hand weed effectively due to sheer numbers and an easily breakable stem that leaves viable roots and stem pieces to regenerate in the soil. Most nurseries ultimately rely on hand labor plus selective herbicides, but with great attention to product label support for the intended use. As pesticide salespeople quickly learn, nurserymen may forgive you for lousy weed control, but not for crop injury.

Nurseries who view weed management as an ongoing program tend to get better results than nurseries who manage weeds reactively, after weeds have become established. In field grown roses, for example, preplant herbicides are broadcast over the field, and followed months later by post-emergence, directed sprays after the crop becomes established. Still, lay-by treatments often fail to completely control weeds like twining Morning glory (*Ipomea sp.*) that interfere with harvest. There are few herbicide solutions

for established weeds in nurseries, especially considering that a nursery may grow hundreds of different species and varieties of ornamentals. It may be possible to control weeds in field grown culture with timely applications of non-selective treatments, but in containers, only selective, pre-emergence herbicides can be used safely.

In a container nursery production cycle, there are predictable windows of opportunity when weeds should be addressed. These include 1) during liner propagation, 2) site preparation before setting containers on ground, 3) at potting, 4) approximately one month after potting.

- 1) Liner propagation is the process of establishing rooted cuttings or seedling plants in small pots or flats prior to transplanting to larger containers. Weeds such as bittercress that grow and reseed rapidly in moist shade can be tremendous problems in liner production, with the added consequence of transplanting these weeds or their seeds into the finished containers or field, where the weeds can increase and spread. Step One in a weed management program involves keeping the entire propagation area as clean as possible. Contact herbicides such as Scythe are labeled for use in greenhouses and propagation areas for control of weeds on the ground or under benches, but liner stock itself is usually too immature for herbicides and needs to be handweeded. Soils used in liner propagation should be clean and weed free. The goal should be for zero weeds going to seed in the propagation area, and zero live weeds leaving it.
- 2) Prior to setting out containers that may sit for months or years prior to sale, nurserymen should have a block-by block plan for managing weed competition from resident weeds that have eluded previous control measures, or simply blown in anew from outside the nursery. Airborne weed seed from fleabane (*Conyza bonariensis*) and sowthistle are notorious for re-infesting sites nurserymen thought were clean. These weeds may emerge in containers or on the ground among containers. The ground may be anything from bare soil, to soil covered with gravel, or the nursery may invest in weed mats as a longterm weed prevention measure. Weed mats must be maintained to repair holes and seams and kept clean or weeds will germinate in spilled soil on top of the mats. To prevent weeds growing up between the containers, nurseries often treat the growing area first with broadcast combinations of glyphosate to kill existing weeds plus pre-emergence such as Gallery (isoxaben), Dimension (dithiopyr), or prodiamine (Barricade). This helps get the crop started clean.
- 3) When the liner stock is mature enough, the plants are transplanted to larger containers or established directly in the field. Many nursery ornamentals can be treated safely over-the-top at this point with selective, pre-emergence herbicides, usually in granular form. Granular formulations of herbicides such as Snapshot (trifluralin + isoxaben) or OH2 (oxyfluorfen + pendimethalin) are often considered safer and easier to apply than spray applications of the same active ingredients, but granules are more expensive than sprayables. The usual sequence is to pot the plants up and settle the soil with a good irrigation before treatment. Treatment should be done as soon as possible after potting up

because the weeds won't wait. Delaying a week or two after potting before applying herbicides allows fast-emerging weeds like chickweed and spurge to germinate and become established, and most selective herbicides lack sufficient "reach-back" activity to catch them from behind. Following application, the plants should be watered overhead to remove granules or spray off the foliage, and begin the process of herbicide activation in the soil.

- 4) About a month after the new crop been treated with pre-emergence herbicides, Plan B begins. Plan B is a planned inspection plus hand weeding or cultivation to remove any weeds that have escaped control thus far. This is an important step, and an opportunity not to be missed, as 95% control still means 5% rapidly growing weeds, and you want to deal with them when they're small. Plan B emphasizes that you can't make a treatment and just turn your back on it. In general, herbicides tend to last about half as long in nursery culture as they do in landscapes, due to microbial breakdown aggravated by constant irrigation, fertilization and the use of high organic soil mixes that adsorb herbicides. This means a product label that promises six months control in landscapes may deliver only three months under nursery culture. Nurseries often need 2-4 treatments per year. Treatments should be timed as one season is ending and another is beginning, and weeds should never be allowed to go to seed.

In the end, weed management, like most pest control, is all about sanitation. Weeds may be a sign to some of healthy biodiversity, but they are also alternate hosts for insects, mites, diseases and nematodes. Their physical presence may shade the crop, impede worker access and disrupt air movement in the crop canopy, which creates conducive conditions for other problems. A tolerance for weeds may indicate a tolerance for other, more serious problems, and runs contrary to the quality standards nurseries seek to instill in their workers and project to their customers. Even if the growing area is clean, nurserymen still need to control weeds around the perimeter of the nursery, targeting weeds whose seed might blow in the wind towards the compost pile or growing area.

An old saying warns that "one years seeding means seven years weeding". This is because weeds not only invade but defend niches where the crop is not competitive. Waiting to spray till weeds are mature and have set seed may be satisfying for revenge, but it is not good weed control.



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Course Outline For: Getting the Most Out Of Your Preemergent Herbicide Application

Todd Burkdoll, BASF Tech Services

This presentation will discuss the properties of common pre-emergent herbicides used in landscape and non-crop sites. The importance of proper application timing, herbicide incorporation, rotation management and weed ID will be discussed.

Common preemergent herbicide properties such as mode of action, water solubility, soil adsorption, vapor pressure and factors affecting herbicide persistence will be discussed for various herbicide families.

(45 min.)

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Evaluation of Herbicides for Weed Control Efficacy and Crop Safety in Field Production of Nursery Fruit and Nut Trees

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Introduction

Weed control is an ongoing management problem facing nursery growers of field-grown fruit and nut trees. Competition from weeds can decrease crop productivity and interfere with field and harvest operations. Control strategies currently rely on methyl bromide, pre-emergence herbicides, hand labor and multiple tillage operations. Soil fumigation alone often does not provide and maintain a consistently high level of weed control over the entire 1- to 3-year nursery tree-cropping cycle. Some weed species are not well controlled by fumigants due to their biology (impermeable seed coat, dormancy), ecology (airborne invasion, large seed bank), or response to environmental conditions (dry soil). This problem likely will be compounded by use of fumigants other than methyl bromide which is being phased out due to environmental concerns. Hand labor can effectively control weeds within rows of nursery stock 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.

Therefore, weed control chemicals and techniques will likely become an important part of an integrated pest management strategy in nursery crops as methyl bromide is phased out and fuel and labor cost increase. Several herbicides are labeled for use in tree and vine nurseries but during the critical rootstock emergence and early-season growth period, residual herbicide choices are limited by number of registered materials and by crop safety concerns. Some herbicides can injure either perennial crop root growth (stunting or malformations) or above-ground growth (meristem damage, stem malformations, stunting, chlorosis, or death). Because nursery-grown tree and vines that are produced in the ground are dug up and sold, e.g., as bareroot stock, any root or stem damage is unacceptable to the buyers and these plants are not marketable. Several new herbicides have been registered in orchard crops for control of a broad spectrum of weeds; however, these herbicides are not currently labeled for tree nursery production.

The goals of these field trials were to evaluate weed control efficacy of several pre-emergence and post-directed herbicide treatments, evaluate nursery root-stock safety of the herbicide treatments, and determine the effect of treatments on the health, vigor and productivity of the field-grown fruit and nut trees at harvest. Ultimately these experiments will provide growers and researchers information on weed control efficacy and crop safety with these herbicides.

Methodology

Field trials were conducted from 2009 to 2010 and 2010 to 2011 at commercial nurseries with Nemaguard peach (seeded) and Krymsk86 plum/peach hybrid (cuttings) rootstocks. Prior to planting, nursery blocks were fumigated with either methyl bromide or a dual application of Telone II. Each experiment was arranged in a randomized complete block design with four replications and individual herbicide plots were 3 feet by 25 feet containing a single tree row. Several pre-(PRE) and post-emergence (POST) applications of registered and unregistered herbicides were applied (table 1). PRE treatments were applied after seeding the rootstock but before emergence using a CO₂-pressurized backpack sprayer calibrated to deliver 25 to 50 gallons per acre in a 3-foot band. In the POST trials, herbicides were applied using a directed or shielded spray boom as appropriate to minimize crop exposure to the treatment.

Crop injury and weed control were monitored throughout the 14-month growing season. Prior to harvest, established trees were counted and trunk caliper was measured.

Results and Discussion

In 2009 to 2010, low weed populations were observed due to either effective fumigation or handweeding operations in all sites. Control of grasses was effective in all treatments except those treated with isoxaben or the low rate of oxyfluorfen, while broadleaf weed control was generally poor with low rates of pendimethalin and oxyfluorfen and both rates of isoxaben (table 2). All treatments resulted in similar Krymsk86 rootstock trunk diameter and demonstrated excellent safety except the high rate of oxyfluorfen which caused significant visual injury. Overall, the most promising materials from a crop safety and weed control standpoint were thiazopyr, dithiopyr, rimsulfuron, and pendimethalin + oxyfluorfen.

From 2010 to 2011, all PRE treatments except oryzalin and low rates of indazaflam and penoxsulam provided good to excellent control of broadleaf weeds (table 3). Among the herbicide treatments, foramsulam at all rates caused the least injury to Nemaguard peach seedlings (fig. 1). One month after PRE applications, significant stunting and malformation were observed in plots treated with dithiopyr, penoxsulam + oxyfluorfen, and high rates of indaziflam and penoxsulam. Low seedling establishment was observed in plots treated with rimsulfuron and in plots treated with the highest rates of indaziflam and penoxsulam. Due to large variability in tree establishment throughout this field, no differences in final tree trunk measurements were observed.

The study showed that application of PRE and POST herbicides provided good to excellent weed control in tree nurseries and caused little injury to rootstocks planted as cuttings but safety was lower in seeded rootstock. However, considerable work on herbicide rates, timing and method of application are needed before these materials can be safely applied to newly planted rootstock on a more broad scale.

Fig. 1. Seedling establishment and weed control in a plot treated with (A) indaziflam at 0.032 lb. a.i./acre for the lowest rate and (B) foramsulfuron at 0.044 lb. a.i./acre two months after treatment. Herbicide treatment applied: January 8, 2011.



A

B

Table 1. Herbicide products used.

2009-2010		2010-2011	
Common name	Trade name	Common name	Trade name
carfentrazone	Shark	indaziflam	Alion
dithiopyr	Dimension	oryzalin	Surflan
flumioxazin	Chateau	rimsulfuron	Matrix
isoxaben	Gallery T&V	penoxsulam	Tangent
oryzalin	Surflan	oxyfluorfen	Goaltender
oxyfluorfen	Goaltender	penoxsulam + oxyfluorfen	Pindar GT
paraquat	Gramoxone Inteon	dithiopyr	Dimension
pendimethalin	Prowl H ₂ O	foramsulfuron	Option
rimsulfuron	Matrix		
thiazopyr	Visor		

Table 2. Effects of POST directed herbicide applications on Krymsk86 plum/peach cuttings in a tree nursery trial in 2009 – 2010.

Herbicide treatment ^a	Rate	Crop injury ^b	Grass control ^b	Broadleaf control ^b	Trunk diameter ^c
	lbs ai/acre	%			mm
untreated	-	0	0	0	15.3
isoxaben	1.0	5	63	28	17.1
isoxaben	1.3	1	82	71	15.8
dithiopyr	1.0	14	98	96	16.9
dithiopyr	2.0	6	97	97	17.4
pendimethalin	1.0	0	88	62	16.6
pendimethalin	2.0	0	94	84	16.0
oxyfluorfen	0.5	6	71	79	17.0
oxyfluorfen	1.0	28	97	91	18.0
thiazopyr	0.5	0	99	84	16.7
thiazopyr	1.0	8	99	97	16.7
pendimethalin + oxyfluorfen	2.0 + 0.5	0	97	89	16.4
pendimethalin + oxyfluorfen	2.0 + 1.0	15	99	98	18.3
rimsulfuron	0.016	5	99	92	15.4
LSD (0.05)		15	19	24	NS

^a Treatments applied: March 5, 2009

^b Evaluated: May 24, 2009

^c Measured: October 30, 2009

Table 3. Effects of PRE herbicide applications on Nemaguard peach seedlings in a tree nursery trial in 2010 – 2011.

Herbicide treatment ^a	Rate	Broadleaf control ^b	Seedling injury ^b	Established trees ^c	Trunk diameter ^d
	lbs ai/A	no./plot	%	no./10 ft	mm
untreated	-	13	-	17	15
indaziflam	0.032	10	9	15	15
indaziflam	0.065	3	48	13	17
indaziflam	0.085	2	43	14	15
indaziflam	0.17	1	71	4	20
oryzalin	2.0	11	13	18	16
rimsulfuron	0.016	5	53	7	17
penoxsulam	0.015	9	49	12	15
penoxsulam	0.03	3	48	5	16
penoxsulam	0.06	4	74	1	16
oxyfluorfen	0.25	4	20	16	17
penoxsulam + oxyfluorfen	0.03 + 0.25	4	53	10	14
dithiopyr	2.20	3	55	14	14
foramsulfuron	0.022	4	0	18	14
foramsulfuron	0.044	2	0	19	14
foramsulfuron	0.088	1	3	18	15
LSD (0.05)		4	24	5	NS

^a Treatments applied: January 8, 2011

^b Evaluated: April 8, 2011

^c Plot size: 3 feet by 25 feet

^d Measured: October 18, 2011

Potential of Precision Weed Control

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Growers strive to improve crop production and harvest efficiency as well as crop yield and quality. Barriers to achieving these goals include the availability of registered herbicides and the accessibility and cost of labor for weed control. The accessibility and cost of labor is greatly affected by State or Federal immigration policy and the economy; the availability of registered herbicides is affected by the chemical registrants' expected sales revenues (which may be low for specialty crops and may not offset registration costs) and projected liability to the registrant if the crop is injured by the herbicides, as well as environmental issues. Immigration policy, the economy and pesticide registration decisions are factors that are difficult or impossible for growers to control or influence. Fortunately, labor issues and the availability of herbicides are less of a hindrance to weed control when growers adopt new technologies that can increase labor-use efficiency.

The application of computer technology to row crop production has been an active area of research and development, and has made significant progress with respect to weed control. Mechanical weed control machines are becoming available that utilize cameras to detect crop plants on a bed. The camera then sends an image of the bed to a computer, which analyzes the data and records the location of crop plants on each bed. Present technology relies on size differences between the crop and the weeds. Computer-assisted mechanical weed control machines are therefore more effective when used on transplanted crops than direct-seeded because transplanted crops are initially larger than the weeds that emerge after planting. Once crop plants are recognized, the machines use a variety of techniques to remove the weeds from the seed line: swinging, spinning, or opening and closing blades, or other techniques such as flaming and the use of timed chemical sprays. All of these mechanisms are designed to avoid crop plants and remove weeds between the crop plants in the seed line. Currently, there are two notable computer-assisted mechanical weed control machines either on the market or close to being commercialized for row crop production. In the following two examples, we describe these machines and our efforts to evaluate efficacy or provide a demonstration opportunity for growers.

Example 1

In 2009 and 2010 we evaluated a commercially available unit, the Tillet Weeder, which is fabricated in England (Garford Corp, <http://garford.com/>). This computer-assisted mechanical weed machine uses a spinning blade with a notched cut-out on one side. The blade travels in the seed line removing weeds, but when it encounters a crop plant, it spins around it by placing the plant in the notch (fig. 1). We evaluated the efficacy of this machine for weed control, crop safety and impact on hand weeding in trials on leafy green vegetables and tomatoes as compared

to standard cultivation with knives and sweeps, which do not remove weeds from the band that is left around the seed line. In one trial with transplanted radicchio, the Tillet removed 64% of the weeds in the seed line and reduced subsequent hand-weeding time by 3.7 hours per acre (table 1). The mechanical action of the Tillet in this trial did not reduce the stand or the yield of radicchio. In contrast, in direct-seeded lettuce, although the Tillet Weeder reduced weed densities by 69% and hand-thinning times by 24% compared to the standard cultivator, the crop yield in the Tillet cultivator treatments were 11.7% less than the standard cultivator treatments. The Tillet cultivator worked much better in transplanted lettuce, where hand-weeding times were only 10% less than in the standard cultivator treatments, but lettuce yields were not affected by cultivator type (data for lettuce are not shown).

In most of our trials for direct-seeded and transplanted lettuce and tomatoes, the Tillet was able to reduce thinning and hand-weeding costs per acre between 15 and 30% over standard cultivation. However, as previously mentioned, the Tillet also reduced yields in a number of trials, resulting in lower net returns to growers. Some fine-tuning of this technology would be helpful in minimizing yield reductions, which in turn may improve net returns to growers. Comparable savings in thinning and hand-weeding costs observed in these trials may be achieved in field-grown flowers if they are planted in bed configurations that are similar to the plant spacing used in the evaluated vegetable crops (double rows on 40-inch beds with 10 to 12 inches between plants in the seed line). Attention to total yield and net returns must be factored into any decision for use of this technology.

Example 2

In May, 2011 we held a field day demonstrating a second type of technology that is soon to be commercially available which is a prototype of an automated weeder/thinner developed by the University of Arizona and Mule Deer Automation (New Mexico). Instead of using a blade to remove weeds as in the Tillet cultivator example, this machine sprays a chemical in a band application to remove unwanted plants. Various chemicals can be used in this machine such as acid or salt-based fertilizers (e.g., phosphoric acid or ammonium nitrate [see fig. 2]) or herbicides such as paraquat or pelargonic acid (Scythe®); organic herbicides can also be used. A number of growers at the field day expressed interest in testing and buying this machine when it becomes commercially available.

Conclusion

In general, computer-assisted mechanical weed control machines will continue to develop and improve in the coming years. This technology has been shown to be useful to vegetable crops and could be used in field-grown cut flower production as well because many of the production practices (e.g., bed configuration and spacing, plant density per acre) are similar. Computer-assisted mechanical weed control machines can provide an alternative option for weed control that reduces the need and cost for labor, as well as help growers cope with the limited availability and loss of effective herbicides due to regulation constraints and issues.



Fig. 1. The Tillet Weeder is a commercially available mechanical weed control machine that uses computer technology and a spinning blade to remove weeds. Note the disc-shaped cultivation blade with a notched cut-out to allow the blade to spin around transplanted cabbage.

Table 1. Effect of the Tillet Weeder on weed control, hand-weeding time and crop yield in transplanted radicchio in 2009. Weed counts pre- and post- cultivation were made in the seed line only — the standard cultivation does not remove weeds in the seed line.

Treatment	Pre-cultivation weed counts Aug 5	Post-cultivation weed counts Aug 7	% weed control	Hand weeding Aug 7	Hand weeding Aug 14	Total weeding time	Stand count Aug 7	Stand count Oct 7	Yield mean head Oct 7	Yield total weight Oct 7
	Total Weeds	Total Weeds	%	hr/A	hr/A	hr/A	Plant/A	Plant/A	lbs/head	tons/A
Standard	40.3	NA	NA	8.4	6.9	15.3	31,245	29,628	0.84	12.4
Tillet	47.6	16.9	64	5.9	5.7	11.6	30,721	29,119	0.88	12.7
LSD 0.05	NS	NA	NA	0.7	0.8	1.3	NS	NS	NS	NS



Fig. 2. Lettuce thinned and weeded with the University of Arizona/Mule Deer Automation prototype. The unwanted plants were treated with ammonium nitrate (AN20) fertilizer (in dark gray rectangular areas) and will die in a matter of days.

For further information and to see videos clips of some of the implements to the following websites:

- Frank Poulsen Engineering
<http://www.visionweeding.com/Products/Intra%20Row%20Weeding/ROBOVATOR.htm>
- Frato Machine Import (torsion weeders) <http://www.frato.nl/UK/torsiewieder-UK.htm>
- Garford Agricultural Equipment <http://www.garford.com/index.html>
- Kress Company (finger weeders) <http://www.kress-landtechnik.de/>
- Ramsey Highlander <http://www.ramsayhighlander.com/products/spinach-spring/spinach.htm>
- Red Dragon http://www.flameengineering.com/Agricultural_Flamers.html
- University of Arizona (Mark Siemens) <http://extension.arizona.edu/programs/specialty-crops-mechanization>
- University of California, Davis (David Slaughter) <http://bae.engineering.ucdavis.edu/pages/faculty/slaughter.html> and <http://baesil.engineering.ucdavis.edu/BAESIL/AutoWeedControl.html> (videos of the implement)

Steaming and other Management Practices for Pre-Plant Weed Control in Nurseries

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Introduction

Weed seed are the means by which annual weeds reproduce and disperse. The seed buried in the soil is referred to as the seedbank. Most seed in the soil seedbank were produced in the same field or greenhouse. Some of the seed in the seedbank moved there through the actions of wind, water, animals or the activities of man. Annual weeds usually regenerate from seed stored in the soil seedbank. The seedbank reflects the effectiveness of recent weed management practices in the field or greenhouse and will determine future weed infestations. This article will outline some of the factors that influence weed seedbanks and how to use steam to kill weed seeds.

Weed Seedbanks

Harper (1977) viewed the soil seedbank much as a bank account to which deposits and withdrawals can be made (fig. 1). Deposits occur as weed seed enter the seedbank from local production or dispersal. Withdrawals occur by germination, death and consumption by birds or insects. Only a small fraction of the seedbank is capable of germinating at any given time.

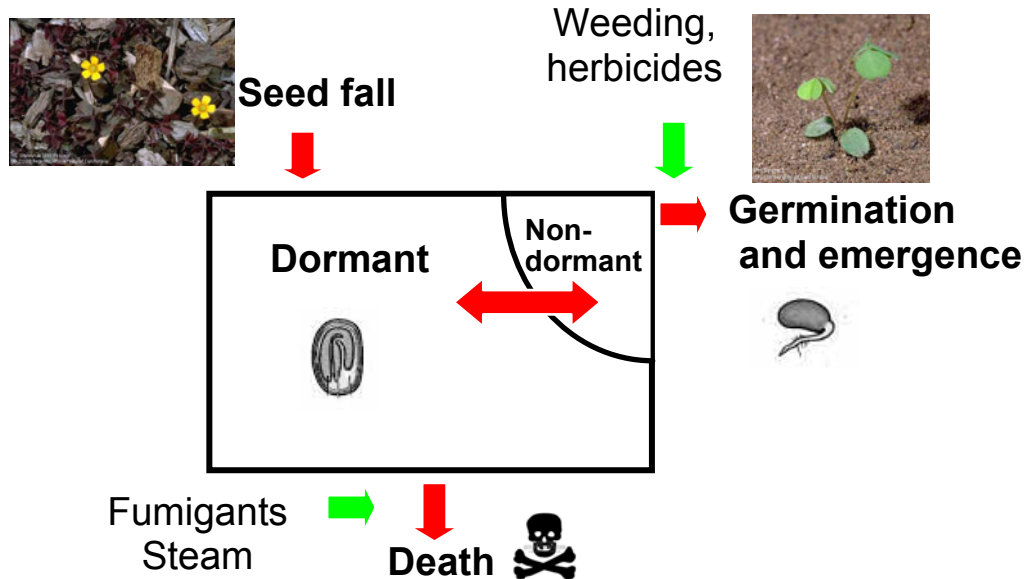


Fig. 1. Flow chart for the dynamics of weed seeds in the soil (Harper 1977).

When we discuss greenhouses we are not talking about “weed seedbanks” as they exist in an agricultural field, but weed seed that are anywhere in the greenhouse — under the bench, in the gravel under pots and in the soil or potting mix. The ecosystem in a greenhouse is much less variable than in an open field, but many of the concepts that weed ecologists have developed to talk about weed seedbanks in the field hold true for greenhouses. Generally seedbanks are composed of a few weed species that make up 70% to 90% of the total. A second group of species comprises 10% to 20% of the seedbank, but is not adapted to the current production system. The final group of seed consists of newly introduced species and seed from previous crops (Wilson 1988).

Soil seedbanks are what we target when we use soil fumigants or steam to disinfest soil. We use steam to eradicate the seedbank in the soil mix. However, after steaming or fumigation, the potting mix can become reinfested with weed seed. Many weed species are well suited for dispersal into greenhouses by wind from uncontrolled weeds surrounding the greenhouse, or by human-aided dispersal such as muddy work boots or tires. If we utilize cultural practices that minimize introduction of weed seed into the greenhouse by using preventative practices such as controlling weeds in and around the greenhouse, we practice preventative weed management rather than reactive weed control. A grower who does not tolerate weed seed set in and around the greenhouse minimizes the risks of higher production costs due to higher handweeding costs. For example a grower with a relatively weed-free greenhouse may have lower production costs due to lower hand-weeding bills.

Additions to the Seedbank

Seed can enter the seedbank by many means, though the largest sources are weeds producing seed within the field (Cavers 1983). Most seed in the seedbanks of farmland came from annual weeds growing on that same land (Hume and Archibold 1986). Just as in open agricultural fields, most weeds that infest greenhouses likely come from seed that were produced in the same greenhouse. Individual weeds can produce large numbers of seed when grown without competition (Table 1). I do not have the data for greenhouse weeds, but the concepts are the same — if weeds are given the chance to set seed they will.

Table 1. Seed production and seed survival (Wilson 1988).

Weed species	No. of seed produced per plant (Stevens 1954, 1957)
Common lambsquarters	72,450
Common purslane	52,300
Common ragweed	3,380
Pennsylvania smartweed	19,300
Prickly lettuce	27,900
Redroot pigweed	117,400
Shepherd’s-purse	38,500
Wild oat	250
Yellow foxtail	6,420

Weed seed can enter a field from external sources such as mud on equipment or shoes, contaminated crop seed, animals, wind, and manure. Many weed seeds have special attachments that allow them to be dispersed by wind, water or animals (Fig. 2). Wind dispersal (Fig. 2 a–d) allows a few seed to move great distances, however, most seed remain close to the mother plant. Windblown seed such as common groundsel can easily blow into the greenhouse from surrounding fields. The introduction and dispersal of noxious weeds is the greatest threat from dispersed seed.

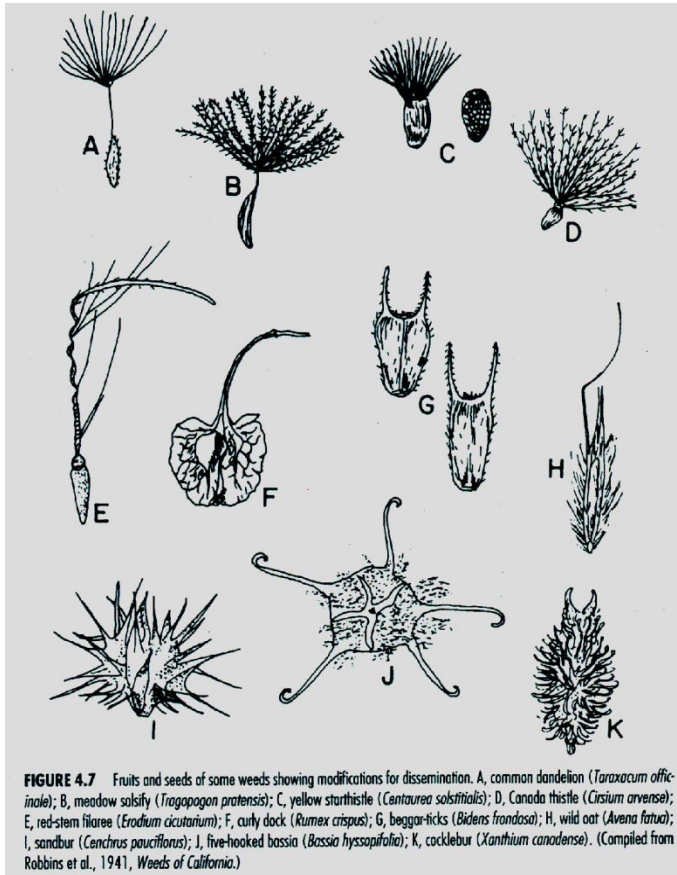


FIGURE 4.7 Fruits and seeds of some weeds showing modifications for dissemination. A, common dandelion (*Taraxacum officinale*); B, meadow salsify (*Tragopogon pratensis*); C, yellow starthistle (*Centaurea solstitialis*); D, Canada thistle (*Cirsium arvense*); E, red-stem filaree (*Erodium cicutarium*); F, curly dock (*Rumex crispus*); G, beggar-ticks (*Bidens frondosa*); H, wild oat (*Avena fatua*); I, sandbur (*Cenchrus pauciflorus*); J, five-hooked bassia (*Bassia hyssopifolia*); K, cocklebur (*Xanthium canadense*). (Compiled from Robbins et al., 1941, *Weeds of California*.)

Fig. 2. Characteristics that aid dispersal of weed seed (Robbins et al. 1941).

Seed Losses

Although seed of many weed species have the potential for long-term survival in the seedbank, most seed have a short life (Murdoch and Ellis 1992). Factors accounting for the loss of weed seed in the soil include germination, decay and predation. The relative importance of each factor varies with species and environmental conditions (Buhler et al. 1997). Fumigation and steam are also means of accelerating the loss of viable seeds in the seedbank (fig. 1).

In a weed management program we are primarily interested in those seed that germinate and seedlings that emerge. Germinated weed seed can result in new plants that may reduce crop yields and require control. Most weed seed in the soil seedbank are dormant with a small fraction of nondormant seed capable of germination at any one time. Several types of dormancy exist and most weeds possess one or more types (fig. 3).

From the moment a seed is shed its dormancy status is one of the key factors that determine when the seed will germinate. Seed dormancy is a means by which a plant species enhances its probability for successful reproduction in a changing environment. Dormancy is relieved by appropriate environmental conditions such as chilling, afterripening, light or scarification.

Embryo dormancy is often reversible and represents a flexible system that allows a weed seed to adapt to its environment. The induction of secondary dormancy is the response of many weeds species to unfavorable environmental conditions. Secondary dormancy and weather conditions are responsible for much of the variation in weed germination from year to year.

Weed Management

Weed seed densities can be greatly reduced by eliminating seed production for a few years; conversely, soils with low seed densities can be quickly reinfested with weed seed if plants are allowed to produce seed. Burnside et al. (1986) found that broadleaf and grass seed density declined 95% after five weed-free years. In the sixth year, herbicide use was discontinued and seedbank density rebounded to within 90% of the original density. Although seed production from most weed species can be reduced by management factors, seed production will likely remain high enough to maintain or increase the seedbank with low to moderate weed infestations. Hartzler found that velvetleaf grown at densities of 2 and 4 plants per 100 square feet and allowed to set seed in year 0 resulted in as many as 1,800 plants per 100 square feet during years one to four, even though no velvetleaf plants were allowed to set seed during that period (Hartzler 1990).

Weeds can survive in a greenhouse either by using seed dormancy or seed dispersal to allow some individuals to escape control and produce seed. Seed dormancy is a characteristic that allows weeds to survive. In a weed species that has seed dormancy, weed seed germinate at a low rate over long periods of time, increasing the chance that a few individuals elude control and reproduce — thus replenishing the seedbank. Another weed survival strategy is dispersal. With the dispersal strategy, some viable seeds find a safe place to reproduce. Management of weeds with seed dormancy requires reducing the seedbank population to low levels, such as with fumigants or steam sterilization, and then maintaining strict weed control measures indefinitely to prevent reestablishment of the weed population. With weeds that have seed that disperse widely, the seed population in the greenhouse seedbank must be reduced and survivors controlled. At the same time the surrounding area must be kept as weed-free as possible to reduce the incidence of new weed seed dispersing into the greenhouse.

Preemergence herbicides kill germinating seeds and therefore act on only a small portion of the soil seedbank. Similarly, postemergence herbicides and tillage can only kill emerged weeds. Therefore, most of our weed control tools do not affect the dormant weed seeds in the soil seedbank. There are some exceptions: soil fumigants and steam can act on the entire seedbank including dormant and nondormant seed (fig. 1).

Steam heating of soil or potting mix uses heat to kill weed seeds. In this process steam is mixed with air and injected into the soil mix to heat it to 180°F for 30 minutes (Baker 1957). Length of time and temperature are critical if weed seeds are to be controlled. The pile must be

covered with a tarp so that the entire pile, including the outer edges, reaches 180°F (Wilén and Elmore 2009; Baker 1957). The moisture of the soil or mix to be steam sterilized is also important — uniform heating of the soil is necessary if we are to kill weed seed throughout the soil mix batch, and moist soil conducts heat more readily than dry soil. Further, weed seed are more easily killed when imbibed with moisture. This includes ungerminated weed seed that are swollen with high water content, which facilitates heat conduction from the seed surface to the embryo, and imbibed weed seed that germinate in the moist soil.

Crop Rotation

Crop rotation is effective for weed management because changing patterns of disturbance diversifies selection pressure. This diversification prevents the proliferation of weed species well suited to the practices associated with a single crop. To better manage weeds one needs to change practices regularly. For example, if you are growing a container plant that requires two years to prepare for the market, this is plenty of time for weeds to become adapted. It is convenient to leave the long-cycle crop in the same greenhouse, but a better strategy is to move a short- and long-cycle crop around so that the production cycle in a greenhouse is varied. Short crops provide frequent dry conditions in the greenhouse between crops that will kill weeds, and the empty greenhouse space between each crop cycle will allow the use of nonselective herbicides to kill weeds.

Conclusions

- Seedbanks are the source of most annual weed species.
- Most seedbanks are dominated by one or two species.
- Most weed seeds in the seedbank were produced in the same greenhouse.
- The greatest threat from weed seed dispersal is the introduction and spread of noxious weed species.
- Seed losses occur from germination, decay and predation.
- Dormancy is a key factor that determines when a seed will germinate and allows weeds to persist in the environment.
- A small number of weeds can produce many seeds and given the opportunity can restore the weed seedbank to high levels in a short time.
- Steam heating of soil or potting mix can kill dormant and nondormant weed seed.
- Crop rotation minimizes the opportunities for one weed species to dominate a field or greenhouse.

Fig. 3. Dormancy Terms

Dormancy: Absence of germination in otherwise viable seed under conditions of light, temperature, water and oxygen that would normally favor germination.

Primary dormancy: Freshly harvested seed that is dormant.

Secondary dormancy: The condition of a formerly nondormant seed that encountered unfavorable conditions such as anoxia or high temperature that induced dormancy.

Coat-imposed dormancy : Seed dormancy is maintained by plant structures that enclose the embryo. Little mallow has this type of dormancy.

Embryo dormancy : Control of seed dormancy lies within the embryo itself.

Afterripening: The release of dormancy under warm-dry conditions.

Chilling (stratification): The release of dormancy in low temperatures (34°F to 50°F) and moist conditions.

Light: Many seed, especially small seed, require light stimulus to relieve dormancy.

Temperature: All species have optimal germination temperatures below and above which the germination rate slows. Temperature controls the rate of dormancy release in a seed population, and temperature can control the rate of secondary dormancy induction.

Water: Required for germination in moderate amounts. Heavy rains or irrigation can create anoxia and induce secondary dormancy.

Source: Bewley and Black, 1994

References

- Alrich RJ, Kremer RJ. 1997. *Principles in Weed Management*. Iowa State University Press, Ames, IA.
- Baker KF. 1957. *The U.C. System for Producing Healthy Container-Grown Plants*. Manual 23. UC ANR Agric. Exp. Sta., Berkeley, CA.
- Bewley JD, Black M. 1994. *Seed: Physiology of Development and Germination* (2nd ed). Plenum Press, New York, NY.
- Buhler DD, Hartzler RG, Forcella F. 1997. Implications of weed seedbank dynamics to weed management. *Weed Sci.* 45:329-336.
- Burnside OC, Moomaw RS, Roeth FW, Wicks GA, Wilson RG. 1986. Weed seed demise in soil in weed-free corn (*Zea mays*) production across Nebraska. *Weed Sci.* 34:248-251.
- Cavers PB. 1983. Seed demography. *Can. J. Botany.* 61:3578-3590.
- Wilens CA, Elmore CL. 2009. UC Pest Management Guidelines: Floriculture and Ornamental Nurseries – Container Nurseries. UC ANR Publication 3392. Available online at www.ipm.ucdavis.edu/PMG/r280701211.html.
- Harper JL. 1977. *Population Biology of Plants*. Academic Press, London, UK.
- Hartzler RG. 1996. Velvetleaf (*Abutilon theophrasti*) population dynamics following a single year's seed rain. *Weed Tech.* 10:581-586.
- Hume L, Archibold OW. 1986. The influence of a weedy habitat on the seedbank of an adjacent cultivated field. *Can. J. Bot.* 64:1879-1883.
- Murdoch AJ, Ellis RH. 1992. Longevity, viability, and dormancy. In: Fenner M (ed.). *Seeds: The Ecology of Regeneration in Plant Communities*. CAB International, Wallingford, UK. p 193-229.
- Robbins WW, Bellue MK, Ball WS. 1941. *Weeds of California*. California State Department of Agriculture, Sacramento, CA.
- Wilson RG. 1988. Biology of weed seed in the soil. In: Altieri MA, Liebman, M (eds). *Weed Management in Agroecosystems: Ecological Approaches*. CRC Press, Boca Raton, FL. p 25-39.

Indaziflam: a New Residual Herbicide for Roadside Weed Control

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Indaziflam (Esplanade 200 SC) is a newly registered herbicide for pre-emergent control of annual grasses and broadleaf weeds in areas such as roadsides, industrial sites and railroads. Indaziflam is a cellulose biosynthesis inhibitor (CBI), and represents a novel mode of action for resistance management and long-term residual activity. Indaziflam provides broad-spectrum control of over 75 weed species, including grasses, broadleaf weeds and annual sedges. Research trials have shown the long-term performance of indaziflam tank mixes on tough broadleaf weeds such as marestail (*Conyza canadensis*), kochia (*Kochia scoparia*), Russian thistle (*Salsola tragus*) and yellow starthistle (*Centaurea solstitialis*), as well as annual grasses such as annual bromes (*Bromus* spp.), wild barleys (*Hordeum* spp.), medusahead (*Taeniatherum caput-medusae*) and sprangletop (*Leptochloa* spp.).

Maximizing the Efficiency of Hand Weed Spraying

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Applying herbicides with hand-held equipment, such as a backpack sprayer or a hose-end sprayer, is a common vegetation management practice in non-crop sites. But how accurate or efficient is the use of these types of equipment? Especially when most applications are based upon a percent concentration of herbicide rather than trying to use a specific rate of herbicide? We wanted to find out, so we conducted four herbicide sprayer calibration schools, with about 20 experienced applicators in each school in 2009/10. The schools were designed to train the participants on a simple calibration method, but also to investigate their application skills. The answers we obtained indicated the actual practice is not too good. The mean value for gallons per acre (GPA) for the spray school students over the four schools varied greatly between the types of equipment (see Table below). The last column in the table is the actual amount of glyphosate applied per acre if the concentration of the herbicide in the tank was 1% of the total spray mix, a commonly used concentration. The 1% concentration in the glyphosate label (Roundup Pro in this case) is meant to be roughly equivalent to 0.5 gallons per acre of herbicide product. On average the backpack spray was a little below this target rate while the orchard gun was nearly three times higher. The spot spray, which we calculated as the amount applied to treated plants, not the whole area, was more than 12 times the target rate. In all cases, the variation between students is large; more so with the orchard gun than with the backpack sprayer and off the charts when spot spraying.

So, what does all this mean and what can be done to improve efficiency? In the first place, applying the wrong amount of herbicide is a bad idea. Apply too little and it won't work, which usually means another trip to get the job done right. Too much and you waste product, time, haul more water than you need to the site, and increase the chances of environmental contamination or off-site movement. The two key factors that can eliminate this inefficiency are learning to apply herbicides according to a rate rather than a concentration and to calibrate the sprayer (which means the equipment and the applicator) before applying herbicide. We used the 128th acre calibration method in our training with our spray school students. It is a simple, no math method that is easy to use. Go to http://ucanr.org/sites/socalinvasives/Research_Papers/Brochures/ for a worksheet for the method.

Table. Gallons per acre (GPA) data from herbicide sprayer calibration training; mean of 80 students.

Sprayer type	Mean GPA	GPA Range	1% glyphosate Gallons/acre
Backpack	41	10-100	0.41
Orchard Gun	127	24-352	1.3
Spot Spray	628	80-1560	6.3

Controlling Annual Bluegrass in Bentgrass Putting Greens

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Annual bluegrass (*Poa annua* L.) is a ubiquitous turfgrass species throughout the world, and especially in coastal climates in California. Although perennial biotypes can provide superior playing surfaces on golf courses, *Poa annua* remains more susceptible to biotic and abiotic stresses than species like creeping bentgrass (*Agrostis stolonifera* L.). Along coastal northern California, annual bluegrass is particularly susceptible to damage caused by *Anguina* nematodes on putting greens, which is causing an increasing number of golf courses to rebuild and re-grass with creeping bentgrass. Thereafter lies the challenge of maintaining *Poa*-free bentgrass turf in an environment that is highly conducive for *Poa* growth and re-infestation.

Selective *Poa* control in putting greens is particularly challenging given the added stresses of low mowing heights and concentrated, intensive traffic. As a result, most chemicals that provide both effective and selective control in taller cut turf can cause objectionable and often serious bentgrass injury on greens and thus are not labeled for use.

Methiozolin (experimental name: MRC-01) is a new herbicide under development in the U.S. by Moghu Research Center, South Korea. It provides selective control of primarily *Poa annua* and some other grassy weeds in nearly all other major cool- and warm-season turfgrass species, regardless of height of cut. On putting greens, methiozolin is particularly effective because of its selectivity and slow activity that allows bentgrass to fill in voids left by *Poa annua*. Methiozolin is an isoxazolinone compound, a new family of herbicide chemistry for turf. It is primarily root-absorbed and provides both pre- and post-emergence activity by disruption of cell wall biosynthesis. Methiozolin is currently registered in South Korea and Japan. It is considered a “Reduced Risk Category” pesticide and plans are underway for registration in the U.S. in the near future. The University of California, Riverside has been studying methiozolin extensively since 2010. On putting greens, excellent (90-100%) control has been achieved with four or more sequential applications of 0.5 to 1.0 lb ai/A applied on 3- to 4-week intervals. Applications made more frequently or when average daytime temperatures exceed 85F on a regular basis should be avoided to ensure bentgrass safety. Methiozolin appears to be more efficacious when applied in late fall vs. spring. There appears to be no synergistic or additive effects when methiozolin is tank-mixed with paclobutrazol, FeSO₄, or other herbicides. Colonial and velvet bentgrasses appear to be more sensitive to methiozolin than creeping bentgrass. Ongoing studies are looking more closely into methiozolin tolerance among bentgrass species and cultivars, as well as developing integrated *Poa* management programs using methiozolin.

**Field Research Results to Support Successful
Poa annua Control Strategies in Cool Season Grasses**

**Prepared for the 2012 CWSS Conference
Santa Barbara, CA**

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Introduction

Annual bluegrass (*Poa annua* or *Poa*) is a cool season grass native to Europe. This highly invasive species continues to be the number one grassy weed problem in cool season turfgrasses.

Annual bluegrass falls within two broad taxonomic classifications. Annual biotypes of *Poa annua* referred to as *Poa annua* var *annua* exhibit true annual seasonal growth response, light green color, broad leaf texture, shallow rooting and prolific seed production. Perennial biotypes of *Poa annua* referred to as *Poa annua* var *reptans* exhibit a perennial growth response, darker green color, limited seed head production, finer texture and a more stoloniferous growth habit.

The objectives of this presentation are to present the answers to the following three key questions:

1. When does annual bluegrass germinate in California?
2. Which preemergent herbicides exhibit the most effective *Poa annua* control?
3. Which postemergent herbicides exhibit the most effective *Poa annua* control?

The *Poa annua* control information presented is based on the results of 12 replicated field trials conducted from 1997 to 2010 throughout California by Mark M. Mahady & Associates, Inc.

Question #1: When does annual bluegrass germinate in California?

The following replicated preemergent field research trials conducted in Southern and Northern California described the interaction between application timing and preemergent performance for *Poa annua* control.

Southern California

Location #1: Desert Dunes Golf Club, Desert Hot Springs, CA, 1997: OVS Bermuda

	3/30/98 <u>% Poa Control</u>
Barricade 0.75 lb ai/A applied 6WBOVS on 8/20/97	86.8%
Barricade 0.75 lb ai/A applied 6WAOVS on 11/12/97	19.6%

- Take Home Message: 80% Poa germination by 11/12/97
- High level of control with August application
- Very poor and unacceptable control with the November application
- November is too late to apply a preemergent for acceptable Poa control

Location #2: Springs Golf Club, Desert Hot Springs, CA, 1997: OVS Bermuda

	3/30/98 <u>% Poa Control</u>
Barricade 0.75 lb ai/A applied 6WBOVS on 8/20/97	86.9%
Barricade 0.75 lb ai/A applied 4WAOVS on 11/13/97	40.7%

- Take Home Message: 60% Poa germination by 11/13/97
- High level of control with August application
- Very poor and unacceptable control with the November application
- November is too late to apply a preemergent for acceptable Poa control

Northern California

Location #3: Carmel Valley, CA, 2002: Non-OVS Bermuda

	5/17/03 <u>% Poa Control</u>
Barricade 0.75 lb + 0.38 lb ai/A applied on 8/27 & 11/14/02	93.0%
Dimension 0.5 lb + 0.25 lb ai/A applied on 8/27 & 11/14/02	94.0%

- Take Home Message: 7.0% Poa germination by 8/27/02
- High level of control with August application

Location #4: Ruby Hill Golf Club, Pleasanton, CA, 2004: Non-OVS Bermuda

	5/17/05 <u>% Poa Control</u>
Barricade 1.0 lb ai/A applied on 9/17/04	43.2%
Barricade 1.0 lb ai/A applied on 10/15/04	22.2%

- Take Home Message: both mid-September and mid-October Barricade applications are too late for effective preemergent control of *Poa* in Northern California.
- Mid-August application timing is most effective for preemergent control of *Poa* in both Northern California and the low desert region of Palm Springs.

Question #2: Which preemergent herbicides exhibit the most effective *Poa annua* control?

Barricade (prodiamine: Syngenta) and Dimension (dithiopyr: Dow AgroSciences) are highly effective preemergent herbicides for control of *Poa annua* in cool season grasses when deployed in a timely manner (August 15 to August 20).

Sequential applications of Barricade 0.75 lb + 0.38 lb ai/A applied on 8/27 and 11/14/02 resulted in 93.0% *Poa annua* control in Northern California. Sequential applications of Dimension 0.5 lb + 0.25 lb ai/A applied on 8/27 and 11/14/02 resulted in 94.0% *Poa annua* control in Northern California.

When comparing properly timed single versus sequential treatment programs, results from replicated field trials in the Palm Springs golf market indicate that the first application is the most critical for highly effective *Poa annua* control. Based on field data there is not a dynamic or statistically significant increase in percent *Poa annua* control when a sequential treatment is deployed. The key factor is a properly timed initial application.

Question #3: Which postemergent herbicides exhibit the most effective *Poa annua* control?

Ethofumesate (Prograss 1.5 EC and PoaConstrictor 4SC) is an active ingredient that has been used successfully for postemergent control of *Poa annua* in solid stand perennial ryegrass fairways and perennial ryegrass overseeded bermudagrass fairways for many years. Perennial ryegrass is very tolerant to ethofumesate applications.

Previous field research conducted by Mark M. Mahady & Associates, Inc. in Northern California showed that three sequential treatments of Prograss 1.5 EC applied at a rate of 1.95 pounds active ingredient per acre (lb ai/A) at 21-day intervals beginning approximately October 1, resulted in very high control levels (90%-94%) of perennial biotypes of *Poa annua* in solid stand perennial ryegrass fairways.

Previous field research conducted by Mark M. Mahady & Associates, Inc. in the Palm Springs, California perennial ryegrass overseeding market, showed that two sequential treatments of Prograss 1.5 EC applied at a rate of 1.125 lb ai/A at 21-day intervals beginning approximately December 7, resulted in very high control levels (90%-95%) of annual biotypes of *Poa annua* control in perennial ryegrass overseeded bermudagrass fairways.

Presently, Trimmit 2SC (paclobutrazol: Syngenta) is the industry standard for suppression of *Poa annua* in creeping bentgrass fairways. With multiple applications, Trimmit 2SC (10-14 oz/A), a plant growth regulator, selectively suppresses the growth of *Poa annua*. *Poa annua* plants treated with paclobutrazol are more diminutive and less competitive. This plant growth regulation effect changes the competitive balance between *Poa annua* and creeping bentgrass allowing the more vigorously growing creeping bentgrass to grow over and into the highly regulated *Poa annua*.

Velocity (bispyribac-sodium: Valent) inhibits ALS enzyme development, provides foliar activity and no soil activity. Velocity is rain fast in 6 hours, exhibits yellowing on *Poa annua* in 3-7 days with maximum effect 21-28 days after treatment. Apply Velocity during spring/summer with air temperatures between 65 and 80° F. Velocity is not registered for use on greens. Field research conducted by Mark M. Mahady & Associates, Inc. on creeping bentgrass fairways in Northern California showed the following:

- Velocity: 20 g ai/A (2x): a 60.4% reduction in percent Poa cover 112 DAA2.
- Velocity 10 g ai/A + Trimmit 10 oz/A (2x): a 66.7% reduction in percent Poa cover 112 DAA2.
- Velocity 15 g ai/A + Trimmit 10 oz/A (5x): a 77.0% reduction in percent Poa cover 21 DAA5.

Summary and Practical Perspectives

For the best *Poa annua* management program results in cool season grasses utilize a two-prong preemergent and postemergent control program. For control of *Poa annua* in solid stand perennial ryegrass:

- Preemergent: apply Barricade 4F 0.6 lb ai/A on 8/15-8/20 followed by a sequential Barricade treatment at 0.3 lb ai/A 8 weeks later.
- Postemergent (late summer): apply three sequential treatments of Prograss 1.5 EC at 1.3 gal/A at 21-day intervals beginning approximately 10/1.
- If overseeding in late summer, it is important to know that Prograss does not affect perennial ryegrass germination or percent cover.
- Do not hollow-tine or open up the canopy after 8/15. Solid tining is acceptable.
- Consider two spring applications Prograss (March) or 2-3 applications of Trimmit 2SC (8-10 oz/A) at monthly intervals.

For control of *Poa annua* in creeping bentgrass fairways:

- Preemergent: apply Barricade 4F 0.5 lb ai/A on 8/15-8/20. Do not make a sequential treatment in the fall or spring.
- Postemergent: during spring/summer (air temperatures between 65 and 80 degrees F) apply 3-5 sequential applications of Velocity 10 g ai/A + Trimmit 10 oz/A at 21-day intervals. During the late summer/fall season apply monthly treatments of Trimmit 12-14 oz/A at 21-day intervals.
- Do not hollow-tine or open up the canopy after 8/15. Solid tining is acceptable.

Be open minded, but always question performance claims when considering the use of new products and/or new agronomic strategies. Always test new products and programs on a small scale before moving to larger acreage.

* * *

Pre-emergent *Poa annua* Control in Non-overseeded Bermudagrass

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Chris.olsen@bayer.com

Poa annua is an endemic weed in US golf turf and is a significant weed problem for non-overseeded Bermudagrass. Control measures are simplified if climatic conditions provide dormant Bermudagrass each winter as low cost post-emergent options can be employed. However, complete dormancy is not predictable in most California locations and pre-emergent herbicides are an especially critical tool. Several pre-emergence herbicide options are available but timing is critical for optimum performance.

Due to the climatic and micro-climatic differences between and within golf courses in California proper timing in relation to fall *Poa annua* germination is more complicated than in other parts of the US. A compilation of research trial results from the Southeast indicates application in August or September is effective. However, trials in CA have shown that September can be too late for some sites some years. A review of conditions that trigger germination may help provide guidelines for specific sites and various fall conditions. Bruce Branham showed that germination primarily occurs when soil temperatures (0-2 inch) are between 60 and 72 degrees F. Ron Calhoun indicated that peak germination was 68-72 degrees at 0-2 inch soil depth and is minimal below 58 degrees and above 78 degrees F.

If one considers that fall germination can begin at the end of summer as soil temperatures at 0-1 inch drop below 78 degrees F (and near optimum at 72 degrees) then mid to late August timing for a pre-emergence herbicide makes sense for many locations in southern CA and mid-September can be too late. A recent entry into the market, Indaziflam (Specticle 20 WSP), simplifies timing as it provides effective pre-emergence control plus post-emergence control of *Poa annua* seedlings. Indaziflam allows for a broader window of application for *Poa annua* control as compared to other pre-emergent herbicides registered in California. Research indicates that indaziflam application in September through early October is effective for *Poa annua* control in California.

Turf and Landscape Weed Control, Towards Integrated Weed Management

Mike Lees, Dow AgroSciences, Granite Bay, CA mdlees@dow.com

Management of weeds in turfgrasses and landscapes has evolved over the last 100 years. Grazing pastures were gradually converted to more meticulously manicured aesthetic areas and gardens were built to approximate natural landscapes to beautify homes and public areas. Along with this evolution have come changes in the tools and practices used for weed control. This presentation explores some of these changes and the impact on current and future practitioners of weed control. The widespread use of herbicides for weed control didn't become commonplace until the late 1950s and 1960s. Initial herbicides were very harsh materials and very difficult to handle and use. Gradually more user-friendly materials were developed in the 1970s and 80s. By this time turf and landscape weed managers began relying heavily on these products for selective control of grass and broadleaf weeds. But societal changes have also caused more close scrutiny of the products being used. Past evaluation focused on the efficacy of potential herbicides but more and more attention was focused on non weed control properties such as non-target effects, persistence and impact on the environment. The weed manager today must not only produce healthy, weed free turf and landscape but also be concerned with how they produce these results. This presentation focuses on several topics that should be considered when planning a weed management program. Three examples are given to spur the audience to think about some of these areas in addition to simple control of weeds. Substituting a new reduced risk low rate herbicide for a former multiple active ingredient standard delivers excellent weed control with more than a 200 fold reduction in pounds of pesticide used per acre. In the second example, understanding the biology of the pest and expanding uses of a current pre-emergent herbicide into postemergent control allows replacement of a phased out herbicide and could possibly provide control of a second major weed pest with a single herbicide application. In the final example, by adding a residual herbicide to a standard contact herbicide programs for weed control in landscape areas, fewer applications are required and risk of weed resistance is reduced. By knowing the biology of pest weeds and the properties of available control tactics, weed manager have the best chance of succeeding in managing weeds and providing these results in the context of ever more stringent oversight and regulations.

Weed Control at Turf Establishment with Tenacity® Herbicide.

Dean K. Mosdell, Field Tech Manager, Syngenta Lawn and Garden

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Successful renovations of turfgrass stands require a weed management plan. Existing weeds can be controlled prior to renovation with a non-selective herbicide, but once the turfgrass species is seeded, water and fertilizer will also encourage weed seeds in the soil to germinate. Unless weeds are controlled, the end result of the renovation will be weed contamination of the desired turf grass species. Key reasons to control weeds at seeding or establishment include:

- Less competition from weeds, faster turf establishment
- Weed (seed) bank in the soil can be significant in a perennial stand like turfgrasses
- Not all seeding can be done in the fall, when competition from annual grasses is minimal
- Turf (like weeds) can be more sensitive to herbicides at the seedling stage, limiting post-emergence weed control

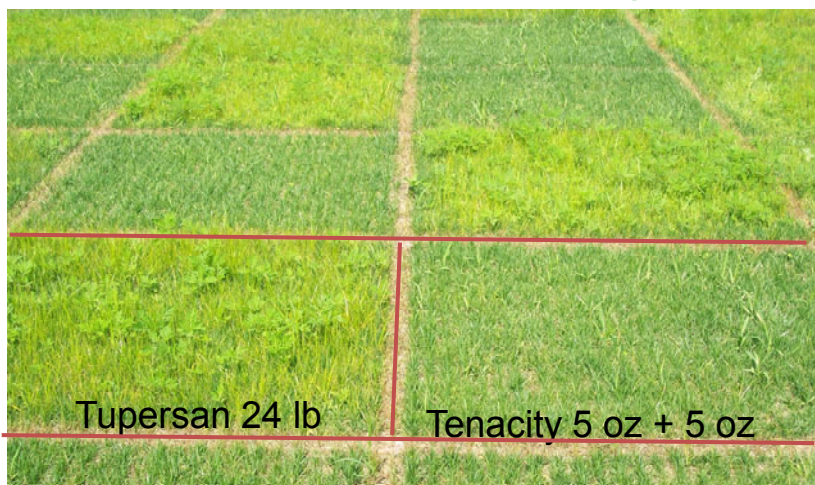
There are very few herbicides that can be safely applied prior to or at seeding of most turfgrass species. Siduron, a substituted urea herbicide, is labeled for use on cool-season species to control annual grasses such as crabgrass, foxtail and barnyardgrass. Rate of application is 6 lbs ai/A at seeding. Siduron, trade name Tupersan®, will not control dicots weeds or *Poa annua* which can be an issue depending on weed pressure. Quinclorac, trade name Drive®, can be applied at seeding of tall fescue, bermudagrass and perennial ryegrass while other turf species are limited to a 28-day post emergence restriction. It is a synthetic auxin herbicide with use rate at seeding of 0.75 lbs ae/A for control of crabgrass, foxtail, barnyardgrass and several dicot weed species.

Mesotrione herbicide was discovered when a Syngenta scientist in Mountain View, CA observed fewer weeds growing under his callistemon shrub than could be explained by shading. The allelochemical isolated from the callistemon plant was the first precursor to what eventually became mesotrione herbicide, trade name Tenacity® in turf. (**Tenacity in not currently registered in CA**). Mesotrione is a HPPD inhibitor (p-Hydroxyphenylpyruvate dioxygenase), which interferes with plastoquinone synthesis, and ultimately carotenoid production. Without carotenoids, light energy breaks down chlorophyll and generates excess energy within the cells. These result in the new growth turning white and susceptible weeds eventually die. Tenacity can

be applied at seeding of several cool-season turf species for control of annual grasses such as crabgrass and foxtail plus many dicots weeds at 0.156 lbs ai/A. It is also labeled for control of yellow nutsedge and suppression of *Poa annua*. The weed control spectrum of Tenacity makes it a valuable tool to manage weeds at turf establishment.

Attached is a picture of a tall fescue seeding trial comparing Tenacity to Tupersan. Both herbicides exhibited excellent safety, however control of ragweed and yellow nutsedge was only observed in the Tenacity treatments.

Tenacity – New Option for weed control at Seeding



syngenta

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Tupersan® is a trademark of Gowan Company, LLC

Drive® is a trademark of BASF Corp.

Effects of Spray Coverage and Nozzle Selection on Weed Control

Kurt Hembree and Brad Hanson

Farm Advisor, UCCE, Fresno County and CE Weed Specialist, UC Davis

Herbicides play an important role in weed control efforts in California orchards and vineyards. Effective weed control with herbicides is influenced by many factors, but hinges on one's ability to apply sprays accurately, uniformly, and efficiently. Spraying with minimal drift and adequate coverage are important factors that influence herbicide performance. Spray droplet size influences both spray drift potential and spray coverage. Spray droplets <200 microns in diameter are light, remain airborne a long time, and are the most prone to drift. To help avoid spray drift, weed sprays should be applied using spray droplets larger than 225 microns (at least medium-sized). As a general rule, nozzles, tip sizes, and operating pressures should be selected to produce large enough spray droplets that reduce the risk of drift, while giving adequate coverage for the herbicide type (contact, systemic, or preemergent) used. Selecting a larger tip size to produce more volume per acre, may or may not be an effective way of mitigating reduced coverage where large spray droplets are used.

Recently, new spray nozzle designs have been introduced to help reduce drift potential by producing larger spray droplets. These new nozzle designs include extended range (XR), chamber (also referred to as "turbo"), venturi I (air assisted), and venturi II (combination of chamber and venturi I). However, little is known how these new spray nozzle designs affect spray coverage and weed control under field conditions. Several trials were conducted from 2008 - 2011 to evaluate drift-reducing spray nozzles and their effects on spray coverage and weed control when contact-type postemergent herbicides were used. Trials were conducted in a variety of settings, including orchards, vineyards, and open ground. Drift-reducing nozzles were compared to standard flat fan nozzles. Flat fan nozzles produced medium-sized spray droplets, while the drift-reducing nozzles produced droplet sizes from coarse to extremely coarse.

Although the number of spray droplets per in² and percent cover on water-sensitive paper increased with an increase in a spray volume of 20 to 40 gpa, it did not necessarily result in significantly better weed control. Turbo and Turbo TwinJet nozzles provided similar weed control to XRs or flat fans. Air induction nozzles gave the least amount of spray coverage and weed control. Although these nozzles gave comparable weed control to the other spray nozzle designs initially, overall control was reduced 10 to 20% later as weed regrowth occurred. A spray volume of at least 50 gpa was needed to help compensate for the larger size in droplets produced by air induction-type nozzles. It appears that drift-reducing nozzles can play an important role in postemergent weed control efforts, even where contact-type herbicides are used.

Benefits and Drawbacks of In-Row Cover Crops in Vineyards

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Cover crops in vineyards in the Monterey County low rainfall production district are typically grown in a narrow band in the row middles. The berms under the row vines are typically kept free of vegetation by a combination of herbicides and mechanical cultivation. Cover crops are an important component of a comprehensive vineyard floor management system. They provide multiple benefits to the soil plant system by increasing levels of soil organic matter, nutrient cycling and water infiltration. Cover crops can also reduce levels of nutrient and sediment loss during winter storms. In a five-year study conducted in Monterey County from 2001-2005 we observed significant improvements in soil health parameters in the row middles where the cover crops are grown. There were increased levels of soil organic matter and microbial activity where the cover crops are grown, but few of these benefits occurred under the adjacent vine row (Smith et al, 2008). In addition, we observed that the majority of the roots occurred under the vine row where the drip emitters were located (root systems are probably limited due to our dry climate). As a follow-up to this study we conducted two trials evaluating the use of cover crops under the vine row in order to bring the soil benefits of cover crops to the soil under the vine where most of the roots are located. However, a key concern of growing cover crops under the vine row was the competitive effect of the cover crops on the growth of the vines due to competition for nutrients and water. In a real way, a cover crop under the vine row would act like a weed. In a low rainfall area such as Monterey County, any water used by the cover crop would have to be replaced by irrigation, which could have negative economic consequences for crop production. As a result, two trials were conducted to evaluate management of vine row cover crops to minimize the detrimental aspects of the cover crops and maximize the benefits that they can provide crop production and vineyard management.

Methods: Two trials with vine row barley cover crops were conducted from 2006 to 2010: 1) A small plot kill-date timing trial with five treatments - cover crops killed with glyphosate at the following heights: 0, 6, 12, 18 and 24 inches tall. And 2) a large scale trial with three treatments – standard cover crop in row middles and strip sprayed vine row; bare row middles and strip sprayed vine row; and cover crop planted in row middles and vine row, and vine row cover crop allowed to grow to 12 inches tall and then killed with glyphosate. The treatments were evaluated for the effects on soil and plant nutrition, soil microbial biomass, levels of soil moisture throughout the year, and crop yield and berry composition.

Small plot trial: This trial allowed us to carefully examine the impact of allowing cover crops to grow in the vineyard for various periods of time. Allowing cover crops to grow to 24 inches tall was clearly detrimental to crop growth, and also reduced levels of nitrogen in the plants (Table 1). Interestingly, potassium levels in the plant were increased with cover crops allowed to grow for longer periods of time. Levels of soil moisture were reduced in the 24 inch treatment in the

late spring which may have accounted for the reduced growth observed in this treatment (Figure 1).

Large plot trial: The small plot trial showed that allowing the cover crop to grow to 12 inches tall did not adversely affect the growth or yield of the vines. As a result, in this trial we allowed the in-row cover crop to grow to 12 inches tall and then killed it with glyphosate. As was observed in the small plot trial, there was a significant reduction in nitrate-N in the petiole tissue at bloom (Table 2). The cover crops increased the levels of soil organic matter in the berm by the third year (2008). Also, there was an increase in potassium and phosphorus. There was no affect of the cover crop treatment on yield. The in-row cover crop did reduce the amount of soil moisture in 2007 in early spring (Figure 2), but increased the levels of soil moisture during the end of the growing season in 2007 and 2008. The increase in late season moisture in the in-row cover crop treatment may have been due to improved infiltration of applied drip irrigation water. We were not able to directly measure greater infiltration in the treatments, but did observe less runoff of water where in-row cover crops were present (Photos 1 & 2).

Conclusions: In-row cover crops have the potential to compete with the vines in low rainfall areas such as Monterey County. In this sense, they can act like a weed. However, if carefully managed, they can provide long-term benefits to the soil under the vines where most of the roots are located. In these studies, we observed that killing the cover crop when they are 12 inches tall safeguarded the yield of the vines and increased the levels of soil organic matter by the third year of the practice. In-row cover crops do reduce the levels of nitrogen in the crop and care must be taken to offset this negative impact. We are not sure why, but in-row cover crops increased the potassium and phosphorus levels in the crop at bloom. We have indirect evidence that the in-row cover crops improved irrigation water infiltration from drip emitters as we observed high levels of soil moisture in the in-row cover crop treatments during the summer irrigation season.

Table 1. Small plot trial: Tissue nutrient levels (at bloom) and vine growth parameters, 2008

Cover Crop Treatment	Petiole NO3-N ppm	Blade nitrogen percent	Petiole potassium percent	Blade potassium percent	Pruning weight kg/vine	Shoot weight grams
Standard - no cover	591 a	2.69 a	1.81 c	1.02 c	1.33 a	34 a
6 inches tall	504 a	2.66 a	1.94 bc	1.04 bc	1.28 a	31 ab
12 inches tall	456 a	2.70 a	1.96 bc	1.05 bc	1.28 a	31 ab
18 inches tall	608 a	2.70 a	2.15 ab	1.09 ab	1.33 a	34 a
24 inches tall	149 b	2.47 b	2.35 a	1.15 a	1.05 b	28 b

Letter followed by the same letter do not differ. Mean separation by Duncan's multiple range test, 5% level.

Figure 1. Small plot trial: Soil moisture during the winter and spring

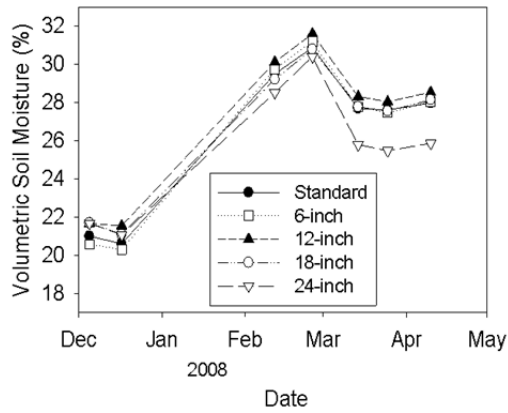


Table 2. Large plot trial: Tissue nutrient levels (at bloom) and vine growth , 2008

Cover Crop Treatment	Petiole nitrate ppm	Petiole potassium percent	Petiole phosphorus percent	Soil organic matter %	Pruning weight kg/vine
Standard Strip spray with cover crop in row middles	900 b	2.30 b	0.43 b	1.00 b	1.60 a
No vegetation Strip spray with bare row middles	1238 a	2.26 b	0.39 b	1.02 b	1.54 a
In-row cover crop Killed when 12" tall	435 c	2.66 a	0.52 a	1.12 a	1.46 a

Letter followed by the same letter do not differ. Mean separation by Duncan's multiple range test, 5% level.

Figure 2. Large plot trial: Soil moisture during the winter and spring and growing season

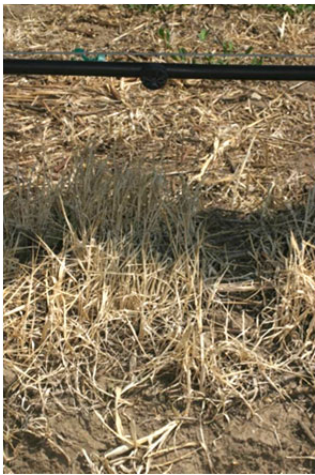
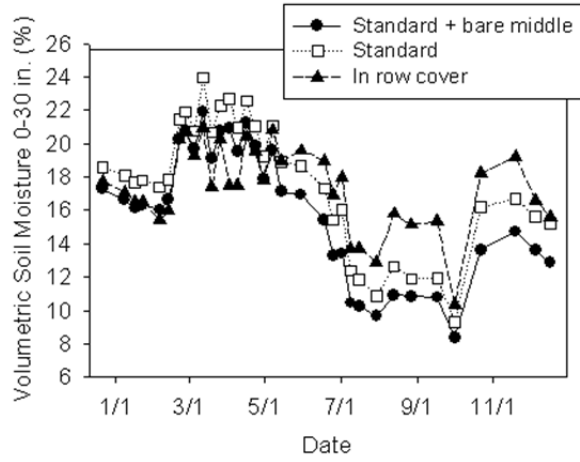


Photo 1. In-row cover crop



Photo 2. Standard bare berm
Note evidence of runoff below drip emitter

The Value of Residual Weed Control

Hank J. Mager, Bayer CropScience, Fountain Hills, AZ, hank.mager@bayer.com

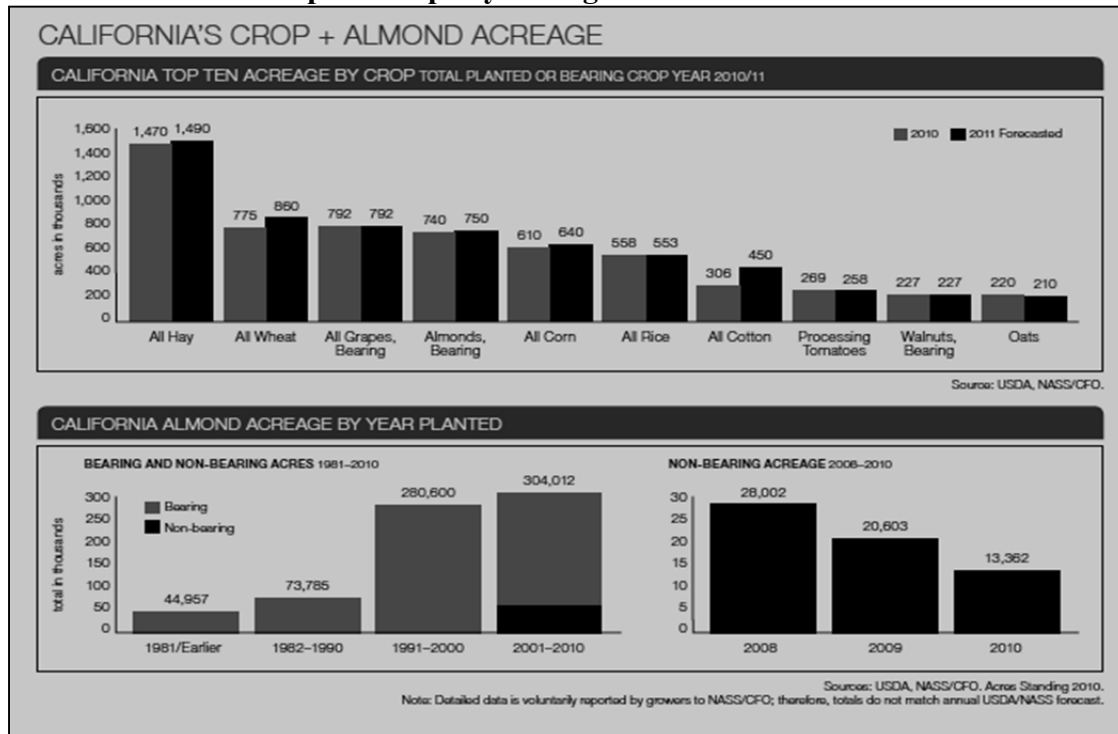
The true monetary value of residual weed control in tree and vine crops varies from one grower to the next as much as it does from one commodity to another. Residual weed control from preemergence herbicides can add value in many ways over mechanical and postemergent methods of weed control. Effective use of preemergent herbicides can reduce trips across the field providing substantial savings in time and labor as well as being beneficial to the environment. Preemergent herbicides play an important role in integrated pest management and can be a key component of an effective resistance management program. While weeds may effectively be controlled after emergence with postemergence herbicides, dead and decaying weeds can harbor pests and interfere with harvest operations. Picturesque weed-free groves and orchards may also add value to a grower's operation with regard to product marketing and agricultural tourism.

Weed control in nut crops

Mick Canevari UCCE San Joaquin Emeritus Farm Advisor, Stockton, California

The nut industry in California continues to grow in acreage, with almonds as the largest crop is estimated at 750,000 acres followed by walnuts, 227,000 and pistachios, 215,000 acres. The production areas occur in the San Joaquin and Sacramento valleys from Butte County in the north to Kern County in the south. Current acreage of major commodities in California is listed in Table 1.

Table 1. California top ten crops by acreage



Weed impacts on orchards

Weeds growing in newly planted orchards, specifically down the tree row compete for water and nutrients especially during the spring establishment period when roots begin to grow. Young orchards are more weed prone because of the smaller canopy that allows more light to reach the soil and stimulate weed germination and growth.

At this young stage, the impacts on tree growth can be most significant as roots are shallow occupying the same area as weed roots. Weeds also harbor rodent pest such as gophers, ground squirrels and voles feeding on roots and tender bark. During harvest, sweeping and pickup operations are hampered when weeds are growing in the tree row. Weeds can slow up the hulling process which increases time and cost.

Weed control techniques

Weed control must fit into an overall management system. Control programs depend upon grower practices, tree configuration and age, irrigation system, and soil type. Irrigation systems vary in design from drip, micro sprinklers, low volume impact sprinklers, furrow and flood. Each system has its own issues related to weed management from water distribution to plugging the orifices.

Soils with poor water penetration or surface seal may require frequent cultivation in row centers. Soil type and soil texture influence tillage practices, herbicide choices and applications rates. When planning your weed control program, consider the effects of herbicides on trees and environment and compare these with the effects of cultivation and weed competition, water penetration, water availability, ease of irrigation, soil structure and erosion, equipment needs, and fertilizer costs.

Chemical weed control

No single herbicide can control all vegetation. Chemical weed control does reduce mechanical trunk and root damage that can result from close cultivation especially on young trees. Combining (tank mixing) or alternating herbicides will enhance broad spectrum control of most weed species. Before selecting an herbicide or a combination of herbicides, consider the orchard weed history so you can choose the right type of herbicides.

New herbicides

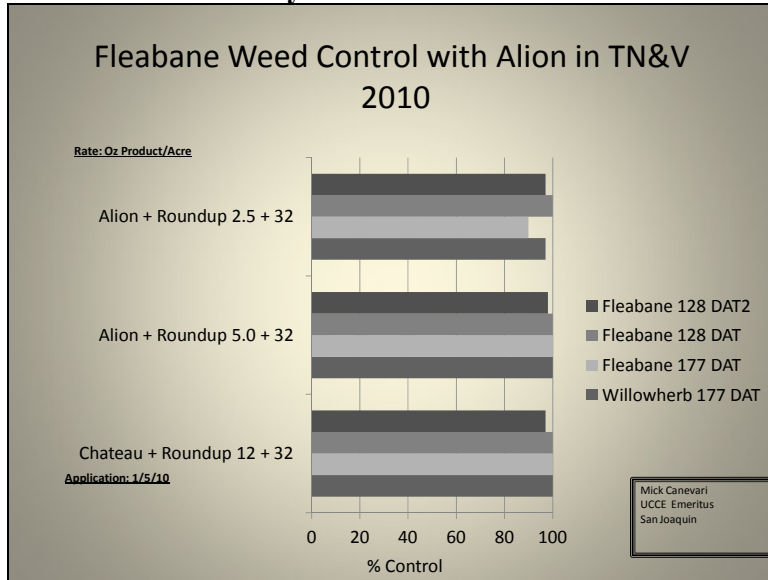
In recent years, several new herbicides have been registered for nut crops. These new active ingredient herbicides generally have reduced rates, many have activity pre and post emergent, and will control both grasses and broadleaf weeds. Most have an environmental profile that is safe to humans, wildlife and aquatic species, never the less, using best management practices are of paramount importance with all pesticides.

Shown below are several of the more recently registered herbicides for tree nuts with trial data. This list provides selected trials done by the author. Consult with the experts in your area to assist with specific conditions and recommendations.

Alion® Herbicide- Bayer

- *Indaziflam*- Preemergence herbicide
- Broadleaf and grasses
- Fruits & Nuts
- Mode of Action: Group 29 –Cellulose Biosynthesis Inhibitor

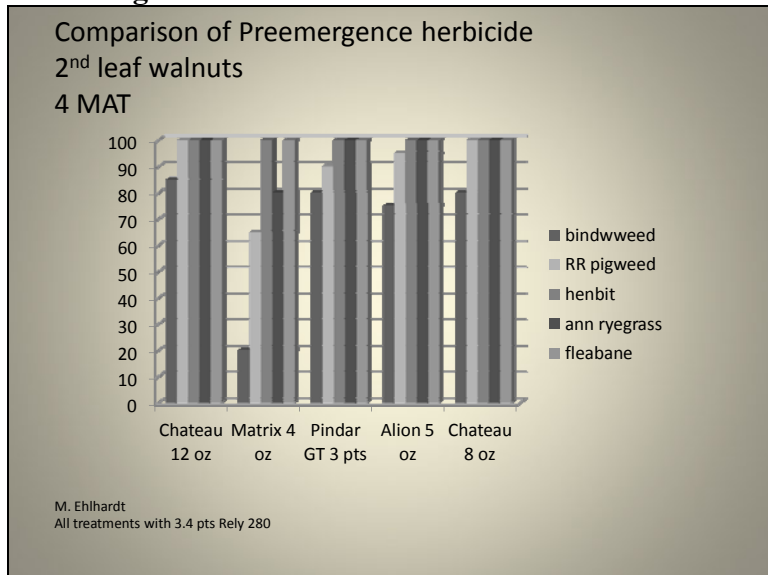
Alion control of hairy fleabane



Chateau® Herbicide- Valent

- *Flumioxazin* Fruits, nuts and vines
- Pre emergent herbicide for broadleaf and grasses
- Post emergent activity on small weeds
- Mode of Action: PPO inhibitor Group 14

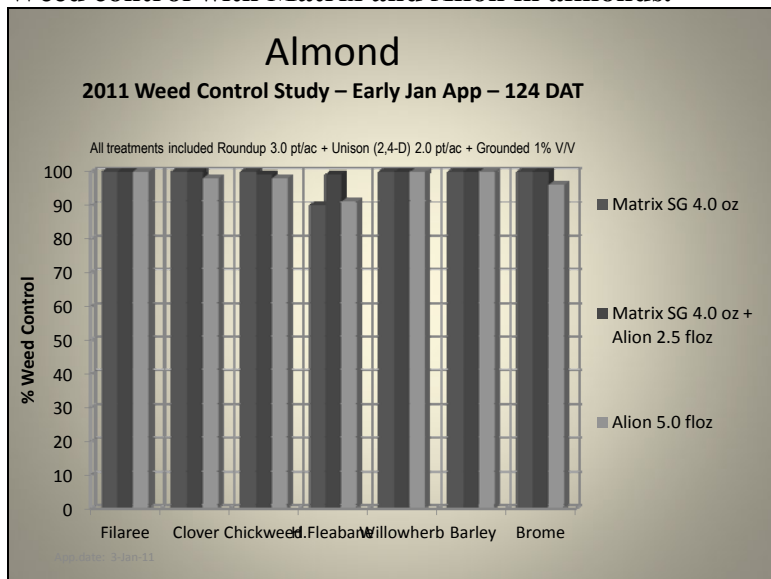
Pre emergence weed control in walnuts



Matrix® SG herbicide- Dupont

- Rimsulfuron (active ingredient)
- Mode of Action: Group 2 ALS inhibitor (sulfonylurea chemical class)
- Broadleaf weed and grass control, including fleabane and marestail
- Pre and Early Postemergence activity

Weed control with Matrix and Alion in almonds.

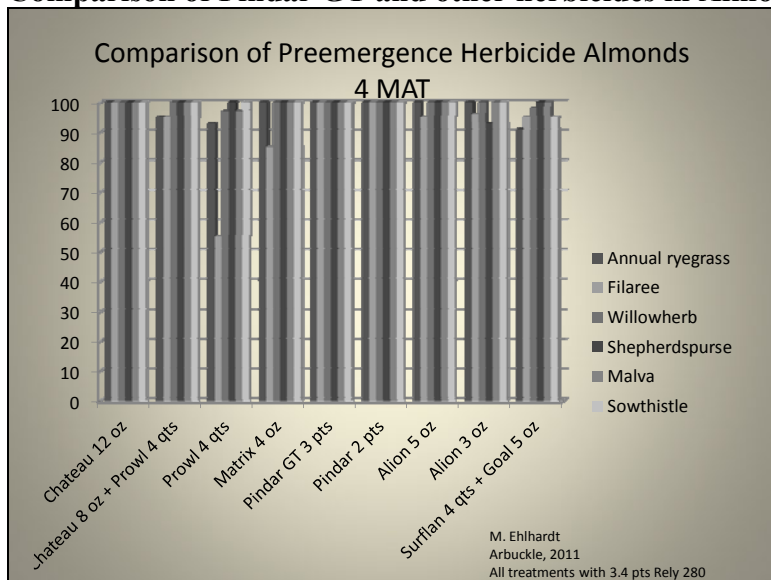


Pindar GT Herbicide- Dow AgriSciences

A premix of: *Penoxsulam*: ALS inhibitor active ingredient with broad spectrum weed control in tree nut crops and *Oxyfluorfen*: for broad spectrum residual and contact weed control.

- Burndown weed activity for many broadleaf and grass weeds
- Mode of Action- Group 2 & 14

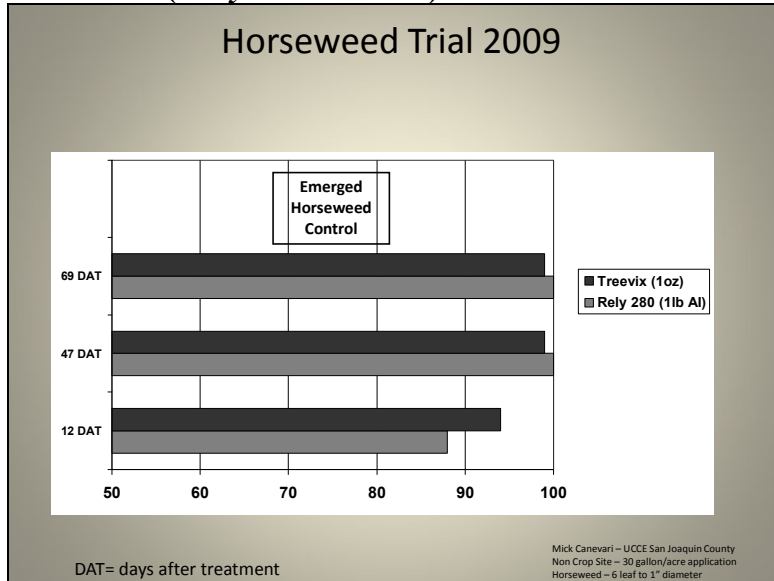
Comparison of Pindar GT and other herbicides in Almonds



Treevix™ BASF

- Saflufenacil – (active ingredient)
- Post Emergent burndown for Broadleaf Weeds
- Mode of Action - Group 14 PPO Inhibitor
- 1oz / Acre: PHI 7 Days for Tree Nuts
- Tank mix options: Glyphosate, Prowl® H₂O, Alion, Matrix®
- Rely® 280, Paraquat, Surflan, Chateau

Horseweed (*Conyza canadensis*) burn down trial with Treevix and Rely



Summary

Today there are many excellent residual herbicides available for growing nut crops.

- Matrix®, Alion™, Chateau®, Pindar™ GT “all” good products similar for residual weed control up to 150 days when applied in the winter months.
- Spring applications of residual herbicides Prowl & Surflan, can be tank mixed with new chemistries and better suited for summer weed spectrums and warmer temperatures.
- Newer post emergent herbicides include, Treevix®, Rely®, Shark® that are recommended with residual products. Glyphosate and Gramoxone can also be tank mixed to enhance weed spectrum control.
- With many different modes of action herbicides, a strategy for weed resistant’s becomes a manageable task.
- Generally newer pesticides are safer to humans, animals, and the environment however, caution should be made for crop safety and utilizing best management practices.

Determining the Yield Effect of Herbicide Drift on Dried Plum Trees

*L.M. Sosnoskie, M.J.M Abit, T. Lanini, and B.D. Hanson
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Introduction:

Dried plums were first introduced to North America in 1856, when cuttings from France were planted in California (CA). In 2010, 63,000 acres in the US, almost 100% in CA, were devoted to dried plum production; 125,000 tons of prune-variety plums were harvested with an estimated crop value of \$153 million.

Recently, dried plum growers have observed instances of leaf spotting, mottling, poor tree growth and poor flower set that are suspected to be the result of off-target herbicide drift. In previous work conducted by the California Dried Plum Board, glyphosate and propanil were found in measureable amounts in dried plum leaf tissue. While the source of propanil was, most likely, aerial applications made to nearby rice fields, the origin of the glyphosate contaminant was not immediately evident. Glyphosate is a commonly applied herbicide in both non-crop and cropping systems, including prunes and other perennial production environments. Regardless of the source, it is not clear what effects sub-lethal rates of these, and other, herbicides are having on dried plum production. If one or both of these products are impacting dried plum productivity, it may be necessary to modify 1) the way they are applied or 2) the timing of the application.

In 2009, a research project, supported by the California Dried Plum Board (CDPB) was initiated to evaluate the effects of simulated propanil and glyphosate drift on the performance and fruit yield of established trees (~15 years old). An additional experiment was begun in 2011 to describe and compare injury symptomology and subsequent yield effects of sub-lethal doses of glyphosate, propanil, penoxsulam, glufosinate, and oxyfluorfen on newly established French prune trees over time.

Materials and Methods:

2009-2011 Wolfskill Farms Experiment

This experiment was conducted (2009 to 2011) in an established French prune orchard (Wolfskill Farms) near Winters, CA, to evaluate the cumulative effects of yearly, low-rate (simulated drift) applications of propanil (Stam 80 DF at 0.002, 0.01, and 0.1X labeled rate) and glyphosate (Roundup WeatherMax 0.01, 0.1, and 0.5X labeled rate) at three application timings (June, July, and August) on fruit set and fresh yield. The reference 1X herbicide rates are 1.5 lbs ae/A for glyphosate and 4.0 lbs ai/A for propanil. Both herbicides were applied to the tree canopies by researchers on an orchard ladder. Trees were sprayed with two-passes of a 3-nozzle spray boom from opposite sides of the tree resulting in approximately 80% of the upper canopy being treated. Applications were made using a CO₂-pressurized backpack sprayer, with 80015 nozzles, delivering 10 gal/A total spray volume. Individual plots consisted of a single tree, each; treatments were replicated up to three times. Visual observations of herbicide injury were recorded throughout the course of the study. Each year, two mid-canopy branches per tree were selected and the number of buds and fruit (set and harvested) per branch and fruit (set and harvested) per bud were counted. Fresh fruit weights were also recorded and the individual fruit weights determined. Several trees were left untreated at the site for the purpose of comparison.

2011-2013 Martinez Farms Experiment

With support of the CDPB and the cooperation of a local grower, a new field experiment was established at Martinez Orchards (Winters, CA) to evaluate the effects of several low-rate (simulated drift)

applications of glyphosate, propanil, penoxsulam, and oxyfluorfen on: canopy injury, flower and fruit set, fresh yield, and prune dry weight in a new French prune planting (1-leaf trees). Bare root French prune nursery stock was planted March 9, 2011 as “interplants” in a new commercial orchard planted by the cooperating grower; test trees will be removed when they are large enough to interfere with the commercial orchard trees. Herbicide treatments were applied above the tree canopies by research personnel using a CO₂-powered backpack sprayer, with 80015 nozzles, delivering 10 gal/A total spray volume. Glyphosate (Durango), propanil (Stam 80 EDF), penoxsulam (Tangent), glufosinate (Rely 280), and oxyfluorfen (Goal 2XL) will be applied at 0, 0.05, 0.1, and 0.2X of the herbicide use rates. The reference 1X herbicide rate is 1.5 lbs ae/A for glyphosate and 4.0, 0.03, 1.0, and 1.25 lbs ai/A for propanil, penoxsulam, glufosinate, and oxyfluorfen, respectively. Non-treated trees have been included in the study as negative controls. Individual plots consist of a single tree, each; all treatments are replicated five times. In 2011, treatments were applied on August 10 due to late planting and slow initial growth; however, treatments in 2012 and 2013 will be applied earlier in the spring. Data collection for the experiment includes: annual trunk diameter measurements, as well as visual estimates of foliar injury. Beginning in 2012, the number of flower buds will be counted on each tree (or representative portion thereof) prior to the first herbicide application and fruit set will be evaluated in mid-summer. Once fruit production begins, fruit on each tree will be counted and weighed and, if appropriate, a subsample will be dried and weighed to determine final prune yield and quality.

Results and Discussion:

2009-2011 Wolfskill Farms Experiment

When it occurred, visual injury was minor (7 to 18%) and transient, as well as consistent with the typical symptoms associated with each herbicide. Glyphosate is both translocated and slow to metabolize, and physical injury symptoms (yellowed tissues and shortened internodes or “witches brooms”) were often not observed until the season following the herbicide treatments. Leaves directly exposed to propanil, a photosynthesis inhibitor, exhibited interveinal chlorosis soon after treatments were applied. Over three fruiting years (2009, 2010, and 2011), no statistical differences were observed with respect to French prune bud and fruit set, as well as fresh fruit weight, in response to herbicide type, rate, or application timing (data not shown). Results from this trial suggest that visual injury from both propanil and glyphosate may not significantly affect fruit yield on established prune trees. If injury does occur, it may be difficult to measure given the variability among trees within an orchard, or among orchards, due to widely varying horticultural practices.

2011-2013 Martinez Farms Experiment

One month after application (MAA), slight to moderate canopy injury was observed for all herbicide treatments applied in 2011. The injury symptoms most often noted were chlorosis of newly emerged leaves (glyphosate), yellowing or dying leaves (propanil), necrotic spots of varying sizes (oxyfluorfen), and chlorosis and necrosis of new and old leaves (penoxsulam) (Figure 1). The greatest injury occurred in those treatments that received the highest rates of each herbicide (Figure 2). Injury ratings at 2 MAA were considerably less severe as compared to the 1 MAA observations, indicating plant recovery (data not shown); however, some degree of injury was still evident for the highest herbicide rates. Despite early season injury, final trunk measurements were not greatly affected by herbicide treatments, except those that were treated with propanil and oxyfluorfen (data not shown). Yield parameter data were not collected in 2011 because the trees were in their first growing season. The Martinez Farm site will be monitored in 2012 to evaluate the effects of simulated herbicide drift in 2011 on both bud and flower initiation. Treatments will be reapplied in 2012 and 2013 and similar data will be collected. The trial is expected to continue through the 2013 growing season before being terminated.

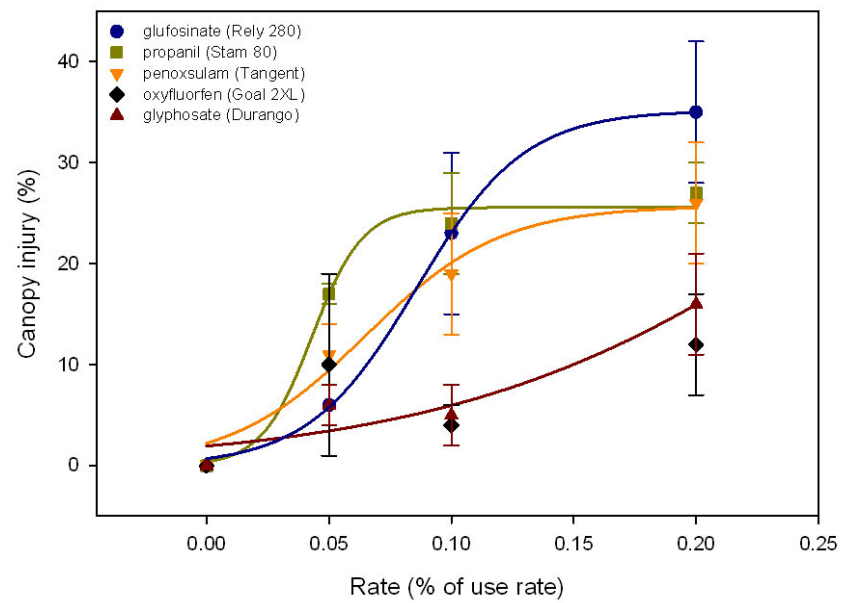
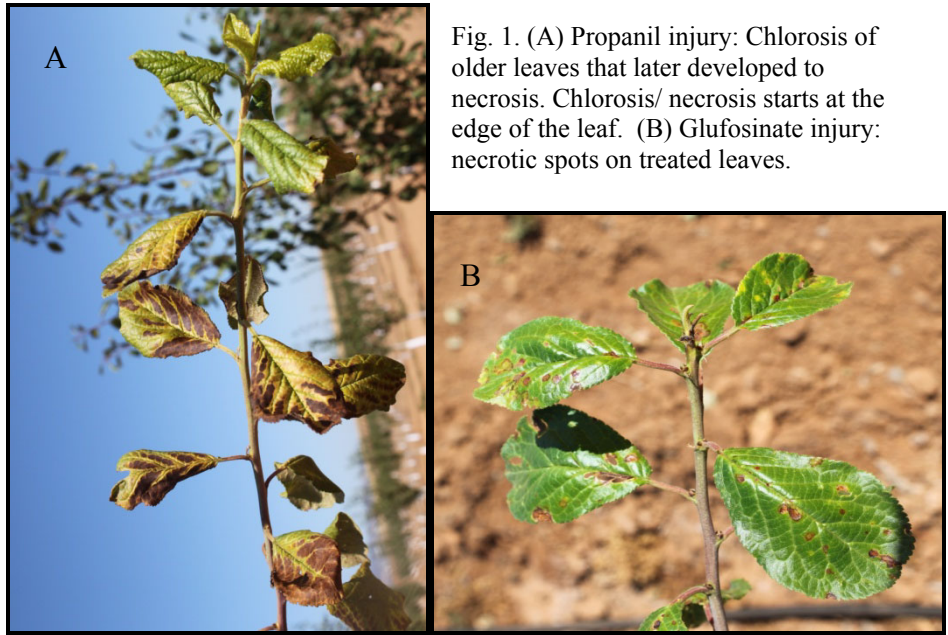


Fig. 2. Effect of simulated herbicide drift on young dried plum trees 1 MAA. Data are means (n=6) plus or minus standard error. A regression could not be fit to oxyfluorfen (Goal 2XL) data.

Partnering for Weed Removal on Santa Cruz Island

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Abstract

Santa Cruz Island is the largest and most biologically diverse of eight Channel Islands off the coast of southern California. The Nature Conservancy (TNC) owns and manages the western 76% of Santa Cruz Island (SCI), and the National Park Service (NPS) owns and manages the eastern 24% of the 95 sq. mi. island as part of the Channel Islands National Park. The weed management program on Santa Cruz Island has many components: scouting, mapping and reporting new infestations; accessing and treating weeds; assuring programmatic continuity for long-term treatment that will result in eradication; and securing funding to maintain the program over time. Managing the weed program on Santa Cruz Island is best accomplished by drawing on the diverse skills and knowledge of many groups and directing them towards a common goal. These groups include government agencies, private organizations and individuals. A variety of techniques and personnel are involved in treating weeds on the island. TNC's weed contractor uses a helicopter to transport weed technicians to rugged, difficult-to-reach locations to treat remote weeds; volunteers and Conservation Corps members under the direction of professionals remove weeds in watercourses and along roads; National Park weed technicians fell large invasive trees; and new invasive species are prevented from reaching the island through implementation of biosecurity protocols. The Nature Conservancy works closely with local, state and federal agencies to fund weed work on the Island and benefits from all these partnerships for an effective weed management program.

***Tamarix* Biocontrol and the Restoration of Riparian Ecosystems**

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Tamarix spp., occupy over one million acres in North America. *Tamarix* is the third most common woody plant in western U.S. riparian areas. *Tamarix* detrimentally impacts ecosystems and biodiversity. It displaces native riparian plants; transpires significant amounts of water; dessicates and salinates soils; increases erosion and sedimentation; increases risk of wildfire and lowers habitat quality for wildlife species.

Conventional control methods can be expensive and unsustainable. Control programs can actually promote secondary resurgence of other invasive weeds. Biocontrol of *Tamarix* is a more environmentally benign and cost-effective alternative.

Classical biocontrol research begins with looking for agents in a weed pest's native range, in this case in Asia, southern Europe and north Africa. Eventually three candidate insects, Chrysomelidae: *Diorhabda carinulata*, Curculionidae: *Coniatus tamarisci*, and Pseudococcidae: *Trabutina mannipara*, were approved for study by the Technical Advisory Group for the Biological Control of Weeds (TAG) with U.S. Fish and Wildlife Service concurrence. *Diorhabda carinulate*, also known as the tamarisk leaf beetle, from central Asia was approved for release in 1996.

A potential conflict emerged with the listing of the Southwestern Willow Flycatcher (*Empidonax traillii extimus*) as an endangered subspecies in 1995. The loss of its habitat, the typically cottonwood/willow riparian woodlands, enhanced by the invasion by *Tamarix*, are factors in the bird's decline. The flycatcher has been found to nest in *Tamarix*.

Ironically, the success of *Diorhabda* at defoliating *Tamarix* caused conflict with conservationists trying to protect the flycatcher. The biocontrol program was halted by the U.S. Fish and Wildlife Service for consultation under the Endangered Species Act. The premises were that defoliation caused by the beetle could expose flycatcher nests to excess heat; tamarisk may be eradicated too quickly before native plants could replace the lost habitat; the habitat would be too degraded for native plants and that the beetles may be toxic.

The beetle was studied in a number of sites throughout the western United States. *Diorhabda* did indeed prove to be successful at defoliating tamarisk in northern areas where the research was conducted. However, below the 38° parallel (San Francisco), the beetle's daylength-induced diapause caused it to enter into overwintering too early to allow survival until the following spring, and control at these sites failed. *Diorhabda carinulata* appears to be evolving a delayed

response to daylength cues to diapause and is establishing further south than the original releases.

Where successful, the initial impact of *Diorhabda* on *Tamarix* defoliation was rapid and dramatic. However, foliage re-growth occurred in a few weeks; die-back was gradual and mortality was slow. But even without mortality, benefits accrued. Canopy cover by *Tamarix* declined sooner and the subsequent season's cover and duration were reduced. Seasonal evapotranspiration was reduced by 65% in year one and by 90% in year two. The beetles even served as an additional food source, and bird diversity and abundance increased.

Well-intentioned but perhaps misguided conservationists are resisting the implementation of biocontrol of *Tamarix*, believing that *Tamarix* forests are needed for flycatcher survival. However, despite the flycatcher nesting in *Tamarix* in a few locations, over 90% of flycatcher nests are in native or mixed native/exotic vegetation. *Tamarix*'s trend is to create monocultures and flycatcher nests are absent in *Tamarix* monocultures. The data suggests that even as little as 30% native element sustains riparian birds but drops rapidly as *Tamarix* dominance goes over 80%. Additionally, flycatchers have responded well to native riparian recovery, showing increased fledgling success in restored habitats over *Tamarix* dominated sites. Fire may be the biggest factor promoting both *Tamarix* dominance and sensitive species decline.

Help to resolve the conflict by facilitating active restoration of native habitat in areas where the flycatcher is present is being provided by The Walton Family Foundation and coordinated by the Tamarisk Coalition, a non-profit alliance working to restore riparian lands.

Abstract for Proceedings, California Weed Science Society Meeting, Jan. 23-25, 2012

Nuance, Naysayers and twenty years of studying invasive species impacts. by Carla D'Antonio (presenter) and Nicole Molinari. Dept. of Ecology, Evolution & Marine Biology. University of California, Santa Barbara, CA. 93106.

Over the past twenty+ years, there has been an explosion of concern and study regarding the presence, control and impacts of non-native plants in wildland settings. Yet recently there has also been a backlash against this movement as well as a substantial reduction in funding allocated to the study and control of invasive plants. We argue that to curtail growth of the naysayer movement, and to enhance efforts at control, we need to, (1) use more careful terminology regarding who these species are that merit control, (2) conduct more targeted research on impacts and (3) embrace and communicate the nuances of species impacts. Since it is only a small (maybe 10%) of established, widespread non-native plant species that cause impacts that we care about, we need to communicate carefully about which species they are and be able to substantiate implications of their impacts. To better direct management efforts and avoid unscientific demonization of species, we need to study and communicate the nuances of species impacts.

Large Scale, Low Cost Restoration of Native Grasslands and Coastal Sage Scrub using Herbicides

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Restoring native habitat in southern California has not met with great success over the past few decades despite lots of effort. It is also expensive, with costs typically in the range of \$3,000 to \$40,000 per acre. Working with several colleagues, such as Edith Allen and Milt McGiffen at UC Riverside (and their students), John Eckhoff at CA Department of Fish and Game, and Marti Witter with the National Park Service, we have been exploring herbicide-based approaches as a low cost alternative.

These approaches concentrate on killing non-native annual grasses and forbs in order to eliminate competition with native plants. We are utilizing broadcast applications of low rates of herbicides; principally glyphosate, fluazifop-P-butyl, and triclopyr, as an efficient and inexpensive way to kill these weeds. We apply the herbicides in winter or early spring to kill the weeds early in the rainy season so the resident natives have access to the limited annual supply of precipitation. We repeat herbicide treatments annually for 3-5 years in order to eliminate the weedy plant seed bank so the problem does not re-occur.

In one site near Ramona in San Diego County, after a five-year regimen of glyphosate, weed whipping the inflorescences of persistent weeds, and seeding with natives; we have increased native cover to 50% compared to less than 5% for the untreated plots. We also have counted over 30 species of natives in the treated plots compared to 3-5 in the untreated plots. Our costs for the treatments for the five years of the study are about \$2000 per acre.

In another site near Jamul in San Diego County, we have been using herbicides to selectively remove non-native weeds in an area with a sparse native stand of purple needlegrass (*Stipa (Nasella) pulchra*, the CA State Grass). In this experiment, we are also applying herbicides broadcast in winter or early spring to kill the weeds. Our most successful treatment has been a combination of fluazifop and triclopyr, which is killing the weeds without visible damage to the native grass. After three years of treatment, our treated plots have purple needlegrass cover ranging from 20-60%, while cover in the untreated plots averages about 5%.

Where the Weeds Are: Prioritizing Regional Response to Invasive Plants Using CalWeedMapper

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Abstract

Land managers need to devise strategic management plans in order to address invasive plants effectively with limited funding. The California Invasive Plant Council (Cal-IPC) interviewed experts throughout California on the abundance, spread and current management of 204 invasive plant species at the USGS 7.5' Quadrangle scale. These expert knowledge data are linked to existing online databases from Calflora and the Consortium of California Herbaria (CCH) and displayed in a new online mapping tool, CalWeedMapper. This website is designed to increase the effectiveness of invasive plant management by providing landscape scale maps that serve as the basis for setting regional priorities, tracking progress and justifying funding. Land managers can see management opportunities for their region divided into surveillance, eradication or containment targets. These reports are derived from maps of current distribution combined with projected suitable range for 2010 and 2050 climate conditions. Some species show likely range expansion with climate change, while others contract or shift their ranges. In other cases, the projected range does not change but the level of suitability does. In addition to providing recommendations for regional management opportunities, CalWeedMapper allows land managers to generate maps of individual species distribution and to explore and update USGS quadrangle data, through an update interface or by submitting occurrence information. We are working with stakeholder groups and agencies to apply CalWeedMapper to their invasive plant management. Check us out at calweedmapper.calflora.org!

Acknowledgments

This project would not have been possible without the data and expert knowledge generously provided by hundreds of individuals and organizations involved in Weed Management Areas across the state. Funding was provided by the California Department of Food and Agriculture (American Recovery and Reinvestment Act funds); National Fish and Wildlife Foundation Pulling Together Initiative; Resources Legacy Fund; Richard and Rhoda Goldman Fund; USDA Forest Service State and Private Forestry Program; and USDA Forest Service Special Technology Development Program.

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Weeds & Their Management in Vegetables: An Entomologist's Perspective

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Effective weed management is critical for the profitable production of vegetable crops for all the obvious reasons. However, weed management is also essential for another important, but often overlooked, reason. Several common weed species found in and around vegetable crops can serve as host plants to many insect pests that can later infest nearby crops. Additionally, when weeds are not controlled in the field, they can be an impediment to effective insect control. Although weeds can serve a beneficial role by harboring insect natural enemies and pollinators, the consequences resulting from weeds harboring insects as pests largely outweighs the benefits they potentially provide. This presentation will address the practical interactions between weeds and insect pests, and focus specifically on how poor weed management can contribute to insect pest problems in vegetable crops.

Weeds as Refuges for Beneficial Insects

There are numerous examples of how weeds can serve as a refuge for natural enemies of insect pests. Parasitic wasps and predatory insect species can build up to large numbers in weedy areas and subsequently migrate into adjacent vegetable fields where they can feed on damaging insect pests. Unfortunately, given the high cosmetic standards in many vegetable crops, these natural enemies are not generally capable of preventing economic damage to the harvested product. In contrast, flowering weed species can provide a source of nectar and pollen for a number of important insects such as honeybees and other native pollinators important for cucurbits and seed crop production. Of course, these same weedy refuges can serve as host sources for many key insect pests that cause economic damage to vegetable crops.

Weeds as Reservoirs for Insect Pests

Many of the common insect pests found in vegetable crops are polyphagous, capable of feeding and reproducing on crops and weeds in numerous plant families. For instance, a weed species such as Common lambsquarters, is known to serve as a host for a variety of economic insect pests in fresh-market vegetables and melons (Table 1). When found on field margins and ditch banks, weeds can provide insect pests with suitable resources needed for rapid population growth which subsequently can lead to insect infestations occurring in adjacent vegetable crops. For example, it is not uncommon for green peach aphids and false chinch bugs to build up to high numbers on cheeseweed and London rocket during the winter, only to invade nearby melon and seed crops later in the spring.

Many weed species can also be important for these economic insect pests by providing host plants that serve as a bridge between cropping seasons when vegetables crops are not in production (May-August). Since most of these key insect pests have the ability to move relatively long distances to find new food sources, weeds that are allowed to grow unchecked in fallow fields during the summer often serve as a key source of insect infestations for fall

vegetable and melon plantings. For example, pale-striped flea beetle and beet armyworm populations will annually develop on common purslane that has been allowed to grow in fallow fields prior to fall plantings.

Another host source for insect pests of vegetables are volunteer crops that are considered weeds ("a plant out of place") when allowed to grow in fallow fields, on field margins and within crops. Each summer, volunteer melons and cotton can be found germinating in fields being prepared for or planted in fall vegetable crops. If not removed in a timely manner, these weedy volunteer plants can sustain large numbers of insect pests that can eventually migrate into newly planted fields.

Table 1. Common weeds that are known to serve as hosts for the major insect pests of leafy vegetables and melon crops grown in the desert southwest.

	Beet armyworm	Corn earworm	Variegated cutworm	<i>Liriomyza</i> leafminers	Western flower thrips	Green peach aphid	Potato Aphid	Sweetpotato whitefly	Pale-striped flea beetle	False chinch bug	Bagrada bug
Sunflower											
Silverleaf nightshade											
Cheeseweed											
Lambsquarters											
Nettleleaf Goosefoot											
Jimsonweed											
Wright's groundcherry											
Common purslane											
Ragweed											
Pigweed											
Sheperd's purse											
Russian thistle											
London rocket											
Wild mustard											

Sources: Common names of weeds from Parker 1972; List of hosts for insects from Capinera 2001.

Weeds as Reservoirs for Insect-transmitted Viruses

Weeds can also serve as alternate host plants for a three important groups of viruses that affect vegetable and melons; tospoviruses, potyviruses and closteroviruses . These viruses utilize a number of important weeds as hosts, and are vectored by several of the key insect pests shown in Table 1. For example, one of the primary insect vectors of the tospovirus, *tomato spotted wilt virus*, is the western flower thrips. Not surprising, two common weed species (lambsquarters and cheeseweed) serve as hosts to both the vector and the virus. Similarly, these two weed species serve as a host reservoir for a number of potyviruses (e.g., *watermelon mosaic virus-2*) vectored by several aphid species, including green peach aphid. Most recently, a new closterovirus, *Cucurbit Yellow Stunting Disorder Virus*, which is vectored by the sweetpotato whitefly, has emerged as a major problem in fall melons. Initially it was believed that only cucurbits could host the virus, but has since been determined that several common weeds serve as reservoir hosts including: redroot pigweed, London rocket, lambsquarters, sowthistle, alkali mallow, Wright's groundcherry, and silverleaf nightshade.

Weeds as Impediments to Insect Control

Foliar Insecticide Sprays: Excessive weed densities during stand establishment can impede insect control by interfering with foliar insecticide sprays directed at small plants. Weeds infesting vegetable or melon fields can negatively influence insecticide deposition onto plant foliage, resulting in reduced insecticide efficacy. This may be especially important for broadleaf weeds such as Wright's groundcherry which are tall growing and capable of producing a canopy over seedling vegetable plants. Dense weed foliage can intercept insecticide spray droplets before reaching the target crop, resulting in less insecticide deposition and unacceptable plant damage from insect feeding on untreated foliage.

Soil Insecticides: A large number of acres planted to vegetable and melons crops each year are treated with soil systemic insecticides (i.e., imidacloprid , rynaxypyr) for early season control of whiteflies, aphids and beet armyworms. These insecticides are injected beneath the seedline just prior to- or at-planting and become systemically active in plants via root uptake during germination and seedling growth. Weeds are known to compete with plants for water and fertilizer during stand establishment, and they can also compete with crops for soil insecticides. Excessive weed densities can significantly intercept insecticides and reduce the amount available for uptake by the target crop.

Herbicide interactions: Anecdotally, it has been suggested that root injury in leafy vegetables resulting from applications of pre-emergent herbicides such as Kerb and Prefar could potentially reduce uptake of soil insecticides during stand establishment. Herbicide effects causing root pruning or clubbed roots could potentially impede normal uptake of the systemic insecticides until root growth resumed.

Relevant References

- Capinera, J.L. 2001. Handbook of Vegetable Pests. Academic Press, New York. 729 pp.
Parker, K.F. 1972. An Illustrated Guide to Arizona Weeds. Univ. of Arizona Press. Tucson.
Wintermantle W.H., L.L. Hladky, A. A. Cortez and E.T. Natwick, 2009. A New Expanded Host Range of *Cucurbit yellow stunting disorder virus*, Plant Dis. 93:685-690

Water Management Effects on Weeds in Vegetable Production

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Introduction: Water plays a central role for managing weeds in vegetable systems. Because moisture is needed for germinating weed seed, water is used in several cultural strategies to reduce weed seedbanks through germination before crop establishment. Irrigation method also affects weed populations in vegetables. Water can also increase weed populations when run-off from rain or irrigation carries and disperses weed seed in agricultural fields. The efficacy of herbicides and fumigants for weed control is often affected by soil moisture. Finally, water is used for non-chemical alternatives to fumigation such as soil solarization, aerobic soil disinfection, and soil steam sterilization.

Water use in cultural weed control strategies: At planting, a large proportion of weed seeds in the soil are in a non-dormant state and ready to germinate with the addition of moisture. Pre-irrigating is not only beneficial for giving the soil an optimal tilth before bed preparation, but also for germinating weed seed that could potentially compete with a young vegetable crop. Shem Tov and Fennimore (2006) reported that weed populations in lettuce were reduced by 50% by pre-irrigating and killing germinated weeds before planting. Similar to pre-irrigation, the *stale bed technique* of controlling weeds involves irrigating after bed shaping to germinate non-dormant weed seed near the soil surface. Newly emerged weeds are then killed using cultural means such as flaming or shallow tillage before planting.

After pre-irrigating and tilling soil for planting, some growers seed directly into soil moisture and avoid irrigating during germination to minimize further flushes of weeds. This technique is most often used with large seeded crops such as melons, squash and beans, which can be planted deeper than small seeded vegetables. In the past, some growers of processing tomatoes also seeded into existing soil moisture in the Sacramento Valley, but because tomato seed is small and planted shallowly, they use an implement on the planter to create a 2 to 3 inch mound of soil, known as a cap, over the seed line. Capillary action of the soil cap wicks moisture near to the surface where the seed is planted. The cap must be removed just before the seedlings emerge to prevent damage to the crop. Although the main objective of dry farming crops such as tomatoes and melons is to improve fruit flavor, another advantage is a reduction in weed numbers because the soil surface remains dry.

Irrigation method effects on weeds: Sprinkler and furrow irrigation tend to stimulate more weed germination than drip irrigation. These irrigation methods wet a greater surface area than drip. In addition, by eroding the soil and suspending shallowly buried seed, furrow irrigation can disperse weed seed within a field or transport weed seed to fields downstream that reuse the water for irrigation. Sojka et al. (2003) determined that the application of polyacrylamide polymer reduced weed seed numbers in furrow tail water by reducing soil erosion and improving water infiltration. Weeds growing along irrigation canals also disperse seed into surface water that is used to irrigate fields. Since drip systems must be filtered to prevent emitters from clogging, weed dispersal from surface water sources is less likely than with furrow and sprinkler.

Subsurface drip may offer the best advantage for reducing weed pressure. While surface placed drip tape will wet a portion of the top of a bed, subsurface drip can maintain a dry soil surface, especially if the tape is positioned at 12 or more inches below the soil surface. By transplanting vegetables into subsurface drip irrigated beds, growers can avoid wetting the soil surface with sprinklers and causing weeds to germinate (Shrestha et al 2007).

Role of water in activating herbicides and fumigants: Water is needed to solublize and transport herbicides to weed seed. Also, weed seed needs to be moist to absorb herbicides. One challenge of using drip alone for establishing a vegetable crop is to move and activate pre-emergent herbicides. Many pre-emergent herbicides used in vegetables are sprayed on the soil surface before planting and rely on overhead sprinkler water to move the herbicide into the soil and near weed seeds. Both pre-emergent herbicides oxyfluorfen and flumioxazin have been shown to be activated using surface drip in transplanted celery and cabbage providing levels of weed control comparable to sprinkler activation. (Table 1). In a study with seeded lettuce, pronamide sprayed on the bed tops did not provide significant weed control under either surface or shallowly buried drip (Fennimore et al. 2007). Injecting pronamide through the drip systems also did not control weeds.

Water also plays an important role in the transport of fumigants. Fumigants used as alternatives to methyl-bromide, such as 1,3 D cis and chloropicrin, have relatively lower vapor pressure and higher water solubility, and therefore require uniform soil moisture in beds to attain optimal weed control.

Water for non-chemical control methods Water can be used to create conditions that kill weed seed. Soil solarization takes advantage of the high heat capacity of water to sustain soil temperatures above 150 °F which is sufficient to kill many weed seed species. In locations too cool to use solarization, steam applications can also kill weed seed. Finally, saturating soil pores with water in carbon augmented soils with plastic mulch cover creates anaerobic conditions that have been shown to reduce weed densities (Daugovish et al. 2011)

References

- Daugovish, O., C Shennan., J. Muramoto and S. Koike. 2011. Anaerobic soil disinfestation for southern California strawberry. MBAO Proceedings. San Diego, CA, 2:1-4.
- Fennimore, S. A, R.F. Smith, and M. Cahn. 2007. Weed management systems for lettuce. Annual Report. California Lettuce Research Board. 137-146.
- Shem-Tov, S., S.A. Fennimore and W.T. Lanini. 2006. Weed management in lettuce (*Lactuca sativa*) with pre-plant irrigation. Weed Technology 20:1058-1065
- Shrestha A. J. Mitchel and W. Lanini. 2007. Subsurface drip irrigation as a weed management tool for conventional and conservation tillage tomato(*Lycopersicon esculentum* Mill.) production in semi-arid agroecosystems. J.Sust. Agric. 31:91-112

Sojka, R.E., D.W. Morishita, J.A. Foerster, and M.J. Wille. 2003 Weed seed transport and weed establishment as affected by polyacrylamide in furrow-irrigated corn. *Journal of Soil and Water Conservation*. 58(5):319-326.

Table 1. Drip and sprinkler activation of herbicides in Ventura County trials, 2005-2010*.

Crop and irrigation method ¹	Weed control ²	
	% (from untreated)	
	Oxyfluorfen ³	Flumioxazin ⁴
Cabbage, (green), transplanted into drip-only irrigated beds	96	88
Celery, transplanted into dry beds, drip-only irrigation	87	87
Celery, transplanted in drip-only pre-irrigated beds	90	79
Cabbage, sprinkler irrigation	92	80
Celery, sprinkler irrigation	75	94

* No significant crop injury or effects on yield were observed in any of the treatments.

¹ All crops were planted 1 day after herbicide applications. In drip-only irrigation, a single high flow line irrigated 2 rows of crop plants. In sprinkler irrigation, overhead water was applied for the first 2-3 weeks after planting and the fields were consequently drip irrigated.

² Major weeds present were: nettleleaf goosefoot, mustards, burnings nettle, shepherd's-purse and annual sowthistle. The weeds were counted at three and six weeks after emergence and the total number compared to untreated check to obtain percent control.

³ Goaltender (oxyfluorfen) was applied at 0.25 lb a. i. /acre (1 pint)

⁴ Chateau (flumioxazin) 0.063 lbs a. i. /acre (2 oz/acre of product)

Weed Control as Part of Soil Disinfestation with Fumigants and Nonfumigants

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INTRODUCTION

Strawberries and vegetable crops are highly susceptible to weed competition immediately after planting when the plants are small and frequent irrigation provides ideal conditions for weed germination. In coastal California, most weeds that invade strawberries and vegetable crops are annuals. Weeds such as little mallow (cheeseweed), burclover, sweet clover, and filaree invade during stand establishment and are common problems in strawberry fields because their seeds survive fumigation. After strawberry transplanting, weeds with windblown seeds, including sowthistle and common groundsel, may become problems. In conventional strawberry fields, effective weed management requires a combination of cultural practices, preplant soil fumigation, and additional herbicide applications when necessary. Proper field and bed preparation is essential for a good weed control program. Fumigation with a mixture of 1,3-dichloropropene/chloropicrin (Telone C35, Inline, Pic Clor 60) or chloropicrin alone for disease control, followed by an application of metam sodium or metam potassium, are among the best alternative disease & weed control treatments available for California strawberry producers. The use of impermeable films enhances weed control provided by Inline and Pic Clor 60, but the higher cost of these films has limited their adoption. For weeds that escape preplant controls, hand-weeding and/or selective herbicides are used.

Nonfumigant methods of soil disinfestation such as solarization or steam use a lethal dose of heat to kill soil pests including weed seed.

Crop Rotation. Rotational crops can be an important part of a weed control program. Rotations can be vegetable crops such as celery, lettuce or cole crops, or cover/ green manure crops such as barley, cereal rye, oats, or wheat. Where the cropping cycle permits, sudangrass may be included in the rotation cycle as a summer annual green manure crop. Intensive cultivation of a vegetable crop rotation such as lettuce or a cole crop helps control many problem weeds. A densely planted cereal rye cover crop or small grain crop is highly competitive with weeds and provides better weed control than a legume cover crop. In addition, alternative herbicides are available in rotational crops. Difficult to control perennial weeds such as field bindweed must be controlled in fallow ground with timely applications of glyphosate. No strawberry production should be attempted while a field is infested with field bindweed, because no fumigant or herbicide available for strawberry can control this weed. Instead field bindweed should be controlled with herbicides during fallow periods and during other crop cycles.

KILLING WEED SEEDBANKS WITH FUMIGANTS AND NONFUMIGANTS

Fumigation. Fumigation with methyl bromide, Telone C35, Inline, Pic Clor 60, chloropicrin, and metam sodium (Vapam, Sectagon 42) before bed preparation kills the seeds of most weeds

and the reproductive structures of some perennials. Nearly all fumigant applications are either immediately covered with plastic mulch or are injected through the drip irrigation system under plastic mulch. Drip injection of fumigants such as Inline or chloropicrin often improves the weed control compared to shank fumigation of these same fumigants. However, it is important to thoroughly wet the planting bed during drip fumigant injection to ensure weed control on the edges of the bed. Where drip fumigation is used, only the bed is treated, and the row middles are not fumigated. Soil-applied herbicides such as flumioxazin, napropamide or pendimethalin can be used to control weeds in the row middles. Soil fumigants control weeds by killing both germinating seedlings and dormant/quiescent seeds. Methyl bromide, Inline, Telone C35, and metam sodium kill weed seedlings and seeds by respiration inhibition. However, to kill weed seeds, fumigants must be able to penetrate the seed coat and kill the seed embryo. It is more effective to kill moistened seed, because the seed tissues swell with water and allow the fumigant to penetrate more thoroughly. Moist seeds also have higher respiration rates and are more susceptible to fumigants than dry seed with low respiration rates. The need for adequate soil moisture to wet weed seed means that proper irrigation before fumigation is one of the keys to effective weeds control with all fumigants.

Heat. Heat treatment can be used for soil sterilization or pasteurization. Studies have shown that most plant pathogens, insects and weeds will die when moist soils are heated to temperatures of 150°F for 30 min. (Baker and Roistacher, 1957). Most annual weeds can be controlled by solarization (Hartz et al., 1993). Annual sowthistle, barnyardgrass, London rocket, black nightshade, common purslane and tumble pigweed were all susceptible to temperatures above 122°F (Dahlquist et al., 2007). Perennial and bulbous weeds are, however, hard to control via solarization (Linke, 1994). Those in the legume family with hard seed coat are also not controlled well with solarization (Linke, 1994). Weeds such as nutsedge can also sprout under solarization treatments and the resulting shoots are generally trapped under the clear tarp (Chase et al., 1998).

Seedbanks. Weed seeds in the soil are called the weed seedbank. Most weeds in the soil are dormant and only a fraction of the seeds are available to germinate under good conditions. Preemergence herbicides kill germinating seedlings, and therefore act on only a small fraction of the weed seedbank. Similarly, postemergence herbicides, cultivators and hoes only kill emerged weeds. Therefore, most of our weed control tools do not affect the dormant weed seedbank. Soil fumigants such as methyl bromide, and metam sodium are an exception and can kill dormant and nondormant weed seeds. Methyl bromide and other fumigants are respiration inhibitors. Dormant, nondormant, and germinating weed seeds are living organisms that respire, and therefore most can be killed with fumigants such as methyl bromide. However, not all weed species are susceptible to fumigants. Among those species that are tolerant to fumigants are: California burclover, sweet clover, little mallow and filaree. Those weed species are tolerant due to the presence of hard seed coats that prevent penetration of the fumigant through the seed coat (Figure 1). The hard seed coat also means that water cannot penetrate and the embryo is dry.

Wetting of seeds with water is necessary to make them swell and respire. Weed seeds that are dry are highly resistant to fumigants. Plant cells in the embryos of dry seed are tightly compacted and the fumigants can only move slowly through dry seed. In contrast, the wet weed seed has cells that are fully expanded and full of free water that allows the fumigant molecule to move more freely. Many people state that before fumigation you need to irrigate the field to “germinate weed seeds”. While it is true that fumigants do a good job of killing weed seedlings, fumigants can also kill ungerminated weed seeds with soft seed coats such as common chickweed. For hard coated seed such as clover, the only seed that will be killed are those that germinate. In summary, if you can get a lethal dose of

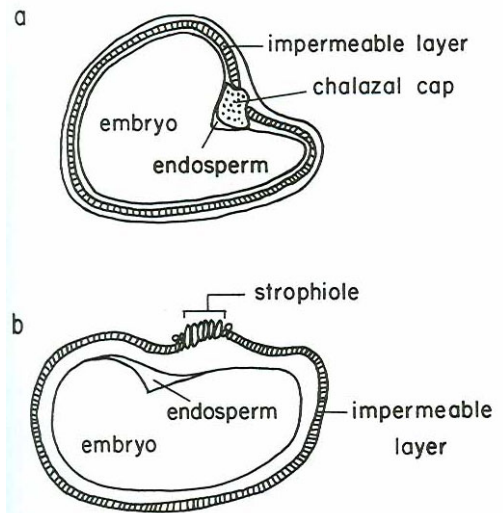


Figure 1. Hard-coated seeds that are difficult to kill with fumigants: a) little mallow, b) clover.

fumigant through the seed coat and into the embryo of a wet seed, then you can kill soft-coat weed seed whether it is germinating or not, but most hard coated seeds can only be killed if they germinate.

WHERE WEEDS MUST BE CONTROLLED

Weeds must be controlled on the top and shoulders of raised beds and in the furrow bottoms. Weed control on the bed top and shoulders are controlled by 1. fumigants, 2. herbicides, 3. mulches, 4. hand weeding.

Table 1. The optimum and maximum depths of emergence for several weeds (Radosevich and Holt 1984).

Weed	Optimum emergence depth (inches)	Maximum emergence depth (inches)
Annual bluegrass	0.4	0.8
Calif. burclover	0.5	--
Common chickweed	0.4	0.8
Common lambsquarters	0.2	1.9
Little mallow (cheeseweed)	0.5	--
Shepherd's-purse	0.2	0.8

Most weed seeds are small and emerge from shallow layers in the soil (Table 1). Because of this, the most critical zone for controlling weeds is the surface soil layer. To kill weed seeds in the surface layer, the fumigant concentration or temperature in the case of heat must reach the critical dose required to kill the weed seed.

Lethal fumigant doses. The objective of using a fumigant is to temporarily create conditions that are lethal for pests, and by doing so to disinfest the soil of pathogens and weed seed. Lethal conditions are created by maintaining the fumigant concentration above a critical level for a sufficient amount of time to kill the weed seed. The lethal conditions are usually described as the lethal dose required to kill 50 or 90 percent of a pest population (LD₅₀'s or LD₉₀'s). For example, Inline maintained at or above 130 lbs/A for 72 hours will kill 90 out of 100 chickweed seeds (Table 2).

Table 2. Inline dose (lbs/A) required to control 90% (LD₉₀) of weed seeds.

Weed species	LD ₉₀ lab (24 hour)	LD ₉₀ field (72 hour)
	----- Lbs/A -----	
Knotweed	340	180
Common chickweed	162	130
Common purslane	121	80
Little mallow (cheeseweed)	>4005	>400
Filaree	>4005	>400

Because weed seeds can emerge from shallow layers anywhere on the bedtop and bed shoulders, good lateral distribution of the fumigants within the bed is necessary. Fumigants applied by drip irrigation must be applied in sufficient water to move them to the edge of the bed at a high enough concentration to kill weed seeds. The edge of the bed is a particularly difficult area for the fumigant to penetrate at concentrations necessary to kill weed seeds there because of the longer distance from the drip tape that the fumigant must travel (see arrow in Figure 2). Proper soil moisture conditions are required to get the lateral distribution necessary for effective weed control at the edge of the bed.

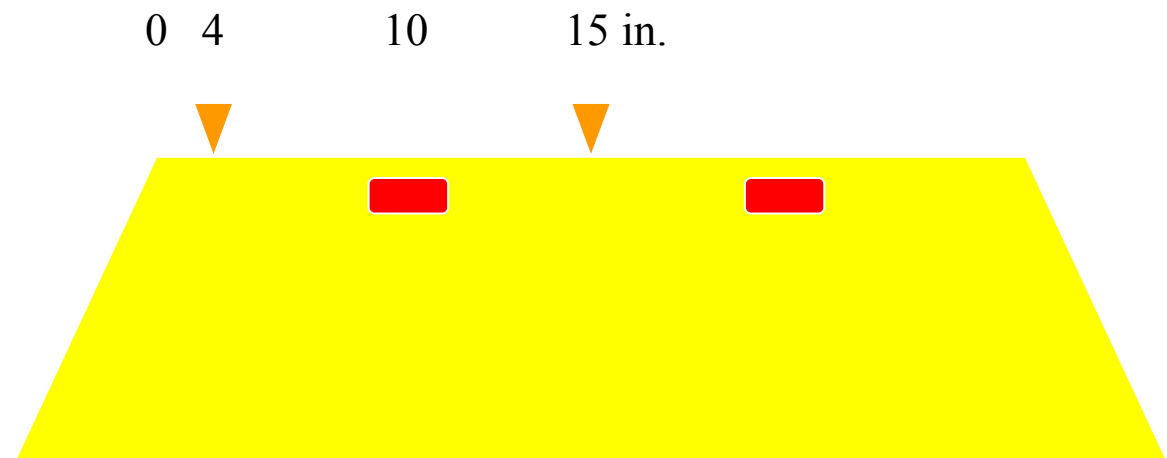


Figure 2. A strawberry bed fumigated by drip irrigation. The arrows show the locations in the center and edge of the bed (distance in inches from the edge) where it is more difficult to get the fumigant at concentrations needed to kill weed seeds.

Sequential applications of metam sodium. With the phase out of methyl bromide, the most effective soil fumigation treatments are a sequential application of chloropicrin or Inline followed 5 to 7 days later by metam sodium or metam potassium. This use of sequential application of complementary fumigants can provide effective control of weeds as well as soilborne pathogens, soil insects and nematodes.

Chloropicrin is effective on soilborne diseases, but less effective on weeds. Inline (1,3-dichloropropene plus chloropicrin) tends to provide better weed control than pure chloropicrin, but generally Inline provides less effective weed control than methyl bromide. One way to improve weed control with chloropicrin and Inline is to use a sequential application of metam sodium or metam potassium.

Metam sodium (Sectagon 42, Vapam HL and others) or metam potassium (Kpam) are used as sequential fumigants following drip applications of chloropicrin or Inline. In this procedure, chloropicrin or Inline can be applied through the drip irrigation system followed 5 to 7 days later by metam sodium/potassium applied through the drip irrigation system. It is necessary to have a 5 to 7 day interval between the chloropicrin or Inline application and the metam application due to chemical incompatibility between the products. Critical aspects to be aware of when using a sequential application of metam sodium/potassium are that: 1) soil must be in seed bed condition with clods no larger than 0.5 inches in diameter, 2) beds must be shaped and ready for planting, and 3) soil moisture must be 50 to 80% of field capacity at time of application. These factors are important to ensure good fumigant distribution throughout the soil profile and to ensure that viable weed seed are moist and easier to kill. It is important to avoid soil disturbance after treatment to avoid movement of viable weed seeds from deeper layers to the soil surface.

USE OF IMPERMEABLE FILMS WITH FUMIGANTS

Impermeable films are designed to reduce fumigant emissions to near zero (Figure 3). Researchers have found that, if impermeable films can be installed intact with minimal stretching or tearing, then fumigant emission is reduced. Reduction of fumigant emissions by impermeable film causes an increase in the fumigant concentration under the tarp. Because fumigant concentrations are higher under impermeable film, more weed seeds are killed and weed control is improved.



Figure 3. Impermeable film consists of at least three layers. In the three layer film shown above, the top and bottom layers consist of normal polyethylene tarp, and the middle layer consists of an impermeable layer.

SUMMARY

The keys to effective weed control with fumigants and heat in strawberry and vegetables are:

1. Careful field selection to avoid difficult to control perennial weeds and severe annual weed populations.
2. Ensure proper soil moisture at time of fumigation so that weed seeds either germinate, or that dormant seed can absorb fumigants.
3. Ensure good lateral distribution of fumigant in the planting bed to control weeds throughout the bed.
4. Sequential applications of metam sodium or metam potassium following chloropicrin or Inline can improve weed control.
5. Increased retention of fumigants with impermeable film can improve weed control.
6. The activity of heat for soil disinfestation with steam or solarization is similar to the activity of fumigants that kill weed seed. Fumigants kill weed seed by reaching lethal concentrations, and heat kills weed seed by reaching lethal temperatures.

References

- Baker, K.F. and C.N. Roistacher. 1957. In: Baker, K.F. The U.C. system for producing healthy container-grown plants. Calif. Agric. Exper. Sta. Ext. Serv. Manual 23.
- Chase, C.A., T.R. Sinclair, D.G. Shilling, J.P. Gilreath, and S.J. Locascio. 1998. Light effects on rhizome morphogenesis in nutsedges (*Cyperus* spp.): implications for control by soil solarization. *Weed Sci.* 46:575-580.
- Dahlquist, R.M., T.S. Prather, and J.J. Stapleton. 2007. Time and temperature requirements for weed seed thermal death. *Weed Sci.* 55:619-625.
- Hartz, T.K., J.E. DeVay, and C.L. Elmore. 1993. Solarization is an effective soil disinfestation technique for strawberry production. *HortScience* 28:104-106.
- Linke, K.H. 1994. Effects of soil solarization on arable weeds under Mediterranean conditions: control, lack of response or stimulation. *Crop Protection* 13:115-120.

A PCA's Perspective on Weed Control in Vegetables

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Introduction:

Started as a PCA for Coastal Ag-Chemical in 1976.

Listened intently to the older PCAs for their wise experiences.

Went independent in 1980.

Celery has been my main crop over the years, but I have also walked a wide array of other vegetable crops and some strawberries.

What has changed over the years:

Celery

36 years ago we were using Caparol and Lorox. Our main herbicides now are Caparol and Lorox. We use them overall or over the drip hose at a reduced rate. We have used them pre-transplant during the seeder period, but control was weak and weeding was expensive. When was the last time you heard a chemical rep say "We have this new selective herbicide for celery that is unbelievable"?

For grasses we were using Treflan. Efficacy was poor. Progressed to Treflan pre-plant, Poast plus Lorox post-emergent. Results were much better for most grasses. Changed to Prism, Shadow or Select Max (Clethodim). Results were excellent. We have been using the Shadow w/ Lorox for nut sedge suppression. Have been seeing synergy activity. It is the only selective herbicide registered for celery since becoming a PCA.

I have been using surfactants with Lorox for years. Just recently started using a MSO surfactant (Dynamic). I haven't seen any extra phytotoxic effects at all. I have been able to pick up more of the groundsel, larger and the entire burning nettle and knot weed which use to come through the Lorox before.

I had a look at Dual Magnum on nutsedge. At the high rate we got pretty good suppression, but in one trial we had some definite stunting while the other trial looked fine. Nutsedge isn't as bad in Ventura without onions being grown.

The only thing changed in celery for me is the use of Select Max and the use of surfactants over the years.

Cole Crops

How many people remember Tok herbicide? Active ingredient is nitrofen. Tok was banned in the late 70's or early 80's as a mutagen I think. It was the herbicide of choice then: a selective herbicide with no phytotoxic effects at all for both transplants and direct seeded Cole crops. After all these years we still haven't replace it as a truly selective herbicide.

We have some selective herbicides we are using now. Goaltender and Prefar are the two we are using in Ventura County. We use Goaltender on Cabbage and Broccoli and Prefar on the bunched coles like Mustard Greens, Kale and Collards. We also used some Dacthal pre-emergent and AN-20 post-emergent in the past.

Goaltender works really well on transplant crops. You can't use Goaltender on seeded Cole Crops because of the phytotoxins on the cotyledon leaves. It's a good thing that most of the Cole Crops in the county are transplanted because of the lack of a good pre-emergent herbicide. We also can't get it to work during the warmer months of the summer in Ventura County. For some reason we lose almost all activity when the temperature reaches around 90. We have tried timing, surfactants, encapsulating, higher rates etc. We are still looking for an answer to this temperature problem.

Prefar is one of those herbicides that are a better than nothing product. We don't have the correct weed spectrum that it works well on. That's why I call it a better than nothing product. You are still going to weed the field if you use Prefar.

Leaf Lettuce

Started using Kerb in 1976. Kerb is still the best herbicide on leaf lettuce now, if you can get it. We really need re-registration on this product. Any other product is a better than nothing product. Prefar is the only other choice. Another reason that we need the registration of Caparol on Cilantro is the only product registered is the ineffective Prefar.

With the lack of effective herbicides we my growers are more aware of keeping their fields cleaner through weeding. One dirty crop and you are paying for that problem for the next 5 years. We are also looking at the neighboring areas for volunteer weeds that may blow in such as groundsel, thistle and ragweed. We've had problems with manure spread on our ground, which was stored next to weedy surroundings. You have to make sure anything spread on your field is clean.

What can we do in the future? Try different things and keep an open mind. Think outside the box. You never know what is going to work.

Industry Update on New Developments in Weed Control in Vegetables

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Two new developments in weed control have been introduced to lettuce producers in California and Arizona. The first is Kerb[®] SC, a new formulation from Dow AgroSciences. This formulation is easier to use than Kerb[®] 50-W. Field research conducted in California and Arizona demonstrated that the new formulation provides weed control and crop safety that is similar to the original formulation.

The second new development is a Kerb[®] SC split chemigation application label, which allows part of the maximum allowable application rate to be initially applied to head lettuce, endive, escarole or radicchio greens, and the balance of the maximum allowable application rate can be applied up to 10 days later. Field research conducted in Bard, CA demonstrated that a split chemigation application of Kerb[®] SC gave better control of nettleleaf goosefoot than a single chemigation application of Kerb[®] SC at 0.5 or 0.63 lb a.i./acre. However, no advantage was seen to the split chemigation application in common purslane and sowthistle control.

[®]Trademark of Dow AgroSciences LLC. KERB SC is not registered for sale or use in all states. Contact your state pesticide regulatory agency to determine if a product is registered for sale or use in your state. Kerb is a federally Restricted Use Pesticide. Always read and follow label directions.

Personal Protective Equipment For Pesticide Applicators

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Pesticide label requirements, company policy, or your own judgment may result in use of Personal Protective Equipment (PPE) during pesticide handling to minimize exposure. The overall goal is to reduce risk by minimizing the pesticide exposure factor from the handling of pesticides based on the general expression, $Risk = Hazard \times Exposure$. Handling includes mixing, loading, and applying pesticides and other work tasks in which concentrates or formulations are used. Basic worker protection standard (WPS) clothing includes long sleeved shirt, long pants, socks and shoes. These clothes are important protection against pesticide particles or liquids that may contact the skin, the most important route of exposure during normal work activities. Skin contact, inhalation, and incidental oral contact with pesticides are exposures with the potential for absorption. Risk is the likelihood of harm resulting from contact with a hazardous substance (pesticide) and the amount of exposure. Guidelines for the use of WPS clothing and PPE are intended to reduce the likelihood of exposure and as a result, reduce risk.

Laws and Regulations Jeopardy

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While many pesticides being used and developed today are safer than ever to use, pesticides must nevertheless be applied according to the laws and regulations of the California Food and Agricultural Code and California Code of Regulations. Compliance with the regulations protects not only the applicator, customer, and the environment, but also protects the pest control company, farmer, and any pesticide user from potential lawsuits by the public, by disgruntled employees, and from enforcement actions by the local agricultural commissioner, because non-compliance immediately places the employer and employee in an untenable position.

Employers must properly train their employees and provide them with appropriate safety gear. Employers should make it easy for their employees to comply by providing properly maintained and comfortable safety gear, treating their employees fairly, and stressing the importance of professionalism in their work ethic by being professional in their own attention to compliance with the regulations.

The regulations promote professionalism and responsible application by licensed and certified application companies. Documentation of compliance through licensing, training records, written safety programs, and pesticide use reports is mandated by the regulations.

The county agricultural commissioners and the California Department of Pesticide Regulation would prefer to catch you applying pesticides properly rather than forcing you to correct your procedures with disciplinary enforcement.

The laws, as promulgated by the state legislature, governing pesticide applications in California are contained in the California Food and Agriculture Code; primarily in Division 6. Pest Control Operations with some laws contained in Division 2. Local Administration; Division 7. Agricultural Chemicals, Livestock Remedies, and Commercial Feeds; and Division 13. Bee Management and Honey Production. The California Department of Pesticide Regulation, and the agricultural commissioners further govern pesticide application by also enforcing Title 3. Food and Agriculture, Division 6. Pesticides and Pest Control Operations of the California Code of Regulations; and Division 3. Professions and Vocations Generally, of the California Business and Profession Code as enacted by the Structural Pest Control Act.

Pesticide Laws and Regulations Jeopardy emulates the Jeopardy television game show, and was developed as an engaging way to present the sometimes mundane details of the laws and regulations. Rather than attempt a summary of the proceedings, here, it is perhaps more useful to direct the audience to these three internet websites for more information:

- California Food and Agriculture Code:
www.leginfo.ca.gov/cgi-bin/calawquery?codesection=fac&codebody=&hits=20
- California Code of Regulations:
www.calregs.com/linkedslice/default.asp?SP=CCR-1000&Action=Welcome
- California Department of Pesticide Regulation – Laws and Legislation:
www.cdpr.ca.gov/docs/legbills/opramenu.htm

Pesticide Labeling Interpretation

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The role of regulating pesticides in California is a joint responsibility of the Director of the Department of Pesticide Regulation (DPR) and county agricultural commissioners (CACs). Food and Agricultural Code (FAC) section 2281 provides that DPR is responsible for overall statewide enforcement and for issuing instructions and making recommendations to the CACs.

The CACs are responsible for local administration of the pesticide use enforcement program. Several other FAC sections (11501.5, 12977, 12982, 14004.5, and 15201) state that CACs conduct pesticide work under the direction and supervision of the Director. The *Pesticide Use Enforcement Program Standards Compendium* (Referred to as the Compendium) is the vehicle used by DPR to deliver DPR's guidance to the CAC's in the form of instructions and recommendations.

The Compendium is a series of eight manuals that contain pesticide use enforcement directives, interpretations, recommendations, and expectations. The Compendium represents the Pesticide Use Enforcement Program's "standard operating procedures." Contents of the Compendium supersede any position or direction on these subjects contained in previous letters to CACs or earlier manuals.

Guidelines for interpreting pesticide product labeling is found in Volume 8 of DPR's compendium. The link is (<http://www.cdpr.ca.gov/docs/enforce/compend.htm>). Volume 8 – Guidelines for Interpreting Laws, Regulations and Labeling includes DPR interpretations of various sections of law and regulations, and guidance on interpreting pesticide labeling, including interpretations of some general and specific labeling statements. It is cross-indexed by subject and section of the law or regulation addressed. Volume 8 is divided into 8 chapters. The guidelines for interpreting pesticide product labeling are found in Chapters 1 through 4 that address General Interpretation Guidelines, Pesticide Product Labeling Interpretations, Specific Labeling Statement Interpretations and DPR Specific Use Site Interpretations respectively. Chapters five through eight address guidance relating to Supplemental labeling, Worker Safety, Pesticide Product Registration, and Research Authorizations respectively.

This presentation will cover the first four chapters in Volume 8. From each chapter, I have selected specific guidelines established by U.S. EPA and DPR that are essential in interpreting pesticide product label and labeling as follows:

- Starting with “General interpretation guidelines” it is very important for you to understand definitions and examples given for: Agricultural use and Non-agricultural use; and production and non-production uses.
- As it relates to interpreting “Pesticide product labeling”, there are established guidance For understanding the definitions of: Label and labeling, Mandatory vs. Advisory, Conflict with labeling exemptions (2ee), and Site listing – Inclusive vs. Exclusive.
- Specific labeling Statement interpretations include: “Avoid breathing spray mists or dusts”, Bee protection statements, Feed restrictions statements, Harvest date, physically present (Certified Applicator), Plant back restrictions and Professional applicator statements.
- DPR Specific Use Site Interpretations include: Cropland/field crops, Non-crop land areas, Fallow land, and Bee protection statements.

Available tools and resources that is available for interpreting pesticide labeling:

- Food and Agricultural Code
- California Code of Regulations.
- Pesticide Use Enforcement Program Standards Compendium
- Internet Resources via Registration Branch Home Page
<http://www.cdpr.ca.gov/docs/label/abelque.htm>
 - Pesticide Registration Branch (Query DPR Databases)
 - Product/label
 - Section 24 labeling
 - Section 18 Exemptions
 - National Pesticide Information Retrieval System (NPIRS)
Maintained by Purdue University
 - U. S. EPA’s Pesticide Information Retrieval System (PR Notices)
 - U. S. EPA’s State Label Issue Tracking System (SLITS)
- U.S. EPA label Review Manual 3rd Edition
<http://www.epa.gov/oppfead1/labeling/lrm/>
- Title 40 Code of Federal Regulations
http://www.access.gpo.gov/nara/cfr/waisidx_02/40cfrv20_02.html.
- American Society of Agricultural and Biological Engineers (ASABE) Standards.

California Pesticide Issues Update
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California 2011 Legislation

2011 was a busy year legislatively despite the fact that the state continued to be broke.

- AB 88 – Assemblyman Huffman: Bill would require all GMO salmon to be labeled. Would set precedent that would be applied to all forms of GMO commodities.
- AB 553 – Would require that permissible exposure limits (PEL's) set by OSHA must correspond with health based exposure limits set by OEHHA. Since OEHHA exposure limits would undoubtedly be much lower, worker exposure limits would be dramatically lowered impacting ability of workers to utilize pesticides particularly fumigants.
- AB 1176 – Assemblymember Williams. Would require pesticides designated by DPR as toxic air contaminants (TAC's) to be reviewed by other agencies including ARB, OEHHA, local air districts in determining appropriate control measures. This would dramatically extend the registration process for pesticides, beginning with fumigants with mitigation controls set well below current standards and ongoing litigation.

California 2011 Legislation

- SB 394 – Senator DeSaulier. Originally would have banned most pesticides/herbicides from use in or around schools. Would have required every school to have an “IPM specialist” on site to authorize the use of any product. Registrants of the products banned from use at schools would have funded the IPM specialist position through a fee. Bill was amended due to cost removing language prohibiting most products and only requiring each district or school to have a designated staff person undergo mandatory IPM training. Bill was re-amended this year back to banning most products not contained in bait stations or gels.

- SB 900 - Senator Steinberg . Originally designed to address the problematic conflict of interest requirements that impact regional water boards. Currently requirements disallow agricultural or local government participation. Legislation would have set water board standards to be reflective of the legislature. Bill was held in committee until gutted, by environmental groups. Governor is indicating he wants to use this bill as a vehicle for his re-alignment of regional water boards.
- California 2012 Legislation
- All of the legislation described earlier for 2011 was held in committees. However, due to the two year California legislative session, all of these bills were eligible to be continued in 2012.
- Good news, all of these bills (except the Governor’s water board re-alignment which was out of its house of origin) were held in committee last week and so died. Bad news, they will all likely be re-introduced in 2012. However, due to California’s ongoing economic issues it will be difficult to move these bills beyond Appropriations.
- The continuing activism surrounding the registration of a new fumigant will result in the introduction of more legislation aimed at making it more difficult to register a product in California or set control measure impractical for industry.
- Environmental Justice
- Environmental Justice is defined as the “fair treatment for people of all races, cultures, and incomes, regarding the development of environmental laws, regulations, and policies.”
- Cal-EPA adopted this concept through regulations, and all boards, departments, and agencies must comply.

Environmental Justice & Air Quality

- Mendota Air Monitoring Project
 - DPR will be partnering with UC Davis to monitor approximately 30 pesticides in and around homes of 100 farm worker families in Mendota.

- Goal is to compare exposure of pesticides used in the home vs. agricultural pesticides
- Air Monitoring Network
 - DPR is looking to do air monitoring studies of 3 communities for the next 5 years.
 - Will be looking to compare exposures to pesticides used in the home and agricultural pesticides.
 - Will be monitoring approximately 21 – 25 pesticides.
- Environmental Justice & Air Quality
- List of Communities for Monitoring
 - Linden/Ripon: San Joaquin Co.
 - Shafter/Wasco: Kern
 - Greenfield/Salinas/Castroville: Monterey

Air Quality Issues

- List of Pesticides for Monitoring

<ul style="list-style-type: none"> - Chlorothalonil (Bravo) - Chlorpyrifos (Lorsban) - Cypermethrin - Diazinon - Dicofol (Kelthane) - Dimethoate (Cygon) - Diuron (Karmex) - Endosulfan (Thiodan) - EPTC (Eptam) - Malathion - Baked as dichiovos (DDVP) - 1,3-Dichloropropene (Telone, Incline) - Sodium tetrathiocarbonate (Enzone) 	<ul style="list-style-type: none"> - Norfluazon (Solicam) - Oryzalin (Surflan) - Oxyfluorfen (Goal) - Permethrin - Phosmet (Imidan) - Propargite (Omite) - S,S,S-tributyl - phosphorotrithioate (DEF) - Simazine (Princep) - S-metolachlor (Dual) - Trifluralin (Treflan) - Acrolein (Magnacide) - Methyl Bromide
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- Also under consideration but with less sampling is: Chloropicrin, Metam-sodium, Metam-potassium & dazomet (Vapam) as methyl isothiocyanate (MITC)

Air Quality Issues

Non-Fumigant Pesticide VOC's

- DPR focused on 4 AIs:
 - Abamectin
 - Chlorpyrifos
 - Gibberellins
 - Oxyfluorfen
- These 4 AI's are the largest use chemicals, so rather than trying to regulate dozens of chemicals in use for small reductions, focus on a few and try to obtain larger reductions.
- If enforcement is necessary DPR is looking at options including having these AI's become restricted use (Ag commissioner approval), retailers authorize sale of higher emitting products, or having PCA's authorize sale of higher emitting products.

DPR planning on releasing proposal this spring with a final rule by spring 2013.

Surface Water Regulations

DPR is submitting surface water quality regulations impacting the urban use of approximately 70 products. When they are finalized the regulations will impact:

- Non-Ag Agriculture
- Industrial Weed Control
- Professional Applications
- Home use via labels
- Focus of regulations are aimed at:
 - Sensitive aquatic sites
 - Runoff likely to enter storm water systems

DPR developing its water quality criteria and methodology that will be extremely important as they move toward developing regulations for agricultural products.

Water Quality Issues

Pyrethroid Re-Evaluation

DPR has undertaken the largest re-evaluation in the history of the department. Currently 1,300 products are under review, excluding natural pyrethrins.

Much of the concern is driven by Water Agencies afraid of being sued by environmental groups over pyrethroid levels.

It is now considered much more likely that urban users are responsible via pet products, outdoor wear laundering, etc., for the levels.

Water agencies will now have to monitor before and after treatment.

WPHA has been working with the Pyrethroid Working Group (PWG), made up of registrants, and who are providing DPR with most of the scientific data on actual contributions and mitigation processes.

The PWG conducted a study in 2009 which establishes that pyrethroids are the largest classes being purchased by consumers.

Pyrethroid Re-Evaluation

- DPR is now shifting the focus to a smaller group of pyrethroids dependant on use rather than chemistry.
- Focus is now on:
 - Pyrethroids used outdoors in residential, industrial, and institutional settings.
 - Possibly may address diazinon & chlorpyrifos in agriculture.

The focused approach should provide a more detailed analysis of the problem.

Should incrementally address surface water contamination.

California Budget Deficit Impacts

- Major Impacts to CDFA
 - General fund reduction of \$18 million in 2011 and another \$12 million this year.
 - Ag Commissioners could have impacts through re-distribution of uncollected gas tax.
 - Counties will have to backfill programs like Med fly Preventive Release Program through other funds.
 - Industry will have to fund programs like Pierce's Disease Program.
 - Elimination of eradication efforts within the Red Imported Fire Ant Program.
 - Programs will have to become self-supporting through registration or packaging fees.