CWSS Research Update and News

Information on Weeds and Weed Control from the California Weed Science Society

Volume 15, Number 2 **October 2021**

In This Issue

Introduction

Whitney Brim-DeForest, Editor

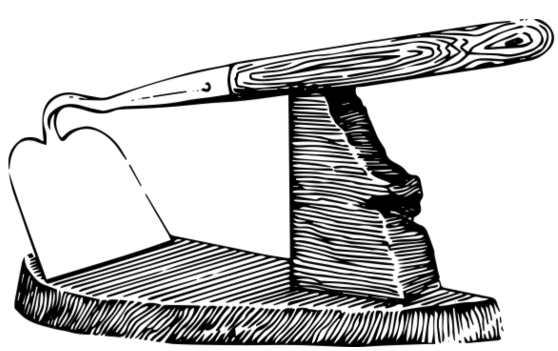
2021 has shaped up to be a great year so far for CWSS: we have new board members, our student scholarship program had many applicants (more than in recent years), and we are looking forward to an in-person (hopefully!) conference in Sacramento in January, which we are in the process of planning.

This issue contains some exciting announcements: a new partnership in managing invasive weeds in forests, and a new non-chemical weed control manual and online decision support tool for natural areas. Research updates include some more unusual crops than what we normally feature: herbicide phytotoxicity evaluations on hemp, avocado and wild rice, and Italian ryegrass control in small grains.

A quick reminder to please submit interesting new information, announcements, and research and extension updates to the newsletter.

We look forward to seeing everyone at the conference in January!

-Whitney



Herbicide Damage Symptoms on Hemp

Sarah Light, UCCE Sutter-Yuba; Brad Hanson, University of California, Davis

The introduction of a new crop into a landscape brings certain unknowns, including the risk of pesticide drift from neighboring crops. Hemp (Cannabis sativa spp.) is a new, high-value commodity that is now being produced in many parts of California. In order to begin an assessment of potential phytotoxicity issues that could occur when hemp is grown in diversified field crop situations, plants were sprayed with herbicides that are widely used in a range of crops during the summer hemp growing season for California's Central Valley (May through September). Materials were selected that are likely to be sprayed on commodities planted adjacent to a hemp field. A new University of California publication provides a brief description of herbicide injury symptoms that could be expected from exposure to 19 specific herbicides or similar modes of action. The publication does not address the relative sensitivity to the full range of potential levels of exposure. A selection of the herbicides evaluated are described in this article and the full publication can be found here: https://anrcatalog.ucanr.edu/Details.aspx?itemNo=8689

Methods: Drift simulation treatments were applied to hemp plants three weeks after transplanting. Herbicides rates for this symptomology demonstration were based on 25% of common label rates in Central Valley agricultural systems (Table 1). Treatments were applied to the foliage of 12-18 inch tall hemp using a two-nozzle boom set up with one nozzle applying 20 gallons per acre and the other 40 gallons per area or twice the volume of spray solution. Thus, one row of plants was sprayed with approximately 25% of labeled rate and the other with 50% of labeled rate but also at greater coverage.

Table 1. Herbicides applied to hemp in a simulated drift symptomology demonstration in 2019.

Active Ingredient*	**Example Trade Name**	**Common registered uses in California**
glyphosate	Roundup (many products)	Many agricultural, industrial, and homeowner uses
paraquat	Gramoxone, Parazone	Preplant burndown in annual crops, orchard and vineyards
glufosinate	Rely, Lifeline, Finale	Preplant burndown in annual crops, orchard and vineyards, in-crop use in Liberty-Link cultivars
saflufenacil	Treevix, Sharpen	Orchards, alfalfa, corn, grasses
carfentrazone	Shark, QuickSilver	orchards and vineyards, cereal crops, some turf products.
oxyfluorfen	Goal, GoalTender, Galigan	Widely used in orchards, vegetable crops, fallow, roadsides, industrial sites.
propanil	Stam, SuperWham	Rice cropping systems
bipyribac-sodium	Regiment, Velocity	Rice cropping systems, some turf products
imazapyr	Polaris, Habitat	Industrial and roadsides, aquatic weeds, riparian and range restoration
rimsulfuron	Matrix, Grapple, Solida	Corn, orchards and vineyards, tomato, noncrop and industrial sites
triclopyr	Garlon, Grandstand, Turflon	Rice, brush and tree control, rights of way, aquatic weeds, turf products
2,4-D	2,4-D (many products)	broadleaf weed control in many grass and cereal crops
clopyralid	Transline, Confront	Rangeland, roadside, cereals and some tolerant crops
mesotrione	Broadworks, Callisto	orchards, corn, some legume crops
clomazone	Serano, Command	Rice systems, some vegetable and berry crops
ammonium nananoate	Axxe	many preplant or directed-spray applications. Organic certified.
methylated seed oil	MSO (many products)	Spray adjuvant used with many pesticides
sethoxydim	Fusilade	Grass weed control in many broadleaf crops and ornamentals, some homeowner products
cyhalofop	Clincher	Grass weed control in rice cropping systems.

**Herbicide rates for this symptomology demonstration were based on 25% of common agricultural use rates and were: glyphosate at 0.1 and 0.2 lb ae/A, paraquat at 0.15 lb ia/A, glufosinate at 0.25 lb ai/A, saflufenacil at 0.009 lb ai/A, carfentrazone at 0.008 lb ai/A, oxyfluorfen at 0.25 lb ai/A, propanil at 1 lb ai/A, bispyribac-sodium at 0.08 lb ai/A, imazapyr at 0.15 lb ai/A, rimsulfuron at 0.015 lb ai/A, 2,4-D at 0.16 lb ae/A, triclopyr at 0.15 lb ai/A, clopyralid at 0.02 lb ai/A, mesotrione at 0.0 43 lb ai/A, clomazone at 0.25 lb ai/A, Axxe herbicide at 10% v/v, and MSO at 10% v/v, sethoxydim at 0.07 lb ai/A, and cyhalofop at 0.07 lb ai/A. Herbicides included appropriate surfactants at full rates if recommended on the product label.*

(continued on Page 3)

(continued from Page 2)

These rates and spray coverage are significantly higher than what would commonly occur in herbicide drift situations, however, the purpose of this demonstration was to compare typical symptoms from several common herbicide modes of action on this crop. The specific herbicide symptoms, progression over time, ultimate severity, and potential for recovery all can vary with route of exposure, spray coverage, droplet concentration, plant health, and environmental conditions. Thus, in a more typical drift situation symptoms may be less severe than those documented in this publication, while direct applications of full rates may cause even more severe symptoms (including plant death).

Plants were photographed over a two-week period (1, 2, 7, 12, and 14 days after application) and photos were selected for inclusion based on illustrating typical herbicide damage. Photos are not intended to show symptom development over time, but rather distinct symptoms for each herbicide. The date of photograph included is indicated in the captions as Days After Application (DAA). For a full set of injury photos, see ANR publication 8689 (https://anrcatalog.ucanr.edu/Details.aspx?itemNo=8689) or refer to the UC-IPM Herbicide Symptoms image database (http://herbicidesymptoms.ipm.ucanr.edu/index.cfm).

Glyphosate (Figure 1) is a postemergence herbicide that affects an enzyme important in the production of several specific essential amino acids in plants. Injury from drift of this type of herbicide typically is seen in the meristematic regions and youngest tissues first because these regions are rapidly growing and have the greatest need for amino acids. Glyphosate can translocate, or move within the plant, and moves from treated tissue to above and belowground meristems. The most typical symptom, which was observed in hemp, includes chlorosis (yellowing) in younger leaves. Glyphosate injury can eventually lead to necrosis beginning with the younger tissues and advancing to older leaves over the course of 5-10 days and some species can take on a purple coloration as well. In large annual plants or established perennial plants, sublethal doses can sometimes lead to “witch’s broom” due to shorter than normal internodes and “stacked” leaves as the plant begins to regrow. Because the herbicide is tightly bound to soil, crop injury from glyphosate is almost always associated with foliar exposure.

Figure 1. Glyphosate 4 Days After Application.

Figure 2. Paraquat 7 Days After Application.

Paraquat (Figure 2) is a postemergence contact herbicide that disrupts energy flow during photosynthesis. The herbicide can act very rapidly (hours), particularly under high-light conditions. Injury is due to membrane disruption by reactive oxygen and other free radicals; this results in leakage of cellular contents and rapid desiccation of affected tissues. Paraquat does not translocate well in plants, thus symptom severity is often a function of coverage. Symptoms can include chlorosis, and specks from individual droplets to full necrosis from complete coverage. If the dose is insufficient to kill the plant, new growth will not be damaged. Paraquat is extremely tightly bound to soil and not likely to be taken up by plants via soil routes.

(continued on Page 4)

(continued from Page 3)

Figure 3. Carfentrazone 4 Days After Application.

PPO-inhibiting herbicides inhibit an enzyme important in chlorophyll synthesis, among other things. These herbicides can quickly lead to the formation of free radicals within the cell which can damage lipids and proteins and cause disruption of membranes. Cells and tissues quickly desiccate and dry out. Drift symptoms include chlorosis usually followed by necrosis at the point of contact. Some PPO herbicides are primarily used as foliar herbicides while others can have both foliar and soil activity. Transport within the plant is somewhat limited and occurs via the xylem (water-conducting vessels). Because of this, symptom severity from PPO-inhibitor drift is a function of coverage; with low doses causing less dramatic and slower-developing symptoms compared to greater exposure. However, if the dose is sublethal, new tissues that develop after foliar exposure usually are not affected. Carfentrazone (Figure 3) is applied as an example in this photo however similar symptoms can be expected from other PPO-inhibitors.

Figure 4. Propanil 4 Days After Application.

Propanil is a contact herbicide that inhibits photosynthesis by blocking electron transport through photosystem II. Propanil is translocated via the xylem (water-conducting tissues). Thus, injury is usually first observed on the older, fully formed leaves because they are more actively photosynthesizing compared to younger, still-forming leaves. Injury often is initially noted at the leaf margins (chlorosis leading to necrosis) and then moving further into the interveinal areas of the leaf. If the plant survives foliar exposure, newly formed leaves may not be affected. Although propanil in this example is primarily used as a foliar herbicide, some other photosystem II inhibiting herbicides such as simazine, atrazine, or diuron are used as soil-applied materials and symptoms can vary somewhat depending on route and amount of exposure.

Figure 5. Imasapyr 4 Days After Application.

ALS Inhibitors: Several classes of herbicides inhibit the ALS enzyme, which is important in the synthesis of branched-chain amino acids. Most of these herbicides have both foliar and soil activity. Like other amino acid synthesis inhibiting herbicides, symptoms from ALS inhibitors are usually first seen in the meristems and youngest tissues because they are rapidly growing and require large amounts of amino acids. At the whole plant level, symptoms are typically are characterized by general chlorosis leading to necrosis. Depending on the dose, sometimes an aboveground growing point may die and axillary meristems released from dormancy, which can result in an abnormal "branching" structure, as well as leaf stacking, and crinkling and stunting of leaves. Imazapyr (Figure 5) is applied as an example in this photo however similar symptoms can be expected from other ALS Inhibitors.

(continued on Page 5)

(continued from Page 4)

Synthetic Auxins: There are several classes of herbicides that are known as synthetic auxins, plant growth regulator herbicides, or auxin-mimics. These foliar-applied herbicides affect primarily broadleaf plants, although there are some grasses affected by some herbicides. In general, as hormone mimics, synthetic auxin herbicides impact many cellular processes and lead to abnormal cell division and cell growth. At the whole plant level, this abnormal growth can take the form of leaf and stem twisting, cupping, bending, cracking, and other epinastic growth. In some cases, leaf thickening, stem cracking, "strap" leaves, and other abnormal growth are observed. These symptoms can start relatively quickly after exposure and progress over days or weeks and eventually lead to necrotic tissues. Most synthetic auxin herbicide exposure is via foliar routes, however there are several herbicides in this class that can persist in soil and be taken up by that route. Triclopyr (Figure 6) is the example in this photo however similar symptoms can be expected from other synthetic auxins.

Figure 6. Triclopyr 4 Days After Application.

HPPD-inhibiting herbicides and PDS-inhibiting herbicides affect different steps in carotenoid biosynthesis. The carotenoids function to protect chlorophyll from damage from excess light energy. When carotenoid synthesis is inhibited, the most common symptom is "bleaching" which can range from yellow in some plants to almost pure white leaf tissue in others. Usually, symptoms are first observed in the newly formed tissue that was never able to produce carotenoids but eventually can progress to older tissues as older carotenoids turn over and cannot be replaced. Bleaching can lead to tissue necrosis. Damage to established plants from drift of bleaching herbicides can be visually dramatic but rarely lethal. Damage to seedlings or young transplants from soil carryover may be more damaging. Mesotrione (Figure 7) is the example shown in this photo however similar symptoms can be expected from other HPPD and PDS-inhibiting herbicides.

Figure 7. Mesotrione 4 Days After Application.

2021 Student Scholarship Award Recipients

Celeste Elliot, CWSS Office Manager

CWSS awarded $1000 scholarships to ten deserving students this year:

Aaron Becerra-Alvarez (*Photo left*) – University of California, Davis

My name is Aaron Becerra-Alvarez and I am a graduate student in pursuit of a Ph.D. in weed science at the University of California, Davis in the Horticulture and Agronomy Graduate Group. Soon after completing my bachelor's degree in Crop Science and Horticulture from California State University, Chico, I joined UC Davis under the supervision of Dr. Kassim Al-Khatib in the rice weed research program. My research pertains to the rice cropping systems of California, focusing on weed management and herbicide crop injury. My research interests include agronomy, rice systems, integrated pest management, and herbicide physiology. In the future, I hope to work in the industry or extension to further develop our science and assist growers. When not hard at work, I enjoy reading and hanging out with friends and family.

Kristine Fajardo (*Photo right*) – California State University, Fresno

A Master's student at California State University, Fresno in the Biology graduate program, Kristine Fajardo is examining the population genetics of Palmer amaranth (*Amaranthus palmeri*). Her project seeks to utilize bioinformatic techniques in order to investigate the genetic diversity and connectivity of Central California populations against their native and nonnative counterparts, focusing on tracing the origin of Central California populations. She is also exploring the genetic makeup of emerging populations in the San Joaquin Valley to identify potential genes linked to invasion, range expansion, and adaptation to California's environment. In the future, Kristine hopes to pursue a career in research with an emphasis in genetics as a means of hopefully making meaningful contributions to her community in the San Joaquin Valley.

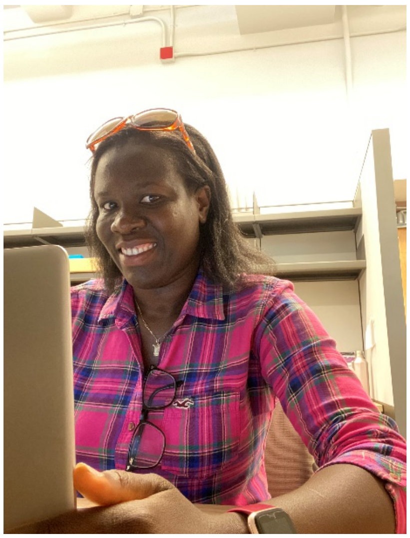
Takui Frnzyan (*Not pictured*) – California State University, Fresno

I come from a family of Fresno State graduates. I am a Viticulture and Ecology graduate student. My area of research is Palmer amaranth with grape competition. Once I have completed my studies in Viticulture and Enology. I plan on working with researchers and farmers within the Central Valley to find solutions to various problems within Viticulture. While developing and implementing educational materials/ resources for the average citizen to understand viticulture and enology process.

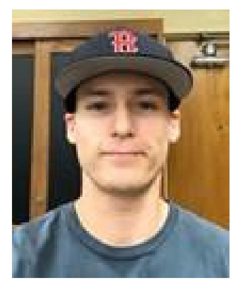
(continued on Page 7)

(continued from Page 6)

Deniz Inci (*Photo right*) – University of California, Davis
Deniz Inci is a Ph.D. student at UC Davis working with Dr. Kassim Al-Khatib. His research focuses on sustainable weed management for ideal rice growth in California water-seeded rice production. He is also interested in the impacts of off-target rice herbicide drift of California nut and vine crops.



Guelta Laguerre (*Photo left*) – University of California, Davis
I recently completed my BS in International Agricultural Development from UC Davis and have been admitted to the MS program in Horticulture and Agronomy and Dr. Brad Hanson is my major professor for my thesis project. I have initiated my thesis research since January 2021. My research is focused on the orchard crop safety and weed control efficacy of an experimental herbicide under consideration for future registration in California specialty crops. Before joining the Hanson Lab, I worked with Dr. Kassim Al-Khatib assisted in a variety of work related to control of weeds and algae.



Alexander Lopez (*Photo right*) – California State University, Fresno
I am a graduate student majoring in Biology at Fresno state. In my thesis work, I am investigating the origins of recently arisen populations of *Amaranthus tuberculatus* (common waterhemp) in Merced county agroecosystems, using both model-based and non-model-based genetic clustering methods.

Bianey Medina (*Photo left*) – California State University, Fresno
I am currently a senior, majoring in Plant Science. Being first generation in my family and coming from immigrant parents inspired me to pursue a career in agriculture.

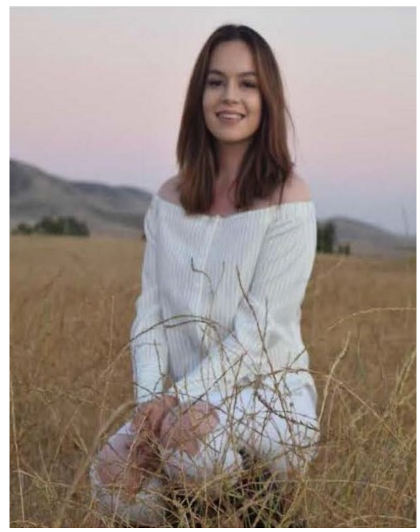
Currently I am in my two last semesters. I have really enjoyed being part of this amazing university. I have been involved with the Plant Science Club through my college experience being able to be part of this wonderful organization. I was able to meet other students that have the same interests and goals as I have.

(continued on Page 8)

(continued from Page 7)

Currently I am working full time at FMC Corporation in Madera CA as a Student Research Technician. After graduation, I plan to get my PCA, CCA and QAL licenses. I plan to work for a couple of years and if God is great, come back to get my Master's Degree once I have enough money saved up to pay for some of my school.

By awarding me with this amazing opportunity, you have reduced the amount of my financial needs. Which will allow me to focus on my academics and not worry about how I am going to pay for school. I hope one day in the near future I will also be able to help struggling students like myself reach their goals in their higher education by assisting them the same way you are helping me. Once again thank you for your generosity. I truly appreciate it.



Jennifer Valdez Herrera (*Photo right*) – California State University, Fresno

My name is Jennifer Valdez Herrrera a current undergraduate student majoring in Plant Science. I assist graduate students and Fresno State professors with various research projects, in hopes of discovering new innovative weed management solutions that will help reduce/avoid detrimental invasive weeds which affect our crops. Currently, I am assisting Fresno State Viticulture & Enology professor, Dr. Anil Shrestha, in several of his ongoing studies on herbicide resistance, biology and ecology of weed species such as common waterhemp and Palmer amaranth (*Amaranthus palmeri*). In one of the studies Dr. Shrestha and I are evaluating a roller-crimper cover cropping, strip-till silage corn production systems with various cover crop species. One of the objectives is to monitor weed population dynamics in these systems. All in all, after graduating from Fresno State I plan on furthering my education by applying to the Masters' program at Fresno State, which will help me expand my knowledge of weed ecology, biology, genetics, and molecular biology. Weed science is a neglected research field, and the scale for herbicide resistance weed will continue to grow if efforts towards emphasizing the importance of weed science aren't acknowledged. I aspire that my research can intrigue and encourage further research in weed science to help develop sustainable weed control practices which will benefit farmers and science.

Matthew Winters (*Photo left*) – University of California, Santa

My name is Matthew Winter (he/him/his) and I am a current undergraduate student at the University of California, Santa Barbara double majoring in Environmental Studies (B.A.) and Geography (B.A.). I am a research assistant with the RIVRLab (Riparian InVasion Research Laboratory) working on the Biological Control of Cape Ivy. Cape Ivy (Delairea odorata) is an invasive vine that forms smothering mats that suppress native vegetation growth. To combat Cape Ivy, the RIVRLab is utilizing the Cape Ivy Fly (P*arafreutreta regalis*), which oviposits into the shoot tips of the ivy and causes galls to form. Further, I am a restoration assistant with the Cheadle Center for Biodiversity and Ecological Restoration (CCBER) working on the restoration of an estuary referred to as North Campus Open Space (NCOS).

(continued on Page 9)

(continued from Page 8)

Wenzhuo Wu (*Photo right*) – University of California, Davis

Wenzhuo Wu is a Ph.D. student working with Dr. Mohsen Mesgaran in the Horticulture and Agronomy graduate group at University of California, Davis. She is conducting research to test the viability of a novel approach for managing weeds by pollinating with irradiated and sterile pollen in unisexual breeding systems.

Avocado Herbicide Trial Evaluating Tree Phytotoxicity

Sonia Rios, Peggy Mauk, Ben Faber, Oleg Daugovish, Gina Ferrari, Deanna Vega
University of California ANR

There are currently only ten herbicide active ingredients with products registered in California for use in bearing avocado groves. Of these, paraquat is a restricted use herbicide and glyphosate is under increasing political scrutiny. A comprehensive evaluation of herbicides for safety and efficacy in bearing avocado orchards has been studied using herbicides currently registered for citrus (the only similar subtropical orchard crop in the state), but not in avocado. This study has provided critical, science-based information to the California Avocado Commission and herbicide registrants to pursue additional product labels and evaluate tank mixtures of effective active ingredients as a next step. We established replicated field trials in two distinct growing regions (Ventura and Riverside County) to account for differences in soil type and climate. Herbicides were applied in spring and fall to capture differences in efficacy in controlling different seasonal weed spectrums and safety for different seasonal phenology in avocado groves. Special attention was paid to immediate and cumulative phytotoxic effects. The study has been repeated in two consecutive years at each site to address inter-year variations in weather and other factors, especially rainfall. Special consideration has been given to products that can be applied with backpack or handheld sprayers, herbicides with suitable restricted-entry and preharvest intervals, herbicide product cost, duration of efficacy, and effectiveness for control of priority management weed species.

We reviewed and selected pre- and post-emergence herbicide products currently labeled for citrus in California. These products have the benefit of being approved for use in another subtropical orchard crop and have known weed control spectra. These included indaziflam (Alion), pendimethalin (Prowl H2O), rimsulfuron (Matrix), S-metolachlor (Pennant Magnum), saflufenacil (TreeVix), isoxaben (Gallery), and glufosinate-ammonium (Forfeit).

(continued on Page 10)

(continued from Page 9)

Herbicide products currently labeled for bearing avocado orchards included: oxyfluorfen (Goal), flumioxazin (Chateau), simazine (Princep), glyphosate (Roundup), clethodim (Intensity) and caprylic acid (Suppress).

The research sites included the UC Hansen Research and Extension Center in Santa Paula and Citrus Research Center-Agricultural Experiment Station at UC Riverside. Herbicides were applied to grove alleys to evaluate efficacy under typical grove conditions, as well as for safety regarding potential uptake by shallow avocado roots. Additionally, tree foliage was sprayed directly to allow for simulation of spray drift and determination of phytotoxicity. The plots at each site were different depending on tree spacing, but approximately 40 to 60 sq ft. Applications were made according to label directions for rate and carrier volume using a calibrated CO2-propelled backpack sprayer with the applicator wearing the appropriate PPE. The spray boom was oriented horizontally for ground application and vertically for foliage application. Because of low rainfall at the time of each application, a temporary sprinkler system was used to incorporate pre-emergence herbicides by simulating a rainfall event of approximately ¼ to ½ inches precipitation. Spring applications were made in April and fall applications were made in either October or November of 2019 and 2020.

Evaluations for efficacy and safety were conducted at 1, 2, 4, and 8 wk after treatment for post-emergence herbicides. Efficacy was evaluated for each weed species. If weed densities were low, counts were made by species in each plot. Tree injury was evaluated on a 1 (none) - 10 (dead tissue) scale for each plot as simulated overspray applications.

Each treatment was replicated four times in a randomized complete block design at each site. Data were analyzed using mixed-model ANOVA to model response variables of efficacy and safety separately, with replications as random effects, and treatment, timing, location, and year as fixed effects. Tukey's HSD was used to identify differences in least squares means of response variables.

Current Results (Figure 1)

- Dry weight of weed biomass in each plot was determined at Santa Paula on September 30, 2019. The biomass results were inconclusive because of the variability among plots.
- All the simazine and glyphosate treatments provided near-complete control of most weeds. Oxyfluorfen also provided lasting control of most broadleaf weed species.
- Phytotoxicity from glyphosate on sprayed trees was consistent among locations and seasons. Glyphosate was most injurious among all treatments and unlike in other herbicide treatments, avocado branches sprayed with glyphosate did not recover.

A more comprehensive evaluation will be forthcoming as data collection finishes and it is evaluated.

(continued on Page 11)

(continued from Page 10)

Figure 1. Glyphosate damage on left, glufosinate in middle, untreated on right. All other treatments had intermediate levels of injury between glufosinate and untreated and generally recovered within 8 weeks after application.

PRESS RELEASE:
Partnership Helps Eradicate Invasive Weeds on National Forest

Public Contact Hotline: (707) 562-9113, SM.FS.R5inquiries@usda.gov
Media Contact: Jonathan Groveman (707) 562-8995, jonathan.groveman@usda.gov

The USDA Forest Service Pacific Southwest Region (Region 5) and the Sierra National Forest (SNF) recently partnered with Corteva Agribusiness to eradicate noxious and invasive non-native weeds from high-priority areas on the SNF. This work is the first project undertaken as part of a Memorandum of Understanding (MOU) between Region 5 and Corteva.

The right amount of herbicide applied at the right time and in the right place can have profound effects on native vegetation, improving the landscape for creatures that make the area their home. The Corteva – SNF partnership aims to control invasive weeds using the right herbicide(s), rate, and timing to maximize results and minimize effects to non-target organisms. Herbicide and professional applicator services were donated by Corteva Agribusiness, and the return on their investment will be the before and after data for their research and development.

The partnership goal is to treat invasive, non-native weeds like Italian thistle, yellow starthistle, and Klamathweed in areas of the SNF, where National Environmental Protection Act (NEPA) compliance exists, and to demonstrate the effective combination and timing of herbicides commonly used for invasive-weed control in California. Controlling invasive weeds allows native plants and wildlife to re-occupy formerly weed-infested landscapes and reduces further spread of weeds.

(continued on Page 12)

(continued from Page 11)

The areas receiving treatment have adjacent, non-treated control plots for comparison over time. On May 1, 2021, the first SNF sites treated under this partnership were at the North Fork administration site, Bass Lake Ranger District, selected to reduce risk of weed spread at a busy Forest Service compound. A Corteva vegetation management specialist and a Forest Service botanist oversaw the treatments, which precisely targeted invasive weeds with Milestone herbicide while avoiding native plants.

On May 24, 2021, the SNF botanist revisited the treatment sites to monitor the effects and progress of these first applications. Invasive weed treatments were very effective, and within a few years there should be a visually striking difference between treated and untreated plots.

Under the MOU between Corteva and Region 5, work will continue to move ahead on efforts to eradicate these and other invasive non-native species in strategic locations throughout the SNF.

ABOUT

The USDA Forest Service manages 18 National Forests in the Pacific Southwest Region, which encompasses over 20 million acres across California, and assists State and Private forest landowners in California, Hawaii and the U.S. Affiliated Pacific Islands. National forests supply 50 percent of the water in California and form the watershed of most major aqueducts and more than 2,400 reservoirs throughout the state. For more information, visit www.fs.usda.gov/R5.

Pioneer Hi-Bred International, Inc (Corteva): Corteva is a publicly-traded, global pure-play agriculture company that provides farmers around the world with the most complete portfolio in the industry - including a balanced and diverse mix of seed, crop protection, and digital solutions focused on maximizing productivity to enhance yield and profitability. With some of the most recognized brands in agriculture and an industry-leading product and technology pipeline well positioned to drive growth, the company is committed to working with stakeholders throughout the food system as it fulfills its promise to enrich the lives of those who produce and those who consume, ensuring progress for generations to come. Corteva became an independent public company on June 1, 2019 and was previously the Agriculture Division of DowDuPont. More information can be found at www.corteva.com.

Best Management Practices for Non-Chemical Weed Control Manual and Online Decision Support Tool are Available!

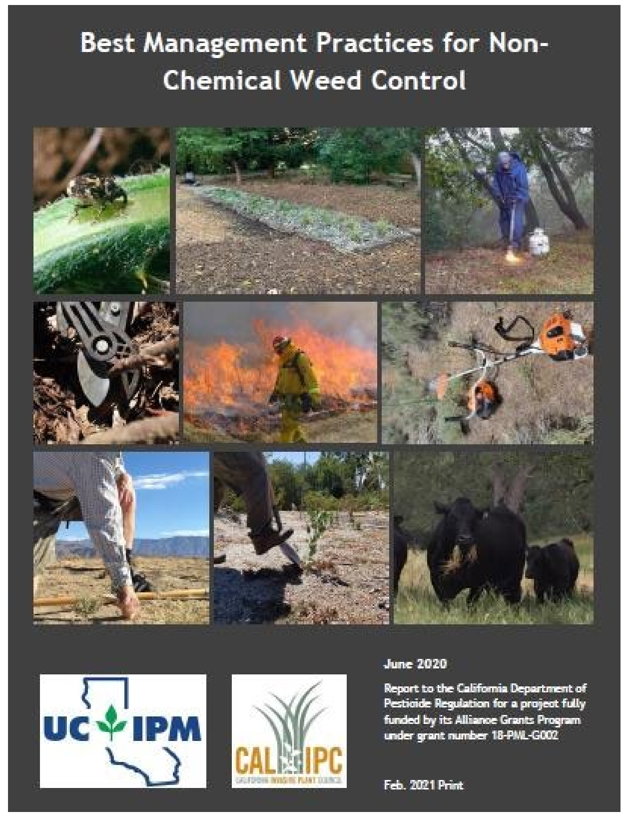
Jutta Burger, Director Cal-IPC Science Program

Anyone who has spent time dealing with weeds has probably gotten into heated debates with friends, colleagues, and maybe even foes about how best to get rid of these unwanted plants. Many have also had the rude awakening of seeing a weed thought long gone suddenly reappear. Can you relate?

(continued on Page 13)

(continued from Page 12)

Non-chemical weed control techniques, which are critical components of integrated pest management (IPM), fail more often than they should because they are used incorrectly: in the wrong way, at the wrong time, with the wrong amount, or for the wrong species. In order to help land managers manage weeds using the most effective and least toxic method, the California Department of Pesticide Regulation (DPR) funded a project though its Alliance Grant program with the California Invasive Plant Council (Cal-IPC) and the UC Statewide IPM Program.



The project resulted in a useful manual for land managers titled “Best Management Practices for Non-Chemical Weed Control” (pictured below). This resource is now available for FREE download on the Cal-IPC website (www.cal-ipc.org/BMPnon-chem).

The manual consists of 21 chapters covering non-chemical methods and an additional 18 chapters for biocontrol agents, making it a rich IPM resource!

In it, you will find:

- descriptions of IPM techniques;
- how, when, and how often to apply techniques to control weeds effectively;
- the types of plants and site conditions that each technique works well for (and those that it doesn’t); and
- hazards to be aware of for both applicators and the environment.

Many experienced practitioners contributed to the manual as primary authors, reviewers, and additional contributors to make it a relevant and robust resource for users across the state.

A companion online decision support tool called Weed Control User Tool (WeedCUT) has just been released! The tool uses information from the BMP manual and helps users compare efficacy of different non-chemical options for specific weed targets and situations. The link to the FREE Online Decision Support Tool is weedcut.ipm.ucanr.edu. For more information about this project please contact Cal-IPC Science Program Director Jutta Burger, jburger@cal-ipc.org.

DPR’s Grants Programs promote research into and the adoption and implementation of effective IPM systems and reduced-risk pesticide use practices. For more information on DPR’s Grants Program and current or future grant opportunities, please visit https://www.cdpr.ca.gov/dprgrants.htm or contact John Gerlach, John.Gerlach@cdpr.ca.gov.

Examining Options for the Control of Italian Ryegrass in Small Grains

Konrad Mathesius, Agronomy Advisor, UC Cooperative Extension

Summary Note
Mechanical cultivation is a useful tool in controlling herbicide-resistant Italian ryegrass individuals in a rainfed wheat system but it is only about half as effective as using Axial as a burn-down in reducing overall pressure from Italian ryegrass (expressed as a percentage of total groundcover). Nevertheless, because of the growing resistance to ACCase- and ALS-inhibitor herbicides among Italian ryegrass (and other winter weeds), growers should consider multiple approaches (chemical and mechanical) and integrate IPM strategies to reduce the spread of resistance genes among Italian ryegrass individuals. Note that this study was specifically looking at pre-plant burn-down efficacy, in-season herbicide applications would reduce weed pressure further.

Background
Italian ryegrass (*Lolium multiflorum*) has been shown to be a persistent weed for growers in rainfed winter grass systems. It is particularly problematic due to its biological requirement for cross-pollination. The subsequent gene transfer that occurs through pollination can include various herbicide resistance traits and resistances that develop can spread quickly within a field or even to neighboring populations. This is one of the reasons why Italian ryegrass in the Sacramento Valley is widely resistant to glyphosate. Other evidence suggests that Italian ryegrass in certain areas of California has developed resistance to some ALS inhibitor herbicides (Osprey) and ACCase inhibitors (e.g. Fusilade or Axial), often in addition to being resistant to glyphosate. Paraquat, often used as an alternative burn-down herbicide, is limited in its efficacy due to the fact that oftentimes the meristem of weed seedlings is already below the soil surface at the time of application.

Because resistance genes can be passed around relatively quickly in Italian ryegrass, physical (non-chemical) control may help stem the spread of resistant individuals. Additional information on chemical management of herbicide resistance can be found here.

Recent California Research
In the 2019 season, we compared the efficacy of mechanical and chemical preseason stale seedbed methods for control of Italian ryegrass in fall-planted wheat trial in Yolo County, CA. Four replicate plots of three treatments were evaluated in a randomized split-plot design. Treatments included a ‘control' (drill-seeding into the prepared seedbed), an ‘Axial' preplant burndown herbicide treatment, and a ‘mechanical cultivation' sequential preplant tillage treatment. In the preplant burndown herbicide treatment Pinoxaden (Axial), an ACCase inhibitor, was applied at the label rate (8.2 oz/ A) 7 days after ryegrass emergence.

In the mechanical cultivation treatment, ryegrass was cultivated 7 days after emergence with a 7.5”-spaced, 1.5”-wide-tine field cultivator, and then cultivated a second time 4 days later to ensure complete control of emerged ryegrass.

The control treatment was drill-seeded into the seedbed, ryegrass seedlings had already emerged and were roughly a ¼-inch in height.

(continued on Page 15)

(continued from Page 14)

Four replicates of two varieties of wheat (Blanca Grande 515 and Westbred 9433) were planted into the three treatments immediately following the second cultivation (December 14th, 2018). In order to determine the relative effects of pre-season treatments, no in-season herbicide was applied. Percent ground cover of wheat, Italian ryegrass, and bare soil was determined using a 1ft^2 quadrat on three occasions throughout the growing season.

Results

Data indicate that by April, both wheat and ryegrass ground cover percentages were significantly different among all treatments. Compared to the control treatment, the mechanical cultivation treatment had 22% less ryegrass ground cover while Axial reduced ryegrass cover by 62%. Wheat ground cover in the mechanical cultivation treatment was less than half that of the Axial treatment (20% and 47% for mechanical cultivation and Axial, respectively). (Figure 1).

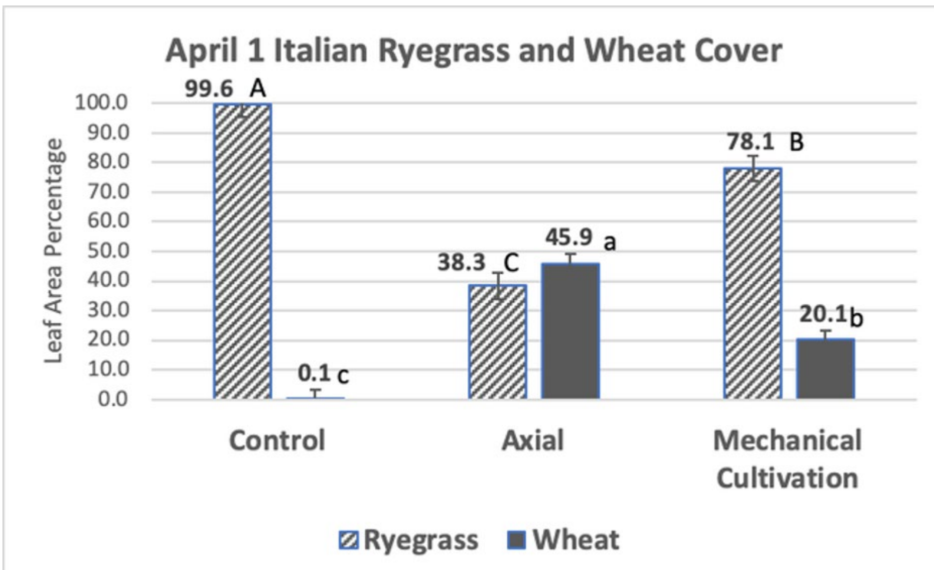


Figure 1. Italian ryegrass and wheat ground cover percentages in April (108 days after planting). Significant differences are indicated by different letters. Uppercase letters correspond to differences in Italian ryegrass ground cover among treatments. Lowercase letters correspond to difference in wheat ground cover among treatments.

Increased competition among the various treatments led to substantial reductions in yields (Figure 2).

(continued on Page 16)

(continued from Page 15)

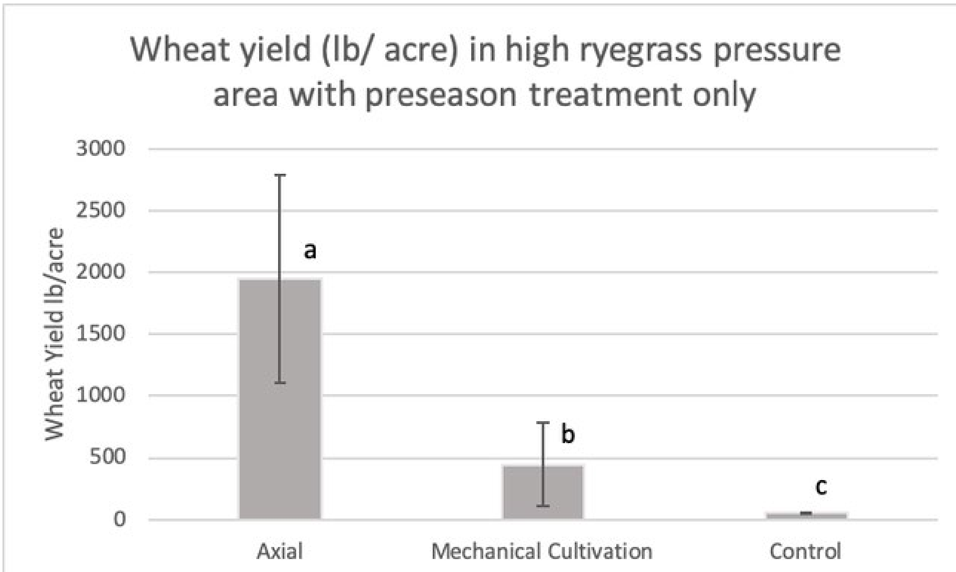


Figure 2. Yields resulting from different preseason treatments averaged across two varieties.

Discussion and Conclusion

The difference in ground cover among these treatments is likely due to several factors. One is the fact that cultivation disturbs the soil, bringing new seeds up to the surface that would subsequently sprout with later rainfall. It is also likely that some not all of the seedlings were terminated by cultivation and managed to re-root in disturbed soils.

While later flushes of weeds occurred in the Axial treatment as well, these were either: a) resistant individuals or, b) late-emerging individuals due to differences in dormancy within the seed bank population. Both of these potential pools would have likely included fewer individual Italian ryegrass seedlings than those in the mechanical treatment.

This study shows that growers can consider the use of mechanical cultivation to remove potentially resistant individuals but should still consider herbicides to be a part of their pre-season tool kit. While some individual weeds may escape mechanical cultivation through a combination of luck and equipment limitations it is unlikely that Italian ryegrass seedlings will develop a resistance to being uprooted and desiccated. This would potentially remove some herbicide-resistant individuals from a given population. As is often cited by IPM specialists, utilizing a wider array of tools to control weeds (both chemical and physical) will help curtail the spread of herbicide resistance and improve grower capacity to maintain economic sustainability.

Additional Data: Variety Effect and the Impact of In-Season Herbicides

An additional factor evaluated in this study was the potential of varieties with shorter and longer 'days until harvest' ratings to establish a canopy and compete with weeds (referred to here as "early" and "late" varieties).

(continued on Page 17)

(continued from Page 16)

Of the two varieties used in this study (Westbred 9433 and Blanca Grande 515), neither performed significantly better in establishing an early-season canopy relative to Italian ryegrass (Figure 3). As other studies have suggested, differences in wheat variety capability to compete with weeds may be rooted in factors other than the number of days until emergence and other key growth stages, and are instead correlated to other variety traits (plant height, leaf physiology, tillering capacity, etc. Lemerle et al. 1996).

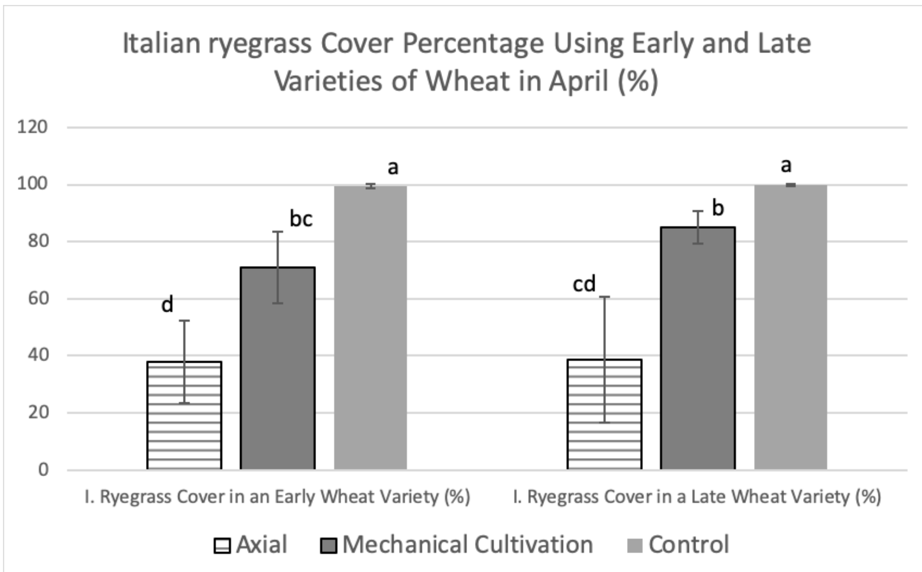


Figure 3. Italian ryegrass ground cover percentage among an early and late variety of wheat and different preseason weed management practices. Letters indicate significant difference between variety x treatment combinations. There was no significant difference between early and late varieties when averaged across treatments.

In-season herbicide treatments play a critical role in reducing weed pressure. In the broader field where this study was conducted, the grower used an in-season mixture of 7oz Simplicity /A, ¾ pt MCPA / A, 1.5 pt Brox 2E / A. In April, the grower field had 2% ryegrass cover and 98% wheat cover, a substantially more favorable outcome than those seen in the preseason treatments. Therefore, although this study did not directly look at the relative effect of in-season herbicides on Italian ryegrass control, the importance of in-season sprays can be inferred from the condition of the grower field in the surrounding area (and by the notably low yields from the data from this study).

Wild Rice (*Zizania palustris* L.) Preliminary Herbicide Screening

Whitney Brim-DeForest, Rice and Wild Rice Advisor, UC Cooperative Extension

Background:
Currently, only one herbicide is registered for use in wild rice (*Zizania palustris* L.) in California: Shark H2O (carfentrazone). Due to the similarity in weed spectrum and environment between rice and wild rice, we conducted a screening using all California rice herbicides (registered and those in the registration pipeline) in a greenhouse in 2020. From this preliminary screening, we propose to move forward with a few of the best candidates for field testing for yield and phytotoxicity, as well as weed efficacy data. Field trials are tentatively scheduled for 2022, pending approval of the IR-4 program and the California Department of Food and Agriculture.

Methods:
Screenings were conducted at the California Rice Experiment Station in Biggs, CA (39.46412233769285, -121.73286567497216) in a greenhouse in April-May, 2020. Wild rice (*Z. palustris*) seed was donated by Lundberg Family Farms (Richvale, CA). Seeds were pre-germinated and planted in 4-inch square pots filled with rice-field soil, at four seeds to a pot. All herbicide applications were made at approximately the 1-2 leaf stage of wild rice. Herbicides applied were SuperWham/Stam (propanil), Londax (bensulfuron-methyl), Clincher (cyhalofop), Sandea (halosulfuron), Grandstand (triclopyr), Loyant (florpyrauxifen-benzyl), Regiment (bispyribac-sodium), Granite GR (penoxsulam), Cerano (clomazone), Bolero (thiobencarb), Butte (benzobicylon + halosulfuron), and pyraclonil at field rates for rice (Table 1). Florpyrauxifen-benzyl is not currently registered in California rice, but registration is expected in 2022. Pyraclonil is also currently not registered, but the anticipated registration date is unknown.

Table 1. Herbicides and rates utilized for 2020 wild rice screening. Rates are in amount of product per acre and grams of active ingredient (a.i.) per hectare.

Product (trade name)	Active Ingredient	Rate (product)	Rate (a.i.)	Application Method
SuperWham/Stam	propanil	6 qt acre^{-1}	6276 g ha^{-1}	Liquid
Londax	bensulfuron-methyl	1.66 oz acre^{-1}	69.7 g ha^{-1}	Liquid
Clincher	cyhalofop	15 fl oz acre^{-1}	263 g ha^{-1}	Liquid
Sandea	halosulfuron	1.33 oz acre^{-1}	69.8 g ha^{-1}	Liquid
Grandstand	triclopyr	0.67 pt acre^{-1}	282 g ha^{-1}	Liquid
Loyant*	florpyrauxifen-benzyl	1.37 pts acre^{-1}	40 g ha^{-1}	Liquid
Regiment	bispyribac-sodium	0.57 oz acre^{-1}	32 g ha^{-1}	Liquid
Granite GR	penoxsulam	15 lbs acre^{-1}	40 g ha^{-1}	Granule
Cerano	clomazone	12 lbs acre^{-1}	673 g ha^{-1}	Granule
Bolero	thiobencarb	23.3 lbs acre^{-1}	3918 g ha^{-1}	Granule
Butte	benzobicylon + halosulfuron	7.5 lbs acre^{-1}	306 g ha^{-1}	Granule
N/A*	pyraclonil	8.1 lbs acre^{-1}	163 g ha^{-1}	Granule

**Not registered in California rice*

(continued from Page 18)

Each herbicide treatment was replicated 4 times, and there was one untreated control per herbicide application method (granular and liquid formulations). The experiment was set up as a completely randomized design (CRD). Granular formulation applications were made into the water in individual bins (1 pot per bin), and water was maintained at approximately 4-6 inches (10 cm) above the soil surface. Foliar (liquid) formulations were applied using a cabinet track sprayer with an 8001-EVS nozzle delivering 40 gallons of spray solution per acre (at a pressure of approximately 20 psi). Phytotoxicity (% injury) ratings (bleaching, stunting, death) were made at 7 days after application on a per pot basis. Plants were harvested and fresh weights were measured at 21 days after herbicide application. A final plant count was also taken. Percent reduction in plant number was calculated from the initial number of plants per pot, and percent reduction in fresh weight was calculated in comparison to the untreated control.

Results:
At 7 days after herbicide application, only Clincher (cyhalofop), Loyant (florpyrauxifen-benzyl), SuperWham/Stam (propanil), Granite GR (penoxsulam), and Grandstand (triclopyr) had less than 50% injury (Figure 1). All other tested herbicides had at least 85% injury.

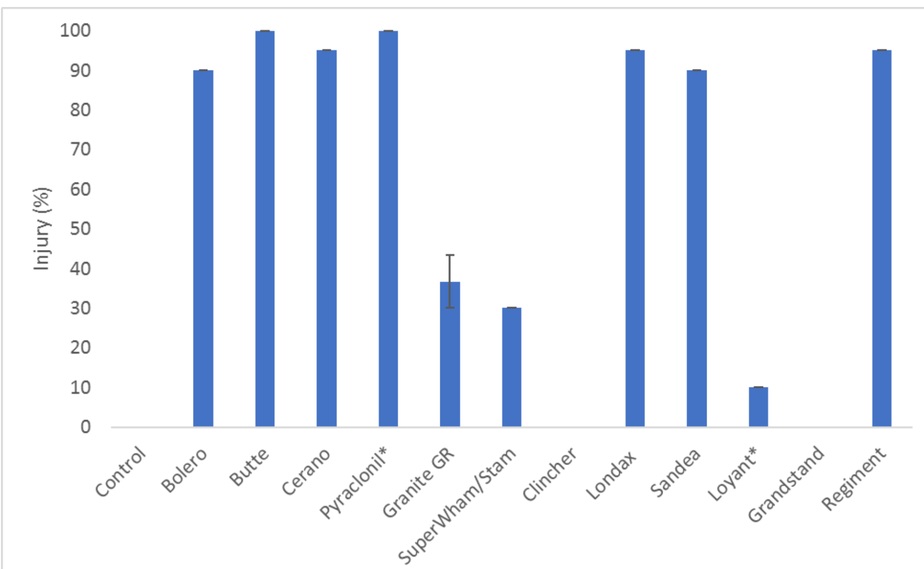


Figure 1. Phytoxicity rating of percent injury (i.e. bleaching, stunting, death) of wild rice at 7 days after herbicide application. Bars indicate standard errors. (*) indicates herbicides not registered in California rice.

At 21 days after herbicide application, the granular formulations had similar results in terms of plants remaining and fresh weight to the observations taken at 7 days after application. For the percent reduction in fresh weight, Granite GR (penoxsulam) had the lowest percent reduction, at less than 40% (Figure 2). All other tested granular formulations had at least a 75% reduction in fresh weight (Figure 2).

For the percent reduction in plant number, Granite GR (penoxsulam) had the lowest percent reduction, at 0% (Figure 3). All other tested granular formulations had at least a 35% reduction in plant number (Figure 3).

(continued on Page 20)

(continued from Page 19)

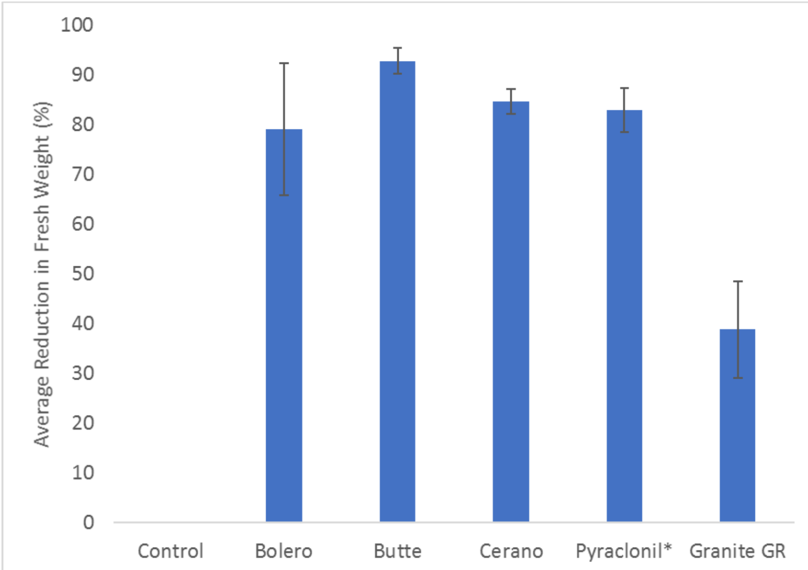


Figure 2. Average percent reduction in fresh weight in comparison to the control at 21 days after herbicide application. Bars indicate standard errors. (*) indicates herbicides not registered in California rice.

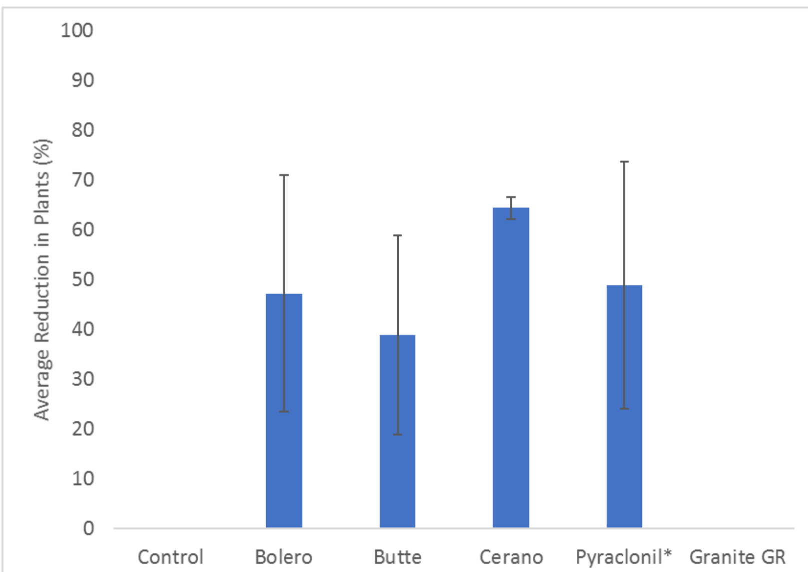


Figure 3. Average percent reduction in plant numbers in comparison to the control at 21 days after herbicide application. Bars indicate standard errors. (*) indicates herbicides not registered in California rice.

(continued on Page 21)

(continued from Page 20)

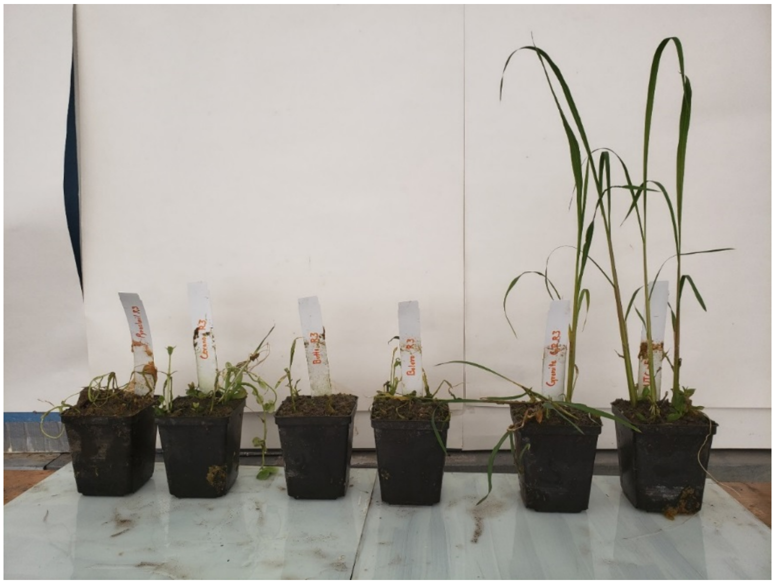


Figure 4. Wild rice treated with granular herbicide formulations at 21 days after herbicide application. From left to right: pyraclonil, Cerano (clomazone), Butte (benzobicylon + halosulfuron), Bolero (thiobencarb), Granite GR (penoxsulam), and untreated control.

At 21 days after herbicide application, the foliar-applied formulations had 100% survival of plants (no reduction in the number of plants per pot). For the percent reduction in fresh weight, Clincher (cyhalofop), Loyant (florpyrauxifen-benzyl), SuperWham/Stam (propanil), and Grandstand (triclopyr) had low reductions in fresh weight, all below 10% on average (Figure 5). All other tested foliar-applied formulations had at least a 75% reduction in fresh weight (Figure 5).

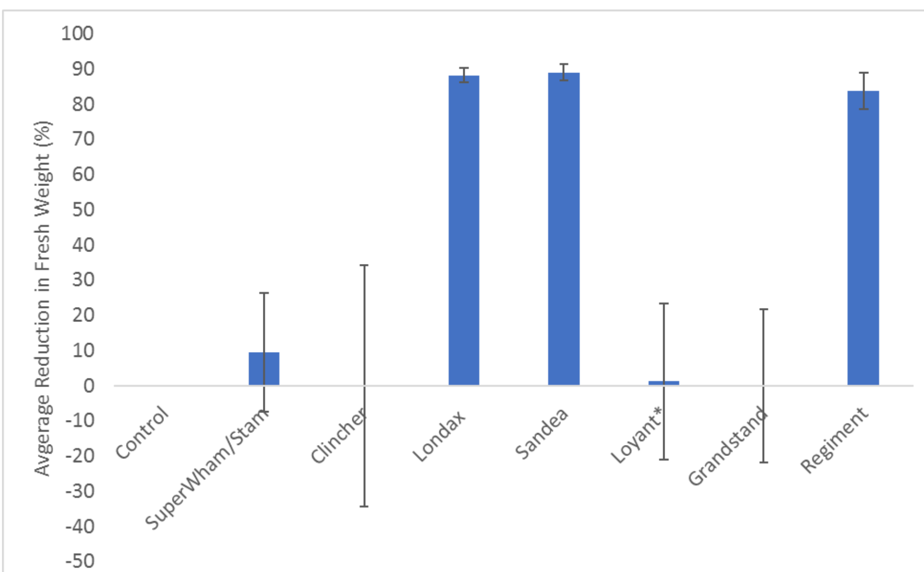


Figure 5. Average percent reduction in fresh weight in comparison to the control at 21 days after herbicide application. Bars indicate standard errors. (*) indicates herbicides not registered in California rice.

(continued on Page 22)

(continued from Page 21)

Conclusion:
Based on the results of this preliminary screening, a few candidate herbicides look promising for further field testing: Clincher (cyhalofop), Loyant (florpyrauxifen-benzyl), SuperWham/Stam (propanil), Granite GR (penoxsulam), and Grandstand (triclopyr). The next step will be to pursue field testing in wild rice to determine if one or more of these herbicides provide good weed control without significant phytotoxicity or reductions in yields.

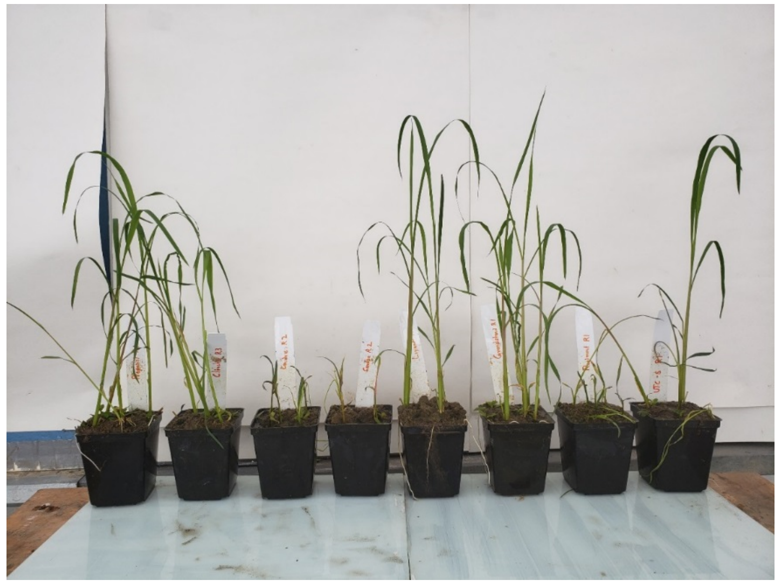


Figure 6. Wild rice treated with granular herbicide formulations at 21 days after herbicide application. From left to right: SuperWham/Stam (propanil), Clincher (cyhalofop), Londax (bensulfuron-methyl), Sandea (halosulfuron), Loyant (florpyrauxifen-benzyl), Grandstand (triclopyr), Regiment (bisbyribac-sodium), and untreated control.

CWSS Research Update and News

Send research updates and news articles to Whitney Brim-DeForest, Non-conference Education Director

wbrimdeforest@ucanr.edu - Office (530) 822-7515

Published twice a year. The CWSS Research Update and News purpose is to provide

Information on Weeds and Weed Control from
The California Weed Science Society
http://www.cwss.org

CWSS Research Update and News

Information on Weeds and Weed Control from the California Weed Science Society