CWSS Research Update and News

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

Volume 10, Number 2 **September 2014**

In This Issue

- Introduction
- Developing an Accuracy Risk Assessment Tool for Evaluating the Potential Invasiveness of Ornamental Plants
- Managing Junglerice in Corn
- Managing Junglerice in Tree Nut Crops – A Summer Weed Resistant to Glyphosate
- Weed Management in Tulelake Processing Onions
- Passive Restoration of California Grassland and Coastal Sage Scrub
- Riding instead of walking: The UTV sprayer system for large-scale invasive plant control

Introduction

Steve Orloff, Editor

Our society's journal, CWSS Research Report and News, will continue to be published twice per year, but the publishing schedule has been changed from the months of January and June to March and September. The journal editor and the CWSS Board determined that this schedule would be more appropriate because our conference is in January, and publishing the CWSS Research Report and News in March and September would provide for a more continuous flow of weed science educational information.

This edition of CWSS Research Report and News has a wide variety of weed science topics including articles addressing weed management in wildland areas, field crops, vegetable crops and orchards. Research presented was conducted from one end of the state to the other (San Diego to Siskiyou County). Junglerice, a warm-season annual grass is becoming an increasing problem in California cropland, especially since glyphosate-resistant biotypes have evolved. One article addresses management options in orchards and a second deals with its control in corn. Many of our invasive weed species were intentionally introduced as ornamental landscape plants--not recognizing their potential to become invasive. An article authored by Joe DiTomaso and Christina Conser explains a weed risk evaluation tool they developed to assess the invasive potential of new ornamental plants. Two other articles were written by Carl Bell and address weed control in wildland areas. One article covers passive restoration efforts and the other talks about his experiences developing a UTV spraying for controlling invasive plants. Another article discusses weed management in onions--weeds have always been a challenge to growers because onions are such poor competitors. The latest information on weed management in onions in northeastern California is presented.

Developing an Accuracy Risk Assessment Tool for Evaluating the Potential Invasiveness of Ornamental Plants

Joseph M. DiTomaso (jmditomaso@ucdavis.edu) and Christiana Conser (cconser@ucdavis.edu)
University of California Cooperative Extension and Department of Plant Sciences, Davis, CA

The nursery and landscape industry have introduced over 50,000 ornamental species to the US (Gordon and Gantz 2008). When you consider the total number of cultivars introduced into North America, the number has increased from 29,000 in 1987 to 105,000 in 2008 (Levine and D'Antonio 2003). Most of these species and cultivars do not cause environmental or economic problems. In fact, only a small percentage (between 0.1% and 1%) have become invasive. However, of the species that are invasive in the US, many have their origins from the horticultural industry. For example, in California, 60% of the 214 invasive plants impacting wildlands were intentionally introduced for human uses, and 47% of those plants are landscape ornamentals (Cal-IPC 2014). Throughout North America, 82% of the 235 invasive woody plants are horticultural in origin (Reichard and Hamilton 1997) and for the entire country, estimates of the invasive plants originating from the nursery industry range from 34 to 83% (Bell et al. 2003).

The most cost effective way to avoid establishment of new invasive plants originating from the ornamental plant industry is to prevent their introduction at the beginning of the nursery supply chain. This can be achieved through risk assessment tools. Weed Risk Assessment (WRA) is a systematic process that uses available evidence to estimate the risk of a plant species becoming invasive in a given region. While there are many WRA tools that have been developed for a variety of applications, including evaluating plants in botanical gardens, none were specifically designed to screen ornamental plants prior to being released into the environment.

The most widely used WRA tool was developed in Australia (Pheloung et al. 1999) for import screening purposes, and has since been adapted for use in other parts of the world. The tool consists of 49-questions. It has been shown to be 90 to 100% accurate in correctly identifying invasive plants, but results varied dramatically in its accuracy levels in categorizing known non-invasive plants, ranging from 21 to 75% accuracy. As a result, the tool is considered by the horticultural industry to be too conservative in predicting invasiveness, with far too many non-invasive species categorized as invasive. This will likely compromise its practical application by the industry. The US also has a WRA tool used by USDA-APHIS to prevent the importation of invasive plants (Koop et al. 2011). Unlike the Australian WRA, this tool has high accuracy in classifying both major-invaders (94% accuracy) and non-invaders (97% accuracy), but is not designed for evaluating potential invasiveness on a regional scale or in determining invasive risk with plants in the early pre-marketing stages.

For the nursery and landscape industry to consider a WRA tool useful, it must not only be highly accurate in predicting potential invasiveness and non-invasiveness, but must also be easy to use and not require a long time to complete. Thus, we initiated a project using a science-based and systematic process to develop a highly accurate (for both invasive and non-invasive plants) Plant Risk Evaluation (PRE) tool specifically for screening ornamental plants. We assessed questions from existing WRA tools and developed the PRE tool with the most predictive and relevant questions for ornamental plants. The long-term goal of the project is to provide a voluntary screening tool for the horticultural industry that ultimately prevents new potentially invasive plants from being introduced or sold in regions of the US where they are likely to become invasive.

The initial step in developing the PRE tool required an evaluation of several pre-existing WRA screening tools to determine the most appropriate and highly predictable questions contributing to model accuracy for orna-

(Continued on page 3)

mental plants. From the various tools available we identified 56 questions that were commonly used to evaluate a set of known invasive and non-invasive plants. These questions covered invasive history, climate match, difficulty of control, environmental impacts, reproductive and dispersal strategies, and growth rate.

Using the 56 questions, we evaluated a total of 35 plants, 21 known invasive and 14 known non-invasive plants. The invasive plants were selected from the California Invasive Plant Council's (Cal-IPC) Invasive Plant Inventory and the non-invasive species were chosen from the PlantRight's Suggested Alternatives for Invasive Garden Plants (PlantRight 2014). As many questions as possible were answered using available literature, as well as searches of online databases and species fact sheets.

For each plant species evaluated, we calculated the total score and the percentage of questions that were answered. To determine which questions contributed most to the predictability of invasiveness and non-invasiveness, we used a two-tailed Fischer's Exact Test, which statistically compared the answers for each question between the known invasive and non-invasive species. In addition, we calculated the percentage of times each question was answered for all known invasive and non-invasive plants. The scores for known invasive plants ranged from 21 to 44, with an average score of 31. The scores for known non-invasive plants ranged from 5 to 14, with an average score of 10. For each plant species screened, the percentage of questions answered for known invasive plants ranged from to 80% to 98%, with an average of 90%. The percentage of questions answered for known non-invasive plants ranged from to 86% to 95%, with an average of 89%.

The Fischer's Exact Test identified a total of 31 questions that had a greater than 95% probability of separating invasive from non-invasive species. The percentage of times each of the 56 questions was answered for known invasive plants ranged from 5% to 100%. The percentage of times each of the 56 questions was answered for known non-invasive plants ranged from to 0% to 100%. Of the 56 questions evaluated, 17 were eliminated because they did not provide statistically significant predictive power to separate known invasive from known non-invasive plants. Other questions were eliminated because they could not be answered at a high enough frequency (only 0 to 19%), they were irrelevant to evaluating ornamental plants or new plant introductions (mostly environmental impact related questions), or the question was inherently biased. For example, the question was only known and answered when the phenomenon was studied, which was nearly always with known invasive species (i.e., allelopathy, palatability to animals, impacts on grazing).

After removing or merging questions, we were left with a PRE tool that contained 19 questions (Table 1). We tested the 19 question PRE tool by screening 94 additional plants, 57 known invasive and 37 known non-invasive plants. Similar to the 56 original questions, we used a two-tailed Fischer's Exact Test to compare the predictability of each question and calculated the number and percentage of times each question was answered. From the analysis, 16 of the 19 questions showed statistical significant between the known invasive and non-invasive species. Similar to the same questions in the 56 question evaluation, each question was answered at a high frequency, ranging from a low of 54% for non-invasive plants to 100% for most other questions. An average of 97% of the questions were answered for both invasive and non-invasive plants for the 94 species evaluated. For individual species, this ranged from 85 to 100% of the questions answered.

The results showed scores for known invasive plants ranging from 12 to 21, while the scores for known non-invasive plants ranging from 2 to 13. Based on the separation in scores among the known invasive and non-invasive species, the scoring scale for the 19 question PRE tool was established (Figure 1) to be <11 as an accept (low invasive risk), 11 to 13 as "needs further evaluation", and >13 as a reject (high invasive risk). Plants which fell into the "needs further evaluation" category may need additional assessment by an expert panel.

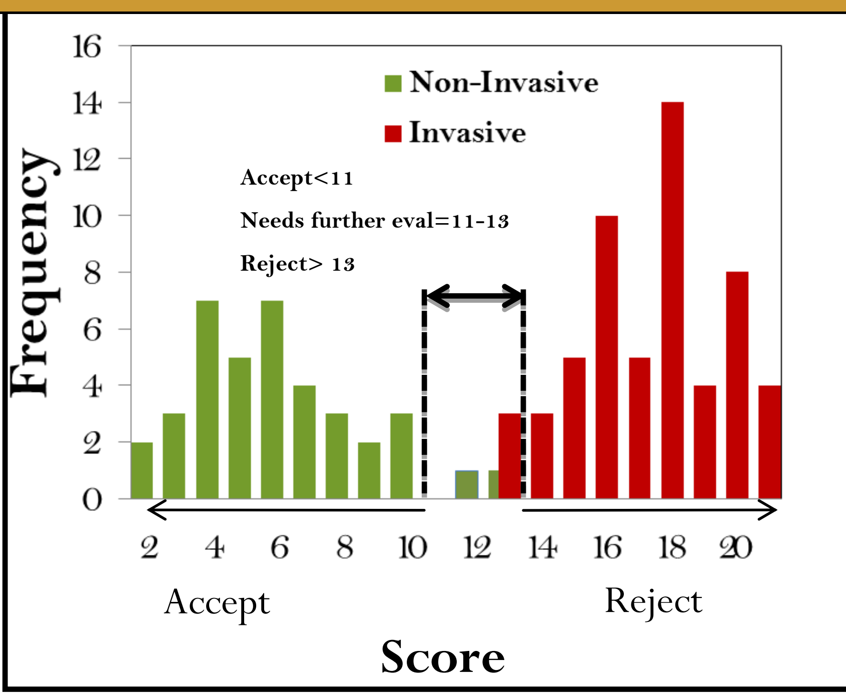
(Continued on page 4)

(Continued from page 3)

Table 1. Final 19 PRE tool questions.

1	Has the species become naturalized where it is not native?
2	Is the species noted as being invasive elsewhere in the US or world?
3	Is the species noted as being invasive elsewhere in the US or world in a similar climate?
4	Are other species of the same genus invasive in other areas with a similar climate?
5	Is the species found predominately in a climate that matches those within the region of introduction?
6	Dominates in areas this species has already invaded (displaces natives). Can overtop and/or smother surrounding vegetation.
7	Is the plant noted as being highly flammable and/or promotes fire and/or changes fire regimes?
8	Is the plant a health risk to humans or animals/fish? (Toxic tendencies) Has the species been noted as impacting grazing systems?
9	Does the plant produce impenetrable thickets, blocking or slowing movement?
10	Reproduces vegetatively via root sprouts/suckers or stem/trunk sprouts/coppicing.
11	Plant fragments are capable of producing new plants.
12	Does the plant produce viable seed?
13	Produces copious viable seeds each year (>1000).
14	Seeds quick to germinate (<2 months).
15	Short juvenile period. Produces seeds in first three years (herbaceous) or produces seeds in first five years (woody).
16	Long flowering period with seeds produced for more than 3 months each year.
17	Propagules are dispersed by mammals/insects or birds or via domestic animals.
18	Propagules are dispersed by wind or water.
19	Propagules are dispersed via agriculture, contaminated seed, farm equipment, vehicles or boats, or clothing/shoes.

Figure 1. Histogram of scoring frequencies for the 19-question PlantRight plant risk evaluation (PRE) tool.



For the 57 known invasive plants evaluated through the 19 question PRE tool, no species were classified as accept. When species within the "needs further evaluation" category were excluded, the accuracy of the PRE tool in prediction invasiveness was 100%. Even when the four species listed as "needs further evaluation" were considered false positives (invasive species incorrectly accepted as non-invasive) the accuracy and sensitivity was 93%. For the non-invasive species, the 19 question PRE tool gave no false negatives (non-invasive species rejected as invasive), but did classify one species in the "needs further evaluation" category. Thus, the percent accuracy of the model when plants classified as "needs further evaluation" are excluded is 100%. Even when the "needs further evaluation" species are considered as false negatives, the accuracy is still a very high 97%. When considering both known invasive and non-invasive species, the overall accuracy of the PRE model was 100% when "needs further evaluation " species were excluded and 95% when they were included.

The next steps in the development and validation of the PlantRight PRE tool will be to: 1) test the consistency of the tool by different users, 2) test the accuracy of the tool in evaluating invasive risk on a national scale (to demonstrate that it can be used beyond California, and at different scales), 3) incorporate climate matching capabilities, 4) develop an online database in partnership with UC Davis, and 5) encourage nursery industry adoption. The PRE tool can be used preventatively by the nursery industry to screen ornamental plants for potential invasiveness prior to introduction to the marketplace. The PlantRight PRE tool can also give a prediction of the risk of invasiveness (low or high) for a given species at a designated location.

The tool is expected to provide the industry with multiple potential benefits, including: 1) an online service utilizing the PlantRight PRE tool to accurately assess invasive risk early in the evaluation process (before making a significant economic investment), 2) additional information regarding taxonomy, reproductive characteristics, culinary and medicinal uses, patent information and more, 3) optional services including maps of CLIMEX climate-matching results under various assumptions (e.g., drought tolerance) and scenarios (e.g., irrigation, climate change), and 4) a tiered-access/password-protected PlantRight PRE database, with both a public database of PREs and password-protected PREs for industry clients (to protect their intellectual property).

Because invasive plants represent only a small percentage of the horticultural inventory (~1%), screening plants for invasive qualities should not present a major economic hardship to the industry. Pre-screening of potential introductions would be expected to categorize the vast majority of species as possessing low invasive potential, and identify relatively few as having a high probability of becoming invasive. More importantly, because development of new cultivars represents a significant economic investment for nursery growers throughout the US, pre-screening would prevent nurseries from spending important research dollars to develop new cultivars with high invasive potential.

References

Bell CE, Wilen CA, Stanton E (2003) Invasive plants of horticultural origin. HortScience 38: 14-16.

Cal-IPC (2014) California invasive plants inventory. California Invasive Plant Council, Berkeley, CA. Available: http://www.cal-ipc.org/ip/inventory/index.php. Accessed 10 March 2014.

Gordon DR, Gantz CA (2008) Screening new plant introductions for potential invasiveness: a test of impacts of the United States. Conservation Letters 1: 227-235.

(Continued on page 6)

References Continued

Koop AL, Fowler L, Newton LP, Caton BP (2011) Development and validation of a weed screening tool for the United States. Biol Invasions 14: 273-294.

Levine JM, D'Antonio CM (2003) Forecasting biological invasions with increasing international trade. Conservation Biology 17: 322-326.

Pheloung PC, Williams PA, Halloy SR (1999) A weed risk assessment model for use as a biosecurity tool evaluating plant introductions. J Env Manage 57: 239-251.

PlantRight (2014) Suggested Alternatives for Invasive Garden Plants. Available: http://www.plantright.org/sites/default/files/pdfs/PlantRight-2014_Plant_List_Final-v2.pdf. Accessed 10 March 2014.

Reichard SH, Hamilton CW (1997) Predicting invasions of woody plants introduced into North America. Conservation Biology 11: 193–20.

Managing Junglerice in Corn

Steve Wright (sdwright@ucanr.edu) and Carol Frate (cafrate@ucanr.edu)
University of California Cooperative Extension Tulare County

The summer annual grass junglerice (Echinocloa colona) has become a difficult weed problem in corn as well as other crops in the southern San Joaquin Valley, especially in minimum-till fields. Glyphosate products do not kill this weed easily unless the grass is quite small. Seed continues to germinate throughout the summer so even if junglerice seedlings are killed with a post-emergent herbicide, new seedlings can emerge soon after application or after the next irrigation.

Stripes across the leaf blades commonly found on junglerice can be seen in this UC IPM photo.

Junglerice identification. Seedling leaves are grayish or dull green in color. Often leaves are banded with purplish-red stripes across the blade; but this feature can be absent. Mature plants are prostrate or erect and 2-3 ft tall. Leaves are rolled in the stem before emerging. Leaf blades are flat and usually the upper surface is hairless. Stems are hairless except at the nodes. There are no ligules or auricles. Purple banding on the leaves is the easy way to distinguish junglerice from barnyardgrass. There are more photographs and details on identification at the UC IPM website: http://www.ipm.ucanr.edu/PMG/WEEDS/junglerice.html.

The evolution of glyphosate (Roundup) resistance in junglerice is a major concern in California. Rotating glyphosate-resistant (RR) corn with other glyphosate-resistant crops 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 or tank-mixing herbicides that have different chemical modes of action.

Research Results. Research conducted in the San Joaquin Valley from 2011-2013 by Steve Wright and Carol Frate with Matrix (rimsulfuron) and Laudis

(Continued on page 7)

(Continued from page 6)

(tembotrione) demonstrated excellent junglerice control could be achieved when these herbicides are applied according to label instructions. Both herbicides will enhance control of broadleaves, grasses, and glyphosate-resistant weeds, while also reducing glyphosate induced weed shifts. Matrix can be applied either preemergent to the corn and junglerice or postemergent to the corn. In the first case, corn is planted dry, the herbicide is applied and then followed with an irrigation to germinate the corn and activate the herbicide. The other approach is to preirrigate, plant or strip till and then plant. After weeds emerge treat postemergent to corn and junglerice. The most consistent results have been observed with a tank mix of glyphosate and Matrix. Matrix can be applied postemergent to corn up to 12 inch tall but weeds must be small. “Steadfast”, a combination of Accent plus Matrix, applied postemergent, has also been demonstrated to control young junglerice.

The herbicide Laudis (tembotrione) adds to the options available to corn growers for junglerice control. Laudis is for postemergence use. Best results are obtained when it is applied to young actively growing weeds. According to the label, Laudis can affect weeds that are larger than the recommended height; however, applications of Laudis when weeds are taller than 4 to 5 inches in height may result in incomplete weed control. Broadcast applications of Laudis may be made to corn from emergence up to the V8 stage of growth. A second post-emergence to corn application is allowable, but it must be a minimum of 14 days after the first application. According to the label, cultivation can help remove suppressed weeds or for control of multiple weed flushes. However, don’t cultivate within 7 days of an application of Laudis, as this could decrease the effectiveness of weed control due to disruption of herbicide translocation in the plant.

Managing Junglerice in Tree Nut Crops-a summer weed resistant to glyphosate

Marcelo L. Moretti[1], Seth Watkins[1], Bill Gary[2] (tech@midvalleyag.com), and Brad Hanson[1](bhanson@ucdavis.edu)

[1]University of California – Davis, CA; [2]Mid Valley Ag – Linden, CA

Junglerice, or *Echinocloa colona*, is a summer grass commonly found in orchards, annual crops, and roadsides of California. This weed germinates in early spring and throughout the summer and can grow and reproduce quickly. Junglerice commonly is identified by purple bands on the leaves. However, in some populations or environmental conditions these stripes are less visible; thus a lack of banding should not be used as a definitive means of identification. In recent years, the feature that makes this summer grass really stand out in California fields is the discovery of glyphosate-resistant populations.

Figure 1. Mature junglerice plant and closer picture showing characteristic leaf bands.

Glyphosate-resistant junglerice was first detected in the northern Central Valley in 2010. A subsequent survey in 2011 found glyphosate-resistant populations in Butte, Madera, and Kern Counties. At that time, glyphosate resistance was not found between Butte and Madera Counties. This erratic distribution of resistance suggested that these populations may have evolved resistance independently. This hypothesis was further supported by the work of Dr. Alarcon-Reverte and collaborators from UC Davis, who documented several different mechanisms of resistance in junglerice populations from California.

These findings have important implications for weed management. First, seed production and dispersal must be stopped to avoid spread of the populations that are already resistant to glyphosate. Even more important is that weed management programs should consider the adoption of strategies to mitigate selection of new glyphosate-resistant populations. Readers interested in more general information about the biology and management of herbicide resistant weeds should refer back to the January 2013 CWSS Research and Update News vol. 9 n. 1 (http://www.cwss.org/uploaded/media_pdf/4749-2013_01_CWSSResearch.pdf). In this article, the discussion will focus on herbicidal management of glyphosate-resistant junglerice in tree and vine crops.

Rotating or combining herbicide modes of actions is one of the first recommended practices to manage herbicide resistance. However, this practice is only effective when the alternate mode of action herbicide also has efficacy on the resistant species. Experiments were conducted during summer of 2013 and 2014 in tree nut crops of the Central Valley to compare postemergence control of junglerice with registered herbicides. Locations included Kern, Contra Costa, and Merced Counties. The Kern County location was known to be infested with glyphosate-resistant junglerice, but the susceptibility of the populations at the other two locations was not known.

The results indicated that glyphosate (RoundUp Powermax) was highly effective in controlling junglerice at the Contra Costa and Merced County locations; however, no control was observed with glyphosate in Kern County (figure 2). Concurrent greenhouse experiments indicated that the Kern population was 4-fold more tolerant of glyphosate than the reference susceptible population (data not shown). The other postemergence herbicides tested, glufosinate (Rely 280), paraquat (Gramoxone SL), or sethoxydim (Poast), all provided good initial control of junglerice; this indicates that there is no cross-resistance to these modes of action. However, because these herbicides have only postemergence activity, junglerice control declined by 28 days after application due to regrowth and emergence of new seedlings (figure 3). The combination treatment of glyphosate plus rimsulfuron in these studies provided good postemergence control of glyphosate-susceptible and –resistant junglerice as well as residual control for several weeks.

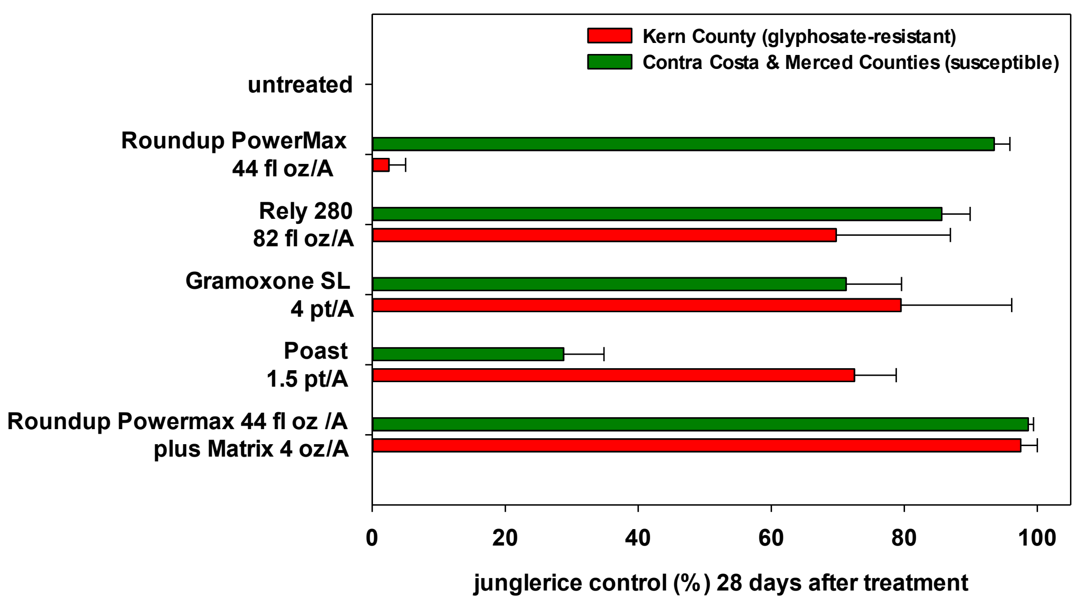


Figure 2. Summary of field trial conducted in tree nut crops of California during the summer of 2013 and 2014 to evaluate postemergence control of junglerice. The Kern County junglerice population was known to be resistant to glyphosate, and the Contra Costa and Merced Counties populations were glyphosate-susceptible.

Complete control of junglerice with postemergence herbicide programs can be a challenge in orchards. Summer grasses like junglerice can germinate throughout the growing season as long as soil moisture and temperature conditions are favorable; thus repeated applications of postemergence treatments will likely be needed. Additionally, junglerice plants grow rapidly and can become too big for effective control with some herbicides. Survivors and new plants can produce seed before tree nut harvest operations and further increase the infestation in the orchard. Therefore, postemergence-only herbicide programs are not likely to provide consistent and economical control of junglerice in orchard but should instead be used as part of a management program that includes preemergence herbicides applied during the winter season.

Preemergence herbicides are an important tool to be included in the weed control of junglerice and other weeds in tree and vine crops. From a resistance management standpoint, most of the preemergence herbicides have different modes of action than the available postemergence herbicides. In addition to aiding rotation of herbicide modes-of-action, the preemergence herbicides provide extended control of multiple flushes of germinating junglerice during spring and part of the summer. For example, excellent control of junglerice was observed for more than 125 days with several preemergence herbicide treatments (figure 4).A list of preemergence herbicides registered in tree & vine crops of California is available at the Weed Research and Information Center (WRIC) website (http://wric.ucdavis.edu).

Figure 3: Junglerice plants 14 and 28 days after application of paraquat (Gramoxone 4 pt/A) in a walnut orchard in Contra Costa County. Plant regrowth and new germination was observed at 28 DAT.

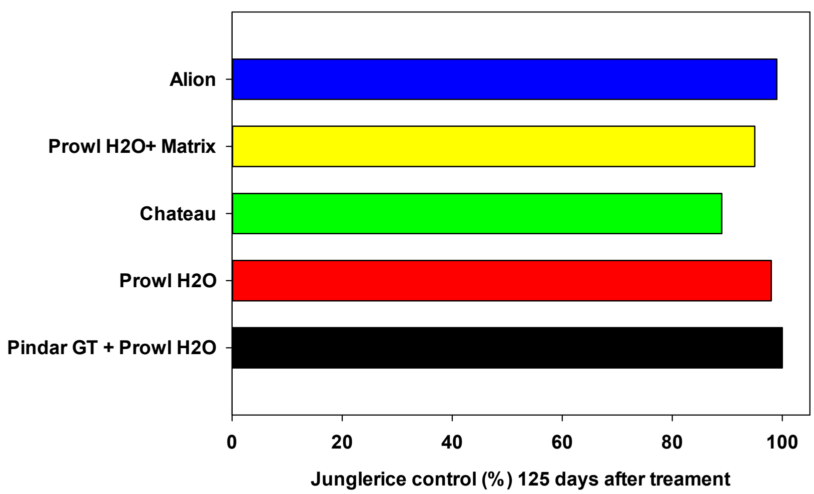


Figure 4: Junglerice weed control (%) of several preemergence herbicides tank mixed with glyphosate (Roundup PowerMax 2qt/A) and glufosinate (Rely 280 2 qt/A) 125 days after application in an almond orchard near Wasco, CA. This population was not well controlled with postemergence treatments of glyphosate alone.

(Continued on page 10)

(Continued from page 9)

Several preemergence and postemergence herbicides provided effective control of glyphosate-resistant junglerice in tree nut crops. This suggests that there is no cross-resistance to these important management tools. Growers can use these herbicides with different modes of action in an integrated approach to reduce the selection pressure for glyphosate-resistant junglerice.

In addition to the herbicide research described here, UC Davis, UCCE, CSU Fresno researchers as well as members of the private sector are also addressing aspects of biology, ecology, and genetics of glyphosate resistance. These collaborative efforts should lead to integrated weed management strategies for junglerice and other problematic weeds in tree and vine crops.

Weed Management in Tulelake Processing Onions

Rob Wilson[1], Center Director/Farm Advisor (rgwilson@ucanr.edu), Darrin Culp[1], IREC Superintendent of Agriculture (daculp@ucanr.edu), Kevin Nicholson[1], IREC Staff Research Associate (kwnicholson@ucanr.edu), Steve Orloff,[2] Siskiyou County Director/ Farm Advisor (sborloff@ucanr.edu),

University of California Intermountain Research & Extension Center[1], UC Cooperative Extension, Siskiyou County[2]

Figure 1. 2012 weed control trial in a processing onion field near Tulelake, CA.

Kochia, common lambsquarter, redroot pigweed, and hairy nightshade are recurrent weed problems in processing onions grown in Tulelake, near the California/Oregon border. These weeds reduce onion stands, decrease yields, and obstruct harvest equipment. Historically, growers have tried to avoid planting onions in fields with a history of high weed populations, but limited water availability and white rot have restricted suitable onion acreage to a point where growers are obligated to plant in certain fields regardless of weed pressure.

Weed control in onions can be particularly difficult due to the early emergence of weeds and the slow emergence and growth of onions. Processing onions are grown on wide beds with close onion spacing, which prevents mechanical cultivation between seed-lines. Thus hand-weeding and herbicides are the two main weed control methods in processing onions. Tulelake growers are heavily reliant on herbicides for weed control, as labor intensive hand-weeding is only economical when weed populations are very low. Preemergence herbicides applied shortly after planting often provide the best weed control in onions because they control rapidly-growing weeds before they compete with the crop. On the flip side, early herbicide applications increase the risk of injury, as small onions are especially sensitive to herbicides.

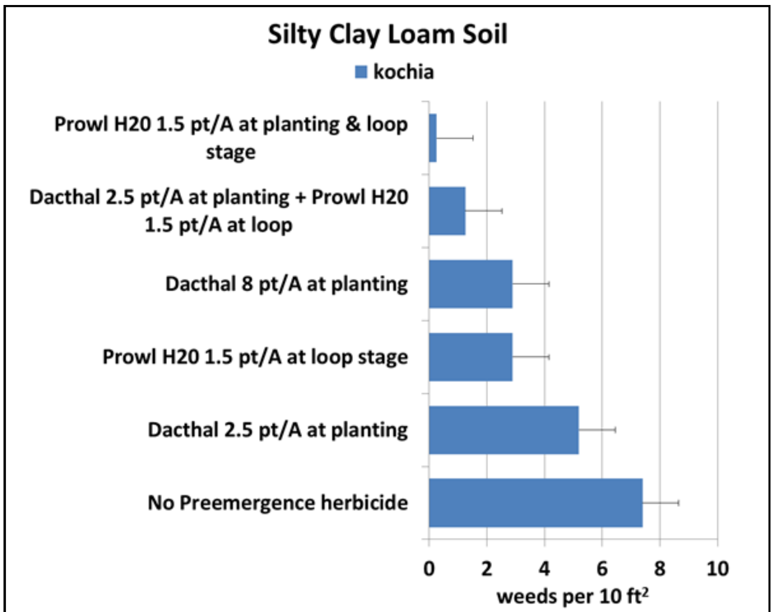
Herbicide screening studies were conducted in Tulelake, CA from 2011 to 2014 with funding support from the California Garlic and Onion Research Advisory Board. Studies were designed to evaluate preemergence and postemergence herbicides applied at several rates and application times on two very distinct soil types, silty clay loam and sandy loam. Weed density, onion stand, crop injury, and onion yield were measured to determine treatments' influence weeds and onion yield.

DCPA (Dacthal) applied post-plant and pendimethalin (Prowl H_20) applied at or before the loop stage reduced kochia, lambsquarters, and hairy nightshade density compared to the untreated control (Figure 3). There was an additive ef-

(Continued from page 10)

fect when these two herbicide treatments were used in combination especially for kochia control (Figure 3). For example, Dacthal at the highest rate (8 pt/A) and Prowl H_20 reduced kochia density by 61% when used alone, while Dacthal at the lowest rate (2.5 pt/A) reduced kochia density by 84% when combined with Prowl H_20. Combining these two herbicides allowed for the Dacthal rate to be reduced to a more economical rate (2.5 pt/A) on all soil types without a decrease in hairy nightshade, kochia, pigweed, and lambsquarter control compared to the label recommended rate of Dacthal (Figure 3). Prowl H_20 application at planting provided better control of kochia compared to Prowl H_20 application at the loop stage (figure 3).

Figure 2. IREC weed crew measuring weed density following herbicide application.



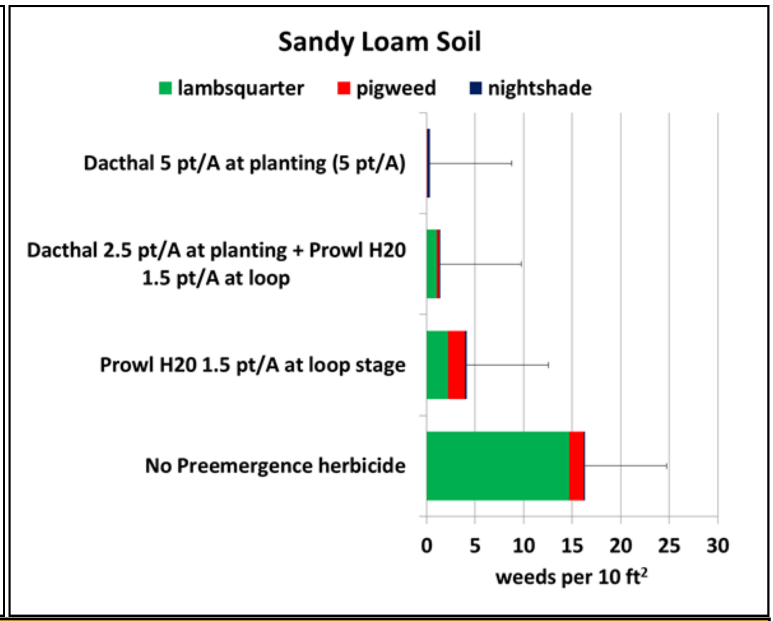


Figure 3. Weed Densities at the 4-leaf onion growth stage for Dacthal and Prowl H20 broadcast applied at various timings on two soil types. Herbicide application at planting occurred after onions were planted immediately before the first sprinkler irrigation. All treatments at both locations received GoalTender at the 1.5-leaf stage and Goal 2XL + Buctril at the 2.5 leaf stage. Error bars represent at 95% confidence interval.

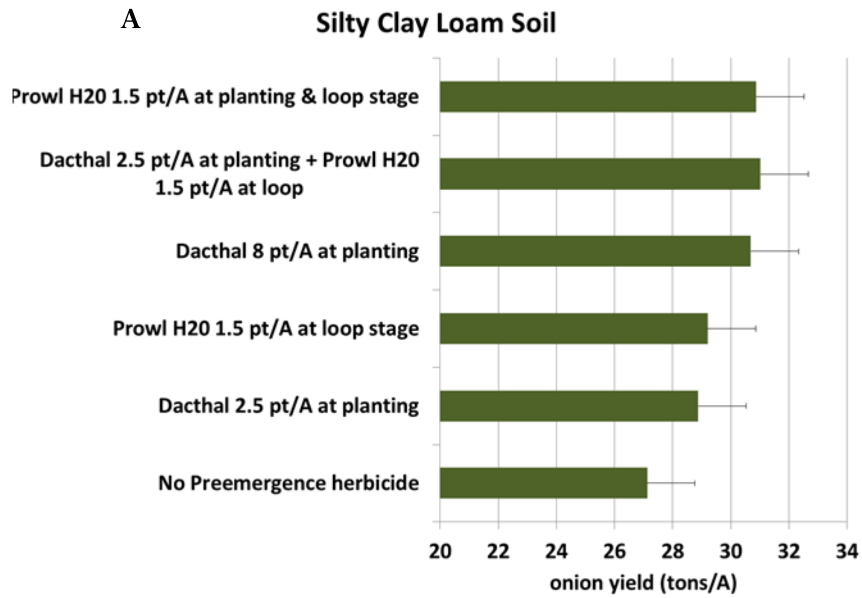
Unfortunately, no preemergence treatment reduced weed density low enough for control to be considered effective without follow-up postemergence treatment. Dacthal and Prowl decreased weed competition during onion seedling development, and they stunted the growth of weed escapes making the weeds more susceptible to postemergence herbicides. Dacthal and Prowl H_20 at labeled rates did not reduce onion stand or onion yield compared to hand-weeded plots in multiple trials on multiple soil types (Figure 4). In fact, Dacthal + Prowl H_20 treatments often had the highest onion yield in the trial due to the lack of weed competition (Figure 4).

(Continued on page 12)

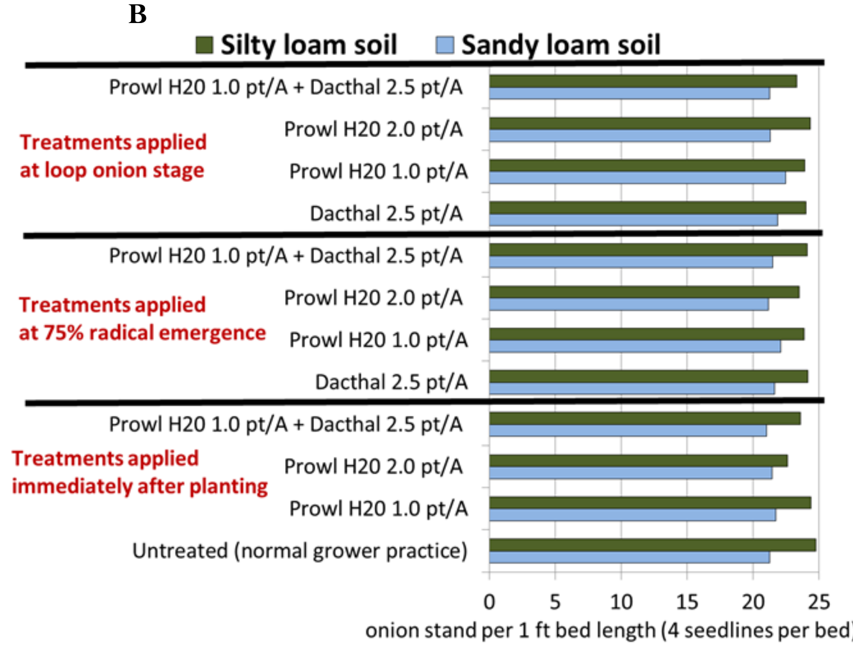
(Continued from page 11)

Figure 4. Influence of Dacthal and Prowl H20 treatments on onion yield in a field infested with kochia (A) and onion stand (B) in two commercial fields with different soil types. Onion stands for all treatments were not statistically different.

A



B

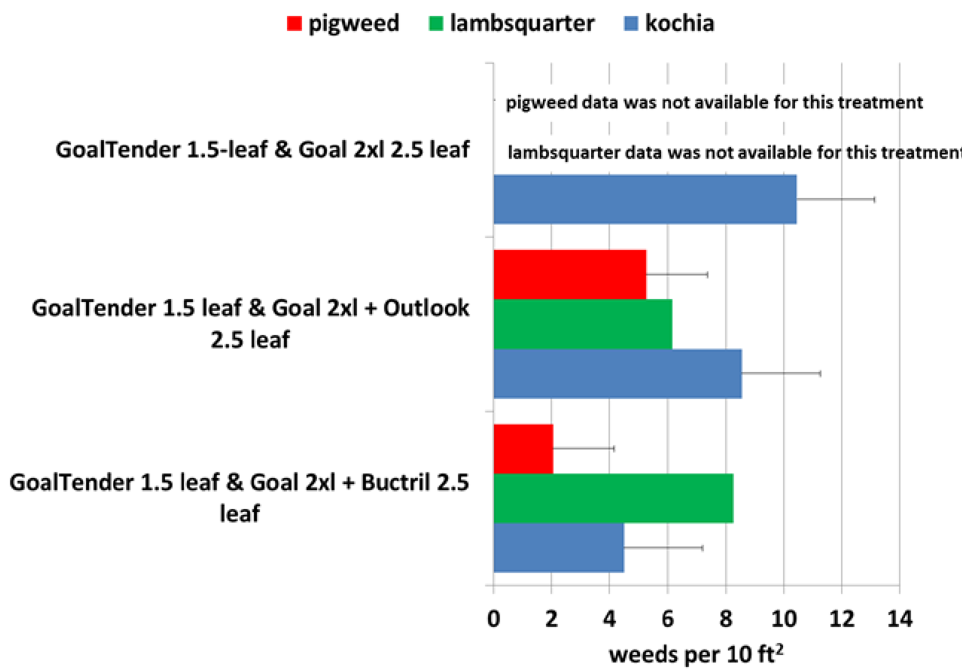


Oxyflurofen (GoalTender) applied at the 1.5 leaf stage followed by oxyflurofen (Goal 2xl) + bromoxynil (Buctril) applied at the 2.5 leaf stage was the most effective labeled postemergence herbicide program for controlling kochia, lambsquarter, and hairy nightshade (Figure 5). Applying GoalTender at the 1.5 leaf stage improved control of most weed species compared to delaying the first application of oxyflurofen until the 2.5 leaf stage. At the 2.5 leaf stage, Goal 2xl + Buctril provided better kochia control compared to Goal 2xl + dimethenamid-p (Outlook) or Goal 2xl alone (Figure 5). Fluroxypyr (Starane) applied between the 3-5 leaf stage provided over 90% kochia control in cases where kochia escaped Goal 2xl + Buctril treatment. Fluroxypyr is currently not labeled for use on onions in CA. All postemergence herbicides injured onions (stunting, leaf curling, or chlorosis), but the injury was usually temporary and did not reduce onion yield. One exception was Goal 2xl + Buctril + Outlook applied as a tank-mix at the 2.5 leaf stage. This treatment reduced onion yield in two of four trials at IREC.

(Continued on page 13)

(Continued from page 12)

Figure 5: Postemergence weed control at the 4-leaf onion growth stage averaged across Dacthal and Prowl H20 preemergence treatments at three sites with different weed problems. Soil type was silty clay loam at the kochia site and sandy loam at the redroot pigweed and common lambsquarter sites. Error bars represent a 95% confidence interval. Lambsquarter control did not differ between treatments.



Tulelake growers have long thought that Dacthal was not effective on Tulelake soils believing that the herbicide was tied up due to the fine soil texture and high organic matter content. This research refutes this previously held belief and demonstrates that Dacthal applied after planting can be effective and economical when used at affordable rates and combined with Prowl H_20. Studies conducted on multiple soil types showed that Prowl H_20 was an effective preemergence herbicide by itself when applied at the loop stage or before onion emergence. Application of Prowl H_20 at the loop stage worked well in most situations, but in fields with a heavy kochia population application before onion emergence improved kochia control. Currently, Prowl H_20 applied at loop has a 24c registration in California and Prowl H_20 applied at 75% radical emergence has a 24c registration in Oregon.

Herbicide programs incorporating both preemergence and postemergence herbicide treatments were capable of reducing weed density by more than 90% compared to the untreated control. No single herbicide or herbicide combination treatment provided 100% weed control at multiple sites, suggesting hand-weeding is necessary for follow-up weed control in most field situations. Top-performing herbicide treatments made hand-weeding economical (less than $75/A) while hand-weeding labor costs associated with poor-performing herbicide treatments and the untreated control were $200/A to $400/A one year when hand-weeding time was estimated.

Passive restoration of California Native Grassland and Coastal Sage Scrub

Carl Bell (cebell@ucanr.edu)
Emeritus, University of California. San Diego, CA

Private organizations and public agencies have done a great job of acquiring and preserving many thousands of acres of open space in Southern California as natural areas over the past few decades. But many of these properties are severely degraded and restoration to native vegetation has been challenging.

Passive restoration (just getting rid of the non-native plants so the remnant native population has a chance) is the simplest and least expensive approach. It has been tried frequently with variable success, mostly limited success in my opinion. As a relative newcomer (since 2000) to the habitat restoration arena (but with 20 years of research experience on weeds), I have tried to observe and learn from others. By 2005 I had concluded that one problem was the practice of killing weeds for one year and planting natives the next, which were swallowed up by the weeds as soon as it rained. My experience told me that the weed seed bank had to be eliminated or at least greatly diminished to give the natives a chance.

So I set out to test my hypothesis. In 2006 we were able to set up a field experiment at the County of San Diego Barnett Ranch Reserve near Ramona to see if concentrating on reducing the weed seed bank would bring back CSS habitat. My collaborators for this project were Edie Allen, CE Natural Resources Specialist & Professor of Plant Ecology; Milton McGiffen, Jr, CE Weed Specialist; Kristen Weathers, PhD candidate in Edie's lab; and several students and technicians in Edie's lab; all at UC Riverside. The County of San Diego provided space at the reserve and financial support for Kristen.

The experiment was very simple; we set up two sites, one on a rocky/gravely south facing slope and another on a flatter area with clay loam soil. In each site we treated some plots with annual applications of glyphosate for four years applied in the spring and compared these to an untreated control. We also split each plot in two, one half was seeded with native shrubs and herbaceous perennials; the other half was not seeded.

As they say, "the manuscript is in preparation" but we can share the basic results. By rigorously killing the weeds for four years, we saw an increase of native plant cover from about zero to 50% in the south-facing site. Over the course of the four years, we observed about 60 native forb and perennial species! The flatter site had similar results, but over time did not hold up very well. Oh yeah, the sowing did not

(Continued on page 15)

work very well either, but it worked far better in the treated plots, the untreated plots had few to no shrubs emerge and survive.

Another experiment was established in 2007 to see if this approach would increase an extant but small population (≤ 2% cover) of purple needlegrass (*Stipa pulchra,* which by the way is the CA State Grass). In this experiment my collaborators were John Ekhoff, Biologist, CA Fish and Wildlife and Marti Witter, Fire Ecologist, National Park Service Santa Monica Mountains National Recreation Area. We tested several herbicides that might be able to kill the weeds and not do significant harm to the needlegrass. The herbicides were applied annually for three years and were sprayed broadcast (over everything in the area, including the needlegrass). There were eight different herbicides tested, some in combination with each other.

We had one real hit, a combination of Fusilade DX and Garlon 4. This combination killed most of the annual grasses and broadleaf weeds. The result was an increase in cover from 0.5% in the untreated control to 20-30% in the treated plots. The plants were also larger and had greater foliage (biomass). Some of the other herbicide treatments showed some possible utility, but were not consistently effective and/or safe to the needlegrass. This research was just published in the California Native Grassland Association Fall 2013 newsletter, Grasslands. They have given me permission to post a pdf of the paper on my website for reading or download, it's at; http://ucanr.edu/sites/socalinvasives/Research_Papers/Journal_and_other_peer_reviewed_papers/.

So I think that I can accept my hypothesis: kill the weedy annuals thoroughly for several years; do not let any of them produce seed; and the natives will respond marvelously. My reward is seeing natives thrive, illustrated by the photos above all taken at these sites over the past 7 years.

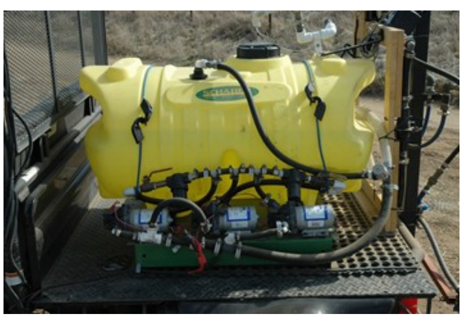
Riding instead of walking: The UTV sprayer system for large-scale invasive plant control

Carl Bell, (cebell@ucanr.edu)
Emeritus, University of California. San Diego, CA

For a You Tube version of this article, please go to http://youtu.be/iMxG9Pfle94

Let's say you are trying to treat a 25-acre site with glyphosate applied broadcast to kill the suite of non-native annuals (wild oats, black mustard, filaree, etc.) to get it ready to re-seed with natives. Let's also say your sprayer is the standard 3 gallon backpack sprayer, fitted with an 8004 flat fan nozzle, you are walking at 2.5 mph (a comfortable walking pace) and you are spraying a 30 inch swath as you go. Using these values, you are applying herbicide at 30 gallons per acre (GPA) and it would take you about 80 minutes to spray one acre or about 33 hours to spray the 25 acres. And that's not counting the time to stop and refill the backpack; one 3 gallon tank load at 30 GPA means you would need 10 tank loads per acre or 250 tank loads for the 25 acres. If we are going to make a serious dent in restoring native habitat from non-native annual grassland there has to be a better way, right ?

One answer is using an all-terrain vehicle, a one person ATV Quad or a two person UTV like a Kawasaki Mule, John Deere Gator, or a Polaris such as the one being driven by Chris McDonald, UCCE Desert Natural Resources Advisor. For a good review of the pros and cons of different types of vehicles, see http://techlinenews.com/articles/2013/selecting-an-herbicide-spray-platform-for-wildland-and-natural-area-weed-management. You then have the ability to safely and easily apply herbicide to many acres a day. There are lots of these vehicles in use around California to get into remote and rugged sites. And some of these have herbicide spray tanks mounted on them with booms or boomless spray nozzles.



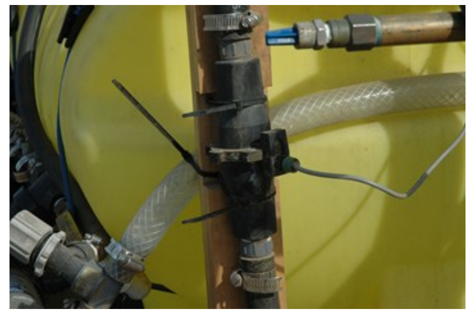
The one I designed and built two years ago is based upon a Kawasaki Mule with a 60 gallon tank in the bed in back, uses electric diaphragm pumps and two boomless nozzles that cover a 34 foot swath. When driven at 5 mph and spraying at 9 GPA, one tank load will cover 6.67 acres. So a 25 acre site can be done with less than four tank loads. It will take less than three minutes to treat an acre so the 25 acres will be finished about 1 hour 15 minutes. Refilling the tank takes time, about 40 minutes, but you only have to refill 3 times, not 249. The previously formidable job is now done in a day. I've also discovered that riding is easier and more fun than walking, just took me 30 years to figure that out.

This UTV sprayer has some "State of the Art" features that are not typical of other ATV or UTV sprayers that I am aware of in California, or at least in southern California. I knew that computer controlled spray and tracking systems are nearly universal in agriculture these days, but I didn't have any information on small-scale systems suitable for ATV's/UTV's. So I turned to Google and found the following document by Gary Kees and colleagues with the US Forest Service Technology and Development Program in Missoula, Montana, http://www.fs.fed.us/t-d/pubs/pdfpubs/pdf08242802/pdf08242802dpi72.pdf. This presents a very detailed description and evaluation of exactly what I was looking for. Their sprayer was on an ATV, but it seemed like it would work just as well on an UTV, so I copied it almost to the letter for the UTV sprayer system. There is much more information in this article on these systems than I can present here, so it is well worth reading carefully if you want to set up your own sprayer.

(Continued on page 17)

The sprayer on the UTV is controlled by a dash-mounted computer and adjusts the spray volume based upon driving speed, which is measured by an integrated GPS system. The computer measures the volume going to the nozzles while spraying with a flowmeter (below). If the target speed of 5 mph varies then the target 9 GPA spray volume will be off and hence the herbicide rate will be wrong. The computer uses speed and flow to decide how much to adjust the spray volume through a servo valve (below).

If the speed is too slow, the volume is decreased to stay at 9 GPA; if it is too fast the volume is increased. There are limits, but between speeds of 3.5 to 7 mph the sprayer will deliver the same spray volume. In some of the rough terrain being treated, it is more important and safer to be concentrating on the path ahead rather than trying to watch a speedometer in order to keep the spray volume constant.



Another electronic device important to using this system to spray large open areas is a GPS based tracking system so you have a path to follow. The tracking device is also a small computer with an easy to read screen that sits on the dash in front of the driver. Before you start you enter a swath width for your sprayer. I narrow it down from my actual width, say 30 feet instead of 34 feet to have some overlap, but not too much. When you start to drive, you mark a beginning point (A), then drive across the site and mark the end point, (B). The device remembers your track, and it doesn't have to be straight, it can curve. After you complete one pass and turn around to head back the screen will show you a line to follow that is one swath width away from the first line. The mule is represented on the screen with an arrow, you just need to keep the arrow on the line as you drive back. Then turn again and repeat until you run out of spray mix. With this tracking system you can confidently treat large unmarked areas without worrying about missing areas or over-spraying too much.

For the most part this system worked well in the first season of use. I was helping Chris McDonald treat some larger areas in San Bernardino and Riverside Counties and we had problems with pump capacity and electrical amperage to run the pumps, so we did a pretty extensive re-model in the summer of 2012, adding more pump capacity and supplying more amperage from deep cycle batteries.

How much will this cost? There are alternative manufacturers and products for everything below; I made decisions based upon getting what I felt was the most value for my financial resources. I also spent about 6 weeks of actual time (8 hour days) researching, designing, shopping, building and testing the mule before it ever got to the field. There are several ATV/UTV choices on the market. I picked the Kawasaki Mule based on price (about $11,000 new) and capacity. It has a 700 pound carrying capacity in the bed, which meant I could easily use a 60 gallon tank, which when full of water at 8.3 pounds per gallon weighed about 500 pounds. One downside to the Mule is that many of the essential elements to using it in the field, like skid plates and headlamp guards, are sold as accessories and I had to install them. The 60 gallon tank cost about $500. The tracking system (Centerline 220 manufactured by TeeJet Company) cost about $1000. The Spray Mate II computer system from Micro-Trak Company cost about $1100. Pumps, solenoid valves, and miscellaneous items added another $1200. And you need a trailer to haul the mule around; that will cost you about $2200. The total is roughly $17,000. Not too bad in my opinion considering the capabilities and being able to really scale up your invasive plant control efforts. If you would are interested in building up something similar, please contact me and we can discuss this in more detail.

CWSS Research Update and News

Send research updates and news articles to Steve Orloff,
Non-conference Education Director
sborloff@ucanr.edu - Office (530) 842-2711

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