Herbicidal Efficacy Testing, Crop Safety Evaluations, and Glyphosate-Resistant Weed Management in Central Valley Almond Orchards

Project No.: **13-HORT12-Hanson**

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Objectives:

The overall goals of the tree and vine weed science research and extension program at UC Davis (http://ucanr.org/brad.hanson) is to provide information on weed management and herbicide issues to California growers, Pest Control Advisers, and the UC Cooperative Extension network. Although the almond industry is one of the key stakeholder groups for this program, the majority of our research is broadly applicable to, and partially supported by, other orchard and vineyard commodities in the state and the pest control industry.

As in previous years, the objectives proposed for the 2013-14 Almond Board of California fiscal year mirror the major research areas in our program:

1. Evaluation and testing of newly registered materials, tank mix partners, and application techniques for control of weeds with a special focus on glyphosate-resistant species.

2. Evaluating herbicide injury symptoms in almonds and developing training tools for Farm Advisors and pest control industry advisers and consultants.

Interpretive Summary:

Weed management issues such as new weeds, herbicide resistance, crop injury, and changing pesticide regulations significantly impact orchard cropping systems. Rapid and accurate responses depend on having an experienced research team with direct knowledge of

weed control tactics used in each crop. The broad weed management research partially supported by this Almond Board of California project provides direct and practical benefits to almond producers, pest control advisers, county-based cooperative extension advisors, as well as related orchard and nursery industries.

Our statewide research and extension program is designed to balance the solutions-based research needs of orchardists and the crop protection industry with the need to develop an understanding of biological principles that impact weeds and weed control in these cropping systems. Results are routinely disseminated through conventional outreach venues such as the annual Almond Industry Conference and the UC Cooperative Extension network as well as online resources like the Weed Research and Information Center (www.wric.ucdavs.edu), the UC Weed Science blog (http://ucanr.edu/blogs/UCDWeedScience/index.cfm), and the Almond Doctor blog (http://thealmonddoctor.com/).

Materials and Methods:

Herbicide efficacy**:** We conducted approximately 30 herbicide efficacy trials in commercial orchards or at research stations in FY2013, primarily in almonds but some protocols were also tested in other orchard and vineyard crops. In order to address differences in weeds, soil conditions, and production practices, orchard trials ranged from Colusa to Kern County during this reporting period.

Herbicides in the small-plot experiments usually were applied using CO2 pressurized backpack sprayers while treatments in large-plot experiments were treated with an ATV mounted research sprayer. In the small plot trials, plots typically were 7 ft wide (strips) by 20-40 ft long and replicated four times. In the large plot trials, plots were 7 ft wide and 100-250 ft long and replicated three times. In most field trials, visual weed control evaluations were made at approximately monthly intervals during the season. In a few specific trials, quantitative weed count and biomass data also were collected. Herbicide efficacy treatments focused on residual herbicide comparisons and on post-emergence control of key weeds including glyphosate-resistant hairy fleabane and junglerice. Control of other common orchard weeds including yellow nutsedge, mallow, and cut-leaf geranium was evaluated if present.

Greenhouse experiments and weed screening tests were conducted to support the field work, answer grower questions, and to develop extension materials. For example, several weed seed samples were submitted by growers concerned about herbicide resistance. These samples which included Palmer amaranth, annual bluegrass, witchgrass, goosegrass, and wild radish were subjected to dose-response testing in the greenhouse to evaluate the level of tolerance/resistance to glyphosate or other herbicides (**Figure 2**).

Because almonds and other tree nuts are harvested from the orchard floor, late season weed control is very important; however, complete control of mature weeds can be difficult to achieve. In some cases, survivors regrow and still set seed and contribute to the soil seed bank. This partial control may be a contributing factor to herbicide resistance in some species. Several greenhouse and field experiments are being conducted to evaluate the effects of weed size on the reproductive ability of glyphosate-resistant weeds in Central Valley perennial cropping systems.

Crop safety experiments**:** Several research and demonstration experiments were initiated or are continuing to address herbicide injury questions from the almond industry and UCCE Farm Advisors. We expect that these types of projects will continue and evolve as needed to address real or perceived evolving issues with herbicide safety in tree crops. Herbicide symptomology demonstrations were conducted on young almond trees at the Nickels Soil Lab near Arbuckle, CA. Research personnel applied simulated drift rates of glyphosate, glufosinate, penoxsulam, oxyfluorfen, simazine, and other herbicides directly to the almond foliage. Rates included 20%, 10%, and 5% of nominal use rates. Short-term injury, long term growth reductions, and a symptomology photo set are being developed to assist in answering industry questions on accidental injury to almond orchards. These photos were used at two separate Farm Advisor training sessions this fiscal year. Additionally, many of the photos from these projects are being included in an online symptomology website being developed by Dr. Kassim Al-Khatib (anticipated launch in late 2014). A new experimental orchard was established at UC Davis to facilitate future crop safety and weed control efficacy studies.

Related research**:** Although not directly supported with funding from the Almond Board of California, two new lines of research were initiated this fiscal year that pertain to weed management in almonds. In the first, the underlying genetics and physiological causes of glyphosate resistance in junglerice and other related grasses are being explored by a recently hired postdoctoral researcher. This project, funded primarily by CDFA and based on earlier Almond Board of California funded research, will directly contribute to almond weed control recommendations and will also provide long-term support toward the understanding of resistance in California perennial crops. In a second project, a postdoctoral researcher working in collaboration with the weed program and Dr. Patrick Brown is conducting preliminary work on potential interactions among glyphosate and almond micronutrient status. Both of these research areas were initiated in direct response to grower and almond industry questions.

Results and Discussion:

Because of the number of almond-related projects conducted and the diverse funding that supported this research, only a portion of the FY2013 weed science research is presented and discussed. The selected data that follows present some of the most relevant results and reflect the breadth of our program partially supported by the Almond Board of California.

Label changes*:* Few major herbicide registration changes were made in FY2013 that affect almond (**Figure 1**). The most important change is that the Alion label now allows use on 1 year old trees rather than 3 years old. The Rely 280 shortage the past couple years should be greatly reduced in the coming year as Bayer CropScience ramps up their production and at several new glufosinate products (e.g., Lifeline, Cheetah, Willowood Glufosinate, Forfeit and Refer) are registered or are under review by the CA Department of Pesticide Regulation.

Residual herbicides: Similar to the situation faced by almond growers, residual herbicide research was challenged by the dry winter. However, several experiments were conducted to compare the efficacy of Pre-emergence (PRE) herbicides alone or in combination and included

a focus on Pindar GT, Alion, Matrix, and Chateau. In particular, combinations of Alion and Matrix were tested to allow comparison of different rates and ratios of these products.

Building on the large plot demonstrations conducted in FY2012 (Project 12-HORT12-Hanson), the same set of treatments were evaluated in an almond orchard near Wasco, a walnut orchard near Atwater, and an almond orchard near Escalon (**Tables 1-3**). At Wasco, weed control was fairly good with most treatments in the first two months after application; only the glyphosate-only program and Trellis and Prowl having a few weaknesses on the weeds present (**Table 1**). By 122 days after treatment (DAT), treatments began to separate with the best performance provided by the split-timings of PindarGT or Prowl followed by glyphosate plus Prowl. At the Atwater site, there were few differences among treatments because of good performance and relatively low weed pressure (**Table 2**). However this site was also uniformly oversprayed in February with glyphosate and oxyfluorfen which may have masked possible treatment differences. At the Escalon site, all treatments performed well though about March (**Table 3**). By the April rating (122 DAT), performance varied widely among treatments and specific weeds. The most uniform and full-spectrum control was provided by Alion or the split applications of PindarGT or Prowl followed by glyphosate and Prowl (**Table 3**).

Several protocols designed to compare various Matrix and Alion combinations were implemented in tree nut orchards in Wasco, Chico, and Escalon (**Tables 4-7**). At the Wasco almond site, performance varied depending on whether the herbicides were effective on junglerice, hairy fleabane, or both (**Table 4**). At the Chico walnut site, which had good herbicide incorporation due to the use of solid set sprinklers, performance on junglerice and fleabane was quite good regardless of treatment combination or Alion rate (**Table 5**) until the field bindweed began to dominate the site. At the Escalon almond site, which had a very timely rain after application, weed control was good up to 122 DAT with most treatments except for Pindar GT or GoalTender due to breakthrough of some grasses and broadleaf weeds (**Table 6**). Even at 196 DAT, a few split application treatments still had over 90% weed control. The second Chico walnut experiment (also sprinkler incorporated) had very good control of both junglerice and hairy fleabane up to 160 DAT until field bindweed began to dominate the site in late spring (**Table 7**).

Post-emergence herbicides: A few trials were conducted over winter and early spring to evaluate post-emergence (POST) weed control. Two experiments were conducted to compare performance of several glufosinate herbicides – in this protocol; Rely 280 was compared to Lifeline, Reckon, and Cheetah at three equivalent rates. At the Davis site (a fallow field); there were no performance differences among formulations (**Table 8**). All glufosinate rates provided excellent (>93%) control of tumble pigweed; however, a rate response was noted for prostrate knotweed with the highest rate (82 fl oz/a) providing better but still marginal control with all formulations. At this location, no significant differences were noted among glufosinate formulations. Similar results were observed in a tree nut site near Chico dominated by ryegrass (data not shown).

Two experiments were conducted to evaluate the addition of pyraflufen-ethyl (Venue) to increase activity of other POST herbicides. At the Davis site (fallow field), pigweed control was slightly reduced when Venue was added to Roundup Powermax (**Table 9**), presumably due to

reduced uptake and/or translocation caused by rapid desiccation. Venue alone caused substantial injury to pigweed but subsequent regrowth resulted in unsatisfactory control by 21 DAT. Compared to Roundup Powermax Rely 280, or Gramoxone SL applied alone, adding Venue increased prostrate knotweed control at the 7 DAT rating; however, the extra activity was no longer apparent by 21 DAT. Similar results were noted at a prune orchard site near Artois (**Table 10**).

A post-emergence treatment comparison was conducted in April in an almond orchard near Wasco dominated by glyphosate-resistant junglerice (**Table 11**). Although somewhat variable among replicates due to weed emergence patterns, junglerice and hairy fleabane control (and weed biomass reductions) were best with Rely 280, and Roundup Powermax plus either 2 or 4 oz/A Matrix (**Table 11**).

Several trials were conducted or are currently underway to evaluate the effect of different low VOC tank mix partners with GoalTender as a replacement for high VOC uses of Goal 2XL and similar herbicides. In the Davis site, GoalTender plus Roundup performed as well as Goal 2XL plus Roundup on pigweed, bindweed, and sharppoint fluevelin. Several of the other tank mix partners did not perform as well on some species (**Table 12**). Additionally, several trials are currently underway to evaluate a wide range of adjuvant partners to increase the post-emergence activity of GoalTender (data not shown).

In support of ongoing greenhouse trials, a field trial was conducted in an almond orchard near Arbuckle to evaluate the effects of later-than-ideal preharvest burndown applications on the regrowth potential and reproductive capacity of glyphosate resistant hairy fleabane. These field data support the need for earlier application timings on glyphosate-resistant fleabane as efficacy drops dramatically once the plants reach reproductive stage (**Figure 3**). Ideally, an effective pre-emergence herbicide program followed by early spring maintenance operations will be used as part of an integrated weed management approach to reduce the dependence on these late treatment that are often only partially effective.

Research Effort Recent Publications:

Okada, M, B.D. Hanson, K.J. Hembree, Y. Peng, A. Shrestha, C.N. Stewart, S.D. Wright, and M. Jasieniuk. 2014. Glyphosate resistance is more widespread in Conyza bonariensis than in closely related C. canadensis in California. Weed Research (in press).

Abit, M.J.M. and B.D. Hanson. 2013. Evaluation of pre-emergence and post-directed herbicides on Prunus rootstock safety infield-grown almond tree nurseries. Hort Technol. 23:462-467.

Miller, T, B. Hanson, E. Peachey, R. Boydston, K. Al-Khatib. 2013. Glyphosate stewardship: keeping an effective herbicide effective. University of California, Division of Agriculture and Natural Resources, ANR Publication 8492. 5 pg.

Al-Khatib, K., B. Hanson, T. Miller, E. Peachey, R. Boydston. 2013. Managing glyphosate-resistant weeds in glyphosate-resistant crops. University of California, Division of Agriculture and Natural Resources, ANR Publication 8494. 7 pg.

Hanson, B., A. Fisher, A. Shrestha, M. Jasieniuk, E. Peachey, R. Boydston, T. Miller, K. Al-Khatib. 2013. Selection pressure, shifting populations, and herbicide resistance and tolerance. University of California, Division of Agriculture and Natural Resources, ANR Publication 8493. 6 pg.

Peachey, E., R. Boydston, B. Hanson, K. Al-Khatib, and T. Miller. 2013. Preventing and managing glyphosate-resistant weeds in orchards and vineyards. University of California, Division of Agriculture and Natural Resources, ANR Publication 8501. 7 pg.

Hanson, B.D. S. Fennimore, G. Browne, D. Doll, A. Johnson. 2014. A non-chemical alternative to soil fumigation: development and optimization of a steam auger system for preplant disinfestation of stonefruit and almond tree sites. Final Report to USEPA Region 9 for project X800T40101. 15 p. Submitted March 31, 2014.

Herbicide Registration on California Tree and Vine Crops -*(updated February 2014 - UC Weed Science)*

	Herbicide-Common Name *(example trade name)*	Site of Action Group[1]	Almond	Pecan	Pistachio	Walnut	Apple	Pear	Apricot	Cherry	Nectarine	Peach	Plum / Prune	Avocado	Citrus	Date	Fig	Grape	Kiwi	Olive	Pomegranate
			----- tree nut -------				- pome -		---------stone fruit ---------												
Preemergence	dichlobenil *(Casoron)*	L / 20	N	N	N	N	R	R	N	R	N	N	N	N	N	N	N	R	N	N	N
	diuron *(Karmex,Diurex)*	C2 / 7	N	R	N	R	R	R	N	N	N	R	N	N	R	N	N	R	N	R	N
	EPTC *(Eptam)*	N / 8	R	N	N	R	N	N	N	N	N	N	N	N	R	N	N	N	N	N	N
	flazasulfuron *(Mission)*	B / 2	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	R	N	N	N
	flumioxazin *(Chateau)*	E / 14	R	R	R	R	R	R	R	R	R	R	R	NB	NB	N	NB	R	N	R	R
	indaziflam *(Alion)*	L / 29	R	R	R	R	R	R	R	R	R	R	R	N	R	N	N	R	N	R	N
	isoxaben *(Trellis)*	L / 21	R	R	R	R	NB	NB	NB	NB	NB	NB	NB	NB	NB	N	NB	R	NB	NB	NB
	napropamide *(Devrinol)*	K3 / 15	R	N	N	N	N	N	N	N	N	N	N	N	N	N	N	R	R	N	N
	norflurazon *(Solicam)*	F1 / 12	R	R	N	R	R	R	R	R	R	R	R	R	R	N	N	R	N	N	N
	oryzalin *(Surflan)*	K1 / 3	R	R	R	R	R	R	R	R	R	R	R	R	R	N	R	R	R	R	R
	oxyfluorfen *(Goal, GoalTender)*	E / 14	R	R	R	R	R	R	R	R	R	R	R	R	NB	R	R	R	R	R	R
	pendimethalin *(Prowl H2O)*	K1 / 3	R	R	R	R	R	R	R	R	R	R	R	N	R	N	N	R	N	R	R
	penoxsulam *(Pindar GT)*	B / 2	R	R	R	R	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	pronamide *(Kerb)*	K1 / 3	N	N	N	N	R	R	R	R	R	R	R	N	N	N	N	R	N	N	N
	rimsulfuron *(Matrix)*	B / 2	R	R	R	R	R	R	R	R	R	R	R	N	R	N	N	R	N	N	N
	sulfentrazone *(Zeus)*	E / 14	N	N	R	R	N	N	N	N	N	N	N	N	R	N	N	R	N	N	N
	simazine *(Princep,Caliber 90)*	C1 / 5	R	R	N	R	R	R	N	R[2]	R	R	N	R	R	N	N	R	N	R	N
Postemergence	carfentrazone *(Shark)*	E / 14	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
	clethodim *(SelectMax)*	A / 1	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	N	R	N	N	NB	N	NB	N
	clove oil *(Matratec)*	NC[3]	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
	2,4-D *(Clean-crop, Orchard Master)*	O / 4	R	R	R	R	R	R	R	R	R	R	R	N	N	N	N	R	N	N	N
	diquat *(Diquat)*	D / 22	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
	d-limonene *(GreenMatch)*	NC[3]	R	R	R	R	R	R	R	R	R	R	R	N	R	N	R	R	R	N	N
	fluazifop-p-butyl *(Fusilade)*	A / 1	NB	R	NB	NB	NB	NB	R	R	R	R	R	NB	R	NB	NB	R	N	NB	NB
	glyphosate *(Roundup)*	G / 9	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
	glufosinate *(Rely 280)*	H / 10	R	R	R	R	R	N	N	N	N	N	N	N	N	N	N	R	N	N	N
	halosulfuron *(Sandea)*	B / 2	N	R	R	R	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	paraquat *(Gramoxone)*	D / 22	R	R	R	R	R	R	R	R	R	R	R	R	R	N	R	R	R	R	R
	pelargonic acid *(Scythe)*	NC[3]	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	N
	pyraflufen *(Venue)*	E / 14	R	R	R	R	R	R	R	R	R	R	R	N	N	R	R	R	R	R	R
	saflufenacil *(Treevix)*	E / 14	R	N	R	R	R	R	N	N	N	N	N	N	R	N	N	N	N	N	N
	sethoxydim *(Poast)*	A / 1	R	R	R	R	R	R	R	R	R	R	NB	NB	R	NB	NB	R	N	NB	NB

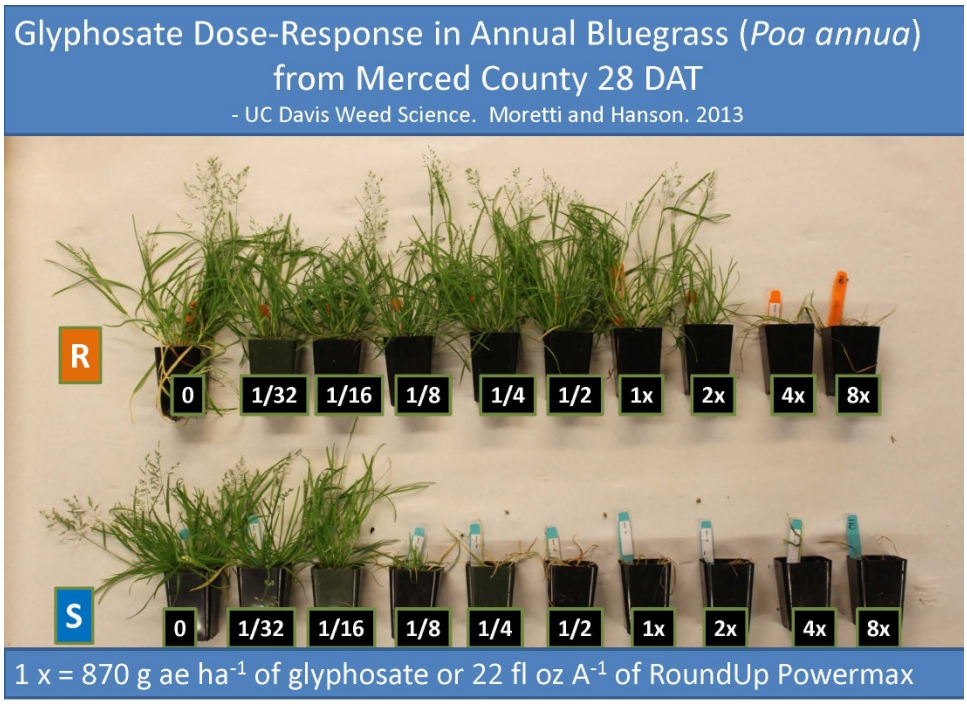
Notes: R = Registered, N = Not registered, NB = nonbearing. This chart is intended as a general guide only. Always consult a current label before using any herbicide as labels change frequently and often contain special restrictions regarding use of a company's product.

[1] Herbicide site of action designations are according to the Herbicide Resistance Action Committee (letters) and the Weed Science Society of America (number) systems. NC = no accepted site of action classification; these contact herbicides are general membrane disruptors.

[2] Simazine is registered on only tart cherry in CA.

Weed susceptibility information and the most up to date version of this table can be found at the Weed Research and Information Center (http://wric.ucdavis.edu)

Figure 1. Most recent update of tree and vine herbicide registration table. (Hanson)



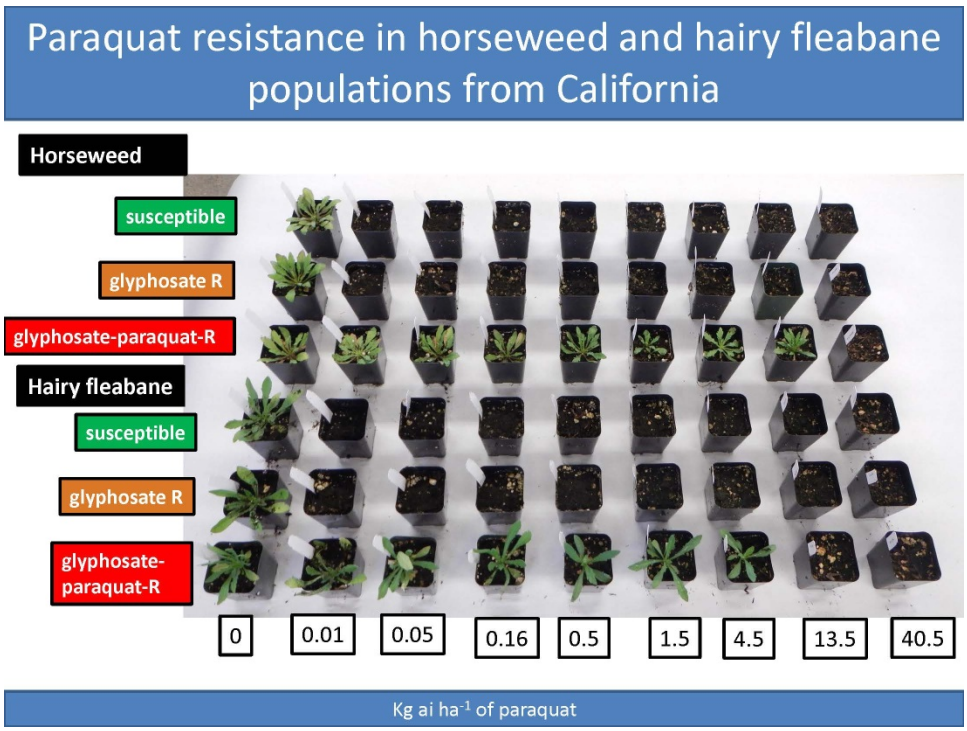


Figure 2. Examples of herbicide dose-response experiments conducted to confirm, describe, and understand new cases of herbicide resistance in California orchard crops. Top figure is annual bluegrass from Merced County with resistance to glyphosate and the lower figure is glyphosate-paraquat hairy fleabane and horseweed from several San Joaquin Valley locations. (Moretti and Hanson)

Table 1. Selected weed control evaluations from 2013-14 large plot demonstration conducted in an almond orchard near Wasco, CA. (Watkins, Moretti, and Hanson)

					---------- 61 DAT-A ----------			---------- 125 DAT-A ----------			
					Annual bluegrass	Chick-weed	Hairy fleabane	Annual bluegrass	Jungle-rice	Hairy fleabane	Overall
	Treatment		Rate		% control						
1	Untreated check				-	-	-	-	-	-	-
2	Roundup PowerMax	1	lb ae/a	A	49	80	55	97	72	99	72
	AMS	2	qt/100 gal	A							
	Roundup PowerMax	1	lb ae/a	B							
	AMS	10	lb/100 gal	B							
3	Roundup PowerMax	1	lb ae/a	A	100	100	83	100	95	79	91
	AMS	2	qt/100 gal	A							
	Goal 2XL	5	pt/a	A							
	Surflan	4	qt/a	A							
4	Roundup PowerMax	1	lb ae/a	A	98	96	90	92	71	80	80
	AMS	2	qt/100 gal	A							
	Pindar GT	3	pt/a	A							
5	Roundup PowerMax	1	lb ae/a	A	90	100	60	100	98	53	80
	AMS	2	qt/100 gal	A							
	Prowl H20	4	qt/a	A							
6	Roundup PowerMax	1	lb ae/a	A	100	100	70	97	89	65	78
	AMS	2	qt/100 gal	A							
	Chateau	10	oz/a	A							
7	Roundup PowerMax	1	lb ae/a	A	100	100	80	100	99	86	92
	AMS	2	qt/100 gal	A							
	Prowl H20	4	qt/a	A							
	Chateau	10	oz/a	A							
8	Roundup PowerMax	1	lb ae/a	A	95	100	98	99	95	90	93
	AMS	2	qt/100 gal	A							
	Prowl H20	4	qt/a	A							
	Matrix SG	4	oz/a	A							
9	Roundup PowerMax	1	lb ae/a	A	100	100	72	100	99	86	96
	AMS	2	qt/100 gal	A							
	Alion	6.5	oz/a	A							
10	Roundup PowerMax	1	lb ae/a	A	53	100	85	60	60	63	66
	AMS	2	qt/100 gal	A							
	Trellis	1.3	lb/a	A							
11	Roundup PowerMax	1	lb ae/a	A	96	100	38	100	100	100	98
	AMS	2	qt/100 gal	A							
	Prowl H20	3	qt/a	A							
	Roundup PowerMax	1	lb ae/a	B							
	AMS	2	qt/100 gal	B							
	Prowl H20	2	qt/a	B							
12	Roundup PowerMax	1	lb ae/a	A	68	95	75	100	100	100	99
	AMS	2	qt/100 gal	A							
	Pindar GT	3	pt/a	A							
	Roundup PowerMax	1	lb ae/a	B							
	AMS	2	qt/100 gal	B							
	Prowl H20	2	qt/a	B							
	LSD (0.05)				***20***	***15***	***40***	***16***	***25***	***27***	***21***

*"A" timing was applied on January 16, 2014 and the "B" timing on March 18, 2014.
Note: the large-plot trials did not include an untreated control and, thus, had only 11 treatments.

Table 2. Selected weed control evaluations from 2013-14 large plot demonstration conducted in a walnut orchard near Atwater, CA. Note: This site was oversprayed with glyphosate + oxyfluorfen in mid-February by the cooperating grower. (Watkins and Hanson)

					65 DAT-A					120 DAT-A		
					Hairy fleabane	Fillaree	Clover	Yellow nutsedge	Overall	Hairy fleabane	Clover	Overall
	Treatment		Rate		% control							
1	Untreated check				-	-	-		-	-	-	-
2	Roundup PowerMax	1	lb ae/a	A	90	100	97	0	98	80	73	80
	AMS	2	qt/100 gal	A								
	Roundup PowerMax	1	lb ae/a	B								
	AMS	10	lb/100 gal	B								
3	Roundup PowerMax	1	lb ae/a	A	97	97	100	0	98	80	87	80
	AMS	2	qt/100 gal	A								
	Goal 2XL	5	pt/a	A								
	Surflan	4	qt/a	A								
4	Roundup PowerMax	1	lb ae/a	A	100	100	100	33	99	83	90	85
	AMS	2	qt/100 gal	A								
	Pindar GT	3	pt/a	A								
5	Roundup PowerMax	1	lb ae/a	A	100	97	97	0	98	80	77	73
	AMS	2	qt/100 gal	A								
	Prowl H20	4	qt/a	A								
6	Roundup PowerMax	1	lb ae/a	A	97	100	100	33	98	77	97	78
	AMS	2	qt/100 gal	A								
	Chateau	10	oz/a	A								
7	Roundup PowerMax	1	lb ae/a	A	97	100	100	67	99	83	93	85
	AMS	2	qt/100 gal	A								
	Prowl H20	4	qt/a	A								
	Chateau	10	oz/a	A								
8	Roundup PowerMax	1	lb ae/a	A	97	100	100	100	99	87	100	87
	AMS	2	qt/100 gal	A								
	Prowl H20	4	qt/a	A								
	Matrix SG	4	oz/a	A								
9	Roundup PowerMax	1	lb ae/a	A	93	100	100	67	99	87	100	87
	AMS	2	qt/100 gal	A								
	Alion	6.5	oz/a	A								
10	Roundup PowerMax	1	lb ae/a	A	97	93	100	33	98	83	93	83
	AMS	2	qt/100 gal	A								
	Trellis	1.3	lb/a	A								
11	Roundup PowerMax	1	lb ae/a	A	93	93	100	33	98	83	73	88
	AMS	2	qt/100 gal	A								
	Prowl H20	3	qt/a	A								
	Roundup PowerMax	1	lb ae/a	B								
	AMS	2	qt/100 gal	B								
	Prowl H20	2	qt/a	B								
12	Roundup PowerMax	1	lb ae/a	A	100	100	100	33	99	90	100	88
	AMS	2	qt/100 gal	A								
	Pindar GT	3	pt/a	A								
	Roundup PowerMax	1	lb ae/a	B								
	AMS	2	qt/100 gal	B								
	Prowl H20	2	qt/a	B								
	LSD (0.05)				***8***	***6***	***4***	***66***	***1***	***14***	***24***	***9***

"A" timing was applied on January 13, 2014 and the "B" timing on March 19, 2014.
Note: the large-plot trials did not include an untreated control and, thus, had only 11 treatments.

Table 3. Selected weed control evaluations from 2013-14 large plot demonstration conducted in an almond orchard near Escalon, CA. (Watkins and Hanson)

					----- 64 DAT-A -------		---------- 122 DAT-A ----------					
					Annual bluegrass	Hairy fleabane	3 spike goose grass	Crab-grass	Annual sowthistle	Hairy fleabane	Spotted spurge	Overall
	Treatment		Rate									
					---------- % control ----------							
1	Untreated check				-	-	-		-	-	-	-
2	Roundup PowerMax	1	lb ae/a	A	98	98	23	0	80	80	33	77
	AMS	2	qt/100 gal	A								
	Roundup PowerMax	1	lb ae/a	B								
	AMS	10	lb/100 gal	B								
3	Roundup PowerMax	1	lb ae/a	A	99	100	0	67	7	17	0	33
	AMS	2	qt/100 gal	A								
	Goal 2XL	5	pt/a	A								
	Surflan	4	qt/a	A								
4	Roundup PowerMax	1	lb ae/a	A	100	100	0	7	10	27	0	27
	AMS	2	qt/100 gal	A								
	Pindar GT	3	pt/a	A								
5	Roundup PowerMax	1	lb ae/a	A	100	100	0	67	7	13	33	23
	AMS	2	qt/100 gal	A								
	Prowl H20	4	qt/a	A								
6	Roundup PowerMax	1	lb ae/a	A	99	100	0	23	43	33	67	60
	AMS	2	qt/100 gal	A								
	Chateau	10	oz/a	A								
7	Roundup PowerMax	1	lb ae/a	A	98	100	0	87	13	13	0	52
	AMS	2	qt/100 gal	A								
	Prowl H20	4	qt/a	A								
	Chateau	10	oz/a	A								
8	Roundup PowerMax	1	lb ae/a	A	100	100	0	67	43	77	53	67
	AMS	2	qt/100 gal	A								
	Prowl H20	4	qt/a	A								
	Matrix SG	4	oz/a	A								
9	Roundup PowerMax	1	lb ae/a	A	100	100	37	100	93	70	100	77
	AMS	2	qt/100 gal	A								
	Alion	6.5	oz/a	A								
10	Roundup PowerMax	1	lb ae/a	A	100	100	0	0	50	50	0	63
	AMS	2	qt/100 gal	A								
	Trellis	1.3	lb/a	A								
11	Roundup PowerMax	1	lb ae/a	A	100	100	0	100	100	80	93	80
	AMS	2	qt/100 gal	A								
	Prowl H20	3	qt/a	A								
	Roundup PowerMax	1	lb ae/a	B								
	AMS	2	qt/100 gal	B								
	Prowl H20	2	qt/a	B								
12	Roundup PowerMax	1	lb ae/a	A	99	100	7	50	90	70	67	83
	AMS	2	qt/100 gal	A								
	Pindar GT	3	pt/a	A								
	Roundup PowerMax	1	lb ae/a	B								
	AMS	2	qt/100 gal	B								
	Prowl H20	2	qt/a	B								
	LSD (0.05)				***12***	***8***	***15***	***59***	***26***	***49***	***59***	***25***

"A" timing was applied on December 17, 2013 and the "B" timing on March 19, 2014.
Note: the large-plot trials did not include an untreated control and, thus, had only 11 treatments.

Table 4. Selected weed control evaluations from 2013-14 comparison of Alion and other pre-emergence tank mix partners in an almond orchard near Wasco, CA. All treatments included a high rate of Rely 280 and Roundup Powermax to ensure good control of existing weeds. (Watkins, Moretti, and Hanson)

				61 DAT-A				125 DAT-A		
				Annual bluegrass	Shepherds-purse	Hairy fleabane	Overall	Junglerice	Hairy fleabane	Overall
	Treatment	Rate		% control						
1	Untreated Check			0	0	0	0	0	0	0
2	Alion	2.5	oz/a	100	100	88	97	97	97	97
3	Alion	3.5	oz/a	100	100	88	97	98	92	92
4	Alion	5	oz/a	100	100	40	85	99	69	76
5	Chateau	10	oz wt/a	100	100	70	94	75	57	77
6	Matrix	4	oz wt/a	100	85	83	95	58	40	40
7	Pindar GT	2.5	pt/a	92	100	93	97	87	96	92
8	Goaltender	4	pt/a	99	100	100	100	98	98	97
9	Alion Chateau	5 6	oz/a oz wt/a	100	100	90	97	100	97	97
10	Alion Matrix	5 2	oz/a oz wt/a	100	100	93	98	100	100	100
11	Alion Pindar GT	5 1.5	oz/a pt/a	100	100	65	95	99	86	96
12	Alion Goaltender	5 2	oz/a pt/a	100	100	88	97	100	98	97
LSD (P=.05)				***6***	***7***	***31***	***9***	***24***	***34***	***25***

Treatments applied on January 16, 2014. All treatments included Roundup Powermax at 2 qt/A, Rely 280 at 2 qt/A, and AMS at 2 qt/100 gal spray solution.

Table 5. Selected weed control evaluations from 2013-14 comparison of Alion and other pre-emergence tank mix and sequential partners in a walnut orchard near Chico, CA. All treatments included a high rate of Rely 280 and Roundup Powermax to ensure good control of existing weeds. (Watkins, and Hanson)

					Overall	Overall	Field bindweed	Junglerice	Hairy fleabane	Overall
					64 DAT-A	124 DAT-A	----------	164 DAT-A	----------	
	Treatment	Rate			----------	----------	% control	----------	----------	
1	Untreated Check				0	0	0	0	0	0
2	Alion	3	oz/a	A	83	100	13	100	98	33
3	Alion	4	oz/a	A	88	100	5	100	100	30
4	Alion	5	oz/a	A	89	100	8	100	100	25
5	Chateau	10	oz wt/a	A	99	100	3	100	100	20
6	Matrix	4	oz wt/a	A	81	100	13	75	100	33
7	Pindar GT	3	pt/a	A	100	100	0	100	100	18
8	Goaltender	4	pt/a	A	100	100	10	100	98	25
9	Alion Chateau	5 6	oz/a oz wt/a	A	97	100	3	100	95	25
10	Alion Matrix	5 2	oz/a oz wt/a	A	88	98	0	100	98	28
11	Alion Pindar GT	5 2	oz/a pt/a	A	98	100	5	100	100	30
12	Alion Goaltender	5 2	oz/a pt/a	A	99	100	0	100	100	23
13	Chateau Alion	10 4	oz wt/a oz/a	A B	99	100	13	100	100	38
14	Chateau Alion	12 5	oz wt/a oz/a	A B	100	100	15	75	100	43
15	Matrix Alion	4 5	oz wt/a oz/a	A B	76	100	28	100	100	44
16	Alion Alion	5 5	oz/a oz/a	A B	89	100	25	100	100	45
17	Alion	4	oz/a	B	68	100	0	100	100	18
18	Alion	5	oz/a		74	100	13	100	95	30
LSD (P=.05)					***9***	***2***	***23***	***24***	***5***	***20***

The 'A' timing was applied December 18, 2013 and the 'B' timing on March 20, 2014. All treatments at both timings included Roundup Powermax plus Rely 280 and AMS for control of emerged weeds.

Table 6. Selected weed control evaluations from 2013-14 comparison of Alion and other pre-emergence tank mix and sequential partners in an almond orchard near Escalon, CA. All treatments included a high rate of Rely 280 and Roundup Powermax to ensure good control of existing weeds. (Watkins and Hanson)

					3 spike goose-grass	Crab-grass	Sow-thistle	Hairy fleabane	Spotted spurge	Overall	Overall	Overall
					---------- 122 DAT-A ----------						164 DAT	196 DAT
	Treatment	Rate			---------- % control ----------							
1	Untreated Check				0	0	0	0	0	0	0	10
2	Alion	3	oz/a	A	45	100	100	88	100	80	70	55
3	Alion	4	oz/a	A	45	100	93	100	100	86	78	68
4	Alion	5	oz/a	A	70	100	100	98	100	92	85	83
5	Chateau	10	oz wt/a	A	38	38	55	93	50	73	43	33
6	Matrix	4	oz wt/a	A	38	50	43	98	0	73	50	28
7	Pindar GT	3	pt/a	A	18	25	15	78	0	65	8	13
8	Goaltender	4	pt/a	A	18	45	5	45	0	55	18	18
9	Alion	5	oz/a	A	58	100	95	93	100	85	86	73
	Chateau	6	oz wt/a									
10	Alion	5	oz/a	A	59	100	100	100	100	91	89	73
	Matrix	2	oz wt/a									
11	Alion	5	oz/a	A	55	100	100	100	100	89	86	80
	Pindar GT	2	pt/a									
12	Alion	5	oz/a	A	90	100	98	98	100	94	91	84
	Goaltender	2	pt/a									
13	Chateau	10	oz wt/a	A	60	100	100	98	100	94	93	84
	Alion	4	oz/a	B								
14	Chateau	12	oz wt/a	A	75	98	100	100	100	98	94	91
	Alion	5	oz/a	B								
15	Matrix	4	oz wt/a	A	63	100	100	100	100	97	94	84
	Alion	5	oz/a	B								
16	Alion	5	oz/a	A	75	100	100	100	100	98	96	91
	Alion	5	oz/a	B								
17	Alion	4	oz/a	B	50	100	100	78	100	92	71	60
18	Alion	5	oz/a		65	100	98	83	100	95	79	74
LSD (P=.05)					***32***	***34***	***20***	***22***	***14***	***11***	***17***	***18***

The 'A' timing was applied December 17, 2013 and the 'B' timing on March 19, 2014. All treatments at both timings included Roundup Powermax plus Rely 280 and AMS for control of emerged weeds.

Table 7. Pre-emergence weed control with Matrix and Alion combinations and sequential treatments in a walnut orchard trial conducted near Chico, CA in 2014. (Watkins and Hanson)

				timing	Overall 64 DAT-A	Overall 124 DAT-A	Junglerice	Hairy fleabane 160 DAT-A	Overall
					%				
1	Untreated Check				0	0	0	0	0
2	Matrix	4	oz wt/a	A	92	63	100	100	60
	Alion	5	fl oz/a	A					
3	Matrix	4	oz wt/a	AB	96	100	100	100	98
	Alion	2.5	fl oz/a	AB					
4	Matrix	4	oz wt/a	A	99	100	100	100	92
	Alion	2.5	fl oz/a	A					
	Matrix	2	oz wt/a	B					
	Treevix	1	oz wt/a	B					
5	Matrix	4	oz wt/a	A	96	97	95	100	76
	Alion	2.5	fl oz/a	A					
	Matrix	4	oz wt/a	B					
	Treevix	1	oz wt/a	B					
6	Matrix	4	oz wt/a	A	96	98	100	100	91
	Alion	2.5	fl oz/a	A					
	Matrix	2	oz wt/a	B					
	Prowl H2O	2	qt/a	B					
7	Matrix	4	oz wt/a	A	99	100	100	100	94
	Alion	2.5	fl oz/a	A					
	Matrix	4	oz wt/a	B					
	Prowl H2O	2	qt/a	B					
8	Matrix	4	oz wt/a	A	96	99	95	100	86
	Alion	2.5	fl oz/a	A					
	Matrix	2	oz wt/a	B					
	Alion	2.5	fl oz/a	B					
9	Matrix	4	oz wt/a	A	91	98	100	100	92
	Alion	2.5	fl oz/a	A					
	Matrix	4	oz wt/a	B					
	Alion	2.5	fl oz/a	B					
LSD (P=.05)					***8***	***19***	***6***	***0***	***18***

The 'A' timing was applied December 18, 2013 and the 'B' timing on March 20, 2014. The entire trial area was oversprayed with Roundup Powermax plus Rely 280 at the same time as the 'A' timing for control of emerged weeds.

Table 8. Treatments and weed visual control ratings for a 2014 burndown trial conducted in a fallow field near Davis, CA to compare new glufosinate formulations to Rely 280 for California orchards and vineyards. (Moretti, Watkins, and Hanson)

				7 DAT	15 DAT	21 DAT	7 DAT	15 DAT	21 DAT
	Treatment*			Pigweed			Prostrate knotweed		
				% control					
1	Untreated			0	0	0	0	0	0
2	Lifeline	48	fl oz/A	98	99	96	98	63	20
3	Lifeline	65	fl oz/A	99	100	99	98	73	30
4	Lifeline	82	fl oz/A	99	100	99	98	87	48
5	Rely 280	48	fl oz/A	99	95	93	98	60	25
6	Rely 280	65	fl oz/A	99	99	99	98	86	33
7	Rely 280	82	fl oz/A	99	100	100	97	89	50
8	Reckon	48	fl oz/A	99	100	97	98	84	20
9	Reckon	65	fl oz/A	99	77	98	98	81	30
10	Reckon	82	fl oz/A	99	100	98	99	96	48
11	Cheetah	48	fl oz/A	98	94	93	98	48	18
12	Cheetah	65	fl oz/A	99	99	96	98	80	20
13	Cheetah	82	fl oz/A	99	99	97	97	86	30
	LSD (0.05)			***1***	***18***	***5***	***3***	***23***	***15***

* All treatments included AMS at 10 lb/100 gal spray solution. DAT = days after treatment.

Table 9. Weed control ratings for a 2014 trial conducted in a fallow field near Davis, CA to compare burndown herbicides with and without the addition of pyraflufen-ethyl (Venue) for California orchards and vineyards. (Moretti, Morales, Watkins, and Hanson)

			7 DAT	15 DAT	21 DAT	7 DAT	15 DAT	21 DAT
	Treatment*		Pigweed			Prostrate knotweed		
			% control					
1	Untreated		0	0	0	0	0	0
2	Roundup P-max	3	100	100	100	15	53	60
3	Roundup P-max + Venue	3 pt/A + 4 fl oz/A	80	81	90	68	65	38
4	Rely 280	48 fl oz/A	97	99	91	48	40	25
5	Rely 280 + Venue	48 fl oz/A + 4 fl oz/A	98	97	89	76	58	28
6	Gramoxone SL	4 pt/A	99	100	92	31	21	28
7	Gramoxone SL + Venue	4 pt/A + 4 fl oz/A	100	100	99	68	28	28
8	Venue	4 fl oz/A	89	30	43	70	20	13
	LSD (0.05)		***11***	***9***	***13***	***27***	***26***	***15***

*All treatments included crop oil concentrate (COC) at 1% v/v and AMS at 10 lb/100 gal spray solution. DAT = days after treatment.

Table 10. Weed control ratings in a 2014 prune orchard trial near Artois, CA conducted to compare burndown herbicides with and without the addition of pyraflufen-ethyl (Venue) for California orchards and vineyards. (Watkins and Hanson)

			7 DAT	14 DAT	29 DAT	7 DAT	14 DAT	29 DAT	29 DAT
	Treatment*		Cutleaf geranium			--- Field bindweed ---			Overall
			% control						
1	Untreated		0	0	0	0	0	0	0
2	Roundup P-max	3	25	58	98	8	50	80	97
3	Roundup P-max + Venue	3 pt/A + 4 fl oz/A	83	98	100	100	100	88	98
4	Rely 280	48 fl oz/A	84	100	100	80	88	53	90
5	Rely 280 + Venue	48 fl oz/A + 4 fl oz/A	95	100	100	100	98	58	90
6	Gramoxone SL	4 pt/A	100	100	100	68	78	28	80
7	Gramoxone SL + Venue	4 pt/A + 4 fl oz/A	100	100	100	95	80	8	73
8	Venue	4 fl oz/A	55	55	3	100	98	0	3
	LSD (0.05)		***18***	***11***	***4***	***14***	***25***	***23***	***9***

*All treatment included COC and AMS according to label recommendations and treatments were applied March 13, 2014 in 20 GPA water.

Table 11. Post-emergence weed control in an almond orchard trial conducted near Wasco, CA in spring 2014. (Moretti, Watkins, and Hanson)

				----- 15 DAT -----		---------- 28 DAT ----------			
				Annual bluegrass	*Hairy fleabane*	*Jungle-rice*	*Annual bluegrass*	*Hairy fleabane*	*Total biomass*
				---------- % ----------					*g/m sq*
1	untreated control			0	0	0	0	0	137.1
2	Roundup Powermax	1	lb ae/a	100	30	65	100	67	23.8
	AMS	2	pt/a						
	NIS	0.25	% v/v						
3	Roundup Powermax	44	fl oz/a	98	73	90	100	93	4.3
	AMS	2	pt/a						
	NIS	0.25	% v/v						
4	Rely 280	48	fl oz/a	100	100	87	98	100	1.4
	AMS	2	pt/a						
5	Rely 280	82	fl oz/a	100	100	91	98	87	0.7
	AMS	2	pt/a						
6	Gramoxone SL	1.25	pt/a	100	0	92	100	50	52.5
	NIS	0.25	% v/v						
7	Gramoxone SL	4	pt/a	100	0	92	100	78	7.9
	NIS	0.25	% v/v						
8	Matrix	2	oz/a	60	50	86	98	72	42.0
	AMS	2	pt/a						
	NIS	0.25	% v/v						
9	Roundup Powermax	1	lb ae/a	100	88	98	67	93	0.1
	Matrix	2	oz/a						
	AMS	2	pt/a						
	NIS	0.25	% v/v						
10	Roundup Powermax	1	lb ae/a	100	53	100	100	86	64.9
	Pindar GT	1.5	pt/a						
	AMS	2	pt/a						
	NIS	0.25	% v/v						
11	Chateau	6	oz/a	100	75	100	100	66	0.1
	NIS	0.25	% v/v						
	Roundup Powermax	1	lb ae/a						
	AMS	2	pt/a						
12	Poast	1.5	pt/a	0	0	0	33	27	217.8
	COC	1	% v/v						
13	Poast	1.5	pt/a	100	40	98	67	95	74.7
	COC	1	% v/v						
	Roundup Powermax	1	lb ae/a						
	AMS	2	pt/a						
14	Roundup Powermax	1	lb ae/a	100	75	100	100	92	0.1
	Matrix	4	oz/a						
	Ammonium Sulfate	2	pt/a						
	NIS	0.25	% v/v						
15	Roundup Powermax	1	lb ae/a	100	34	97	100	98	12.6
	AMS	2	pt/a						
	NIS	0.25	% v/v						
	Goal 2XL	0.125	lb ai/a						
LSD (P=.05)				***1***	***44***	***26***	***41***	***50***	***115.3***

** All treatments applied POST on April 23, 2014.*

Table 12. Weed control ratings following post-emergence applications of low VOC oxyfluorfen partners in a fallow field near Davis CA in 2014. (Moretti, Watkins, and Hanson)

			7 DAT			17 DAT		
			Tumble pigweed	Field bindweed	Fluevelin	Tumble pigweed	Field bindweed	Fluevelin
			% control					
1	untreated	Rate	0	0	0	0	0	0
2	Goal 2XL (oxyfluorfen) + Roundup WM (glyphosate)	0.125lb ai/a 1lb ae/a	66	50	8	75	74	74
3	Goal 2XL (oxyfluorfen) + Roundup WM (glyphosate)	0.25lb ai/a 1lb ae/a	90	82	10	100	97	93
4	GoalTender (oxyfluorfen) + Roundup WM (glyphosate)	0.125lb ai/a 1lb ae/a	89	76	18	100	97	97
5	GoalTender (oxyfluorfen) + Roundup WM (glyphosate)	0.25lb ai/a 1lb ae/a	85	83	18	100	96	95
6	GoalTender (oxyfluorfen) + Roundup WM (glyphosate)	0.5lb ai/a 1lb ae/a	90	78	15	100	88	97
7	GoalTender (oxyfluorfen) + Gramoxone (paraquat)	0.25lb ai/a 0.625lb ai/a	95	84	68	99	38	43
8	GoalTender (oxyfluorfen) + Shark (carfentrazone)	0.25lb ai/a 0.031lb ai/a	50	56	20	23	18	25
9	GoalTender (oxyfluorfen) + Rely 280 (glufosinate)	0.25lb ai/a 22fl oz/a	89	91	80	93	88	70
10	GoalTender (oxyfluorfen) + Venue (pyraflufen)	0.25lb ai/a 4fl oz/a	71	90	53	33	33	50
11	GoalTender (oxyfluorfen) + Treevix (saflufenacil)	0.25lb ai/a 1oz/a	84	91	56	48	40	50
12	GoalTender (oxyfluorfen) + Hasten (est. veg. oil)	0.25lb ai/a 2pt/a	46	58	10	20	10	23
	LSD (0.05)		***21***	***33***	***20***	***23***	***31***	***28***

**Treatments applied May 23, 2014 in 20 GPA water.*

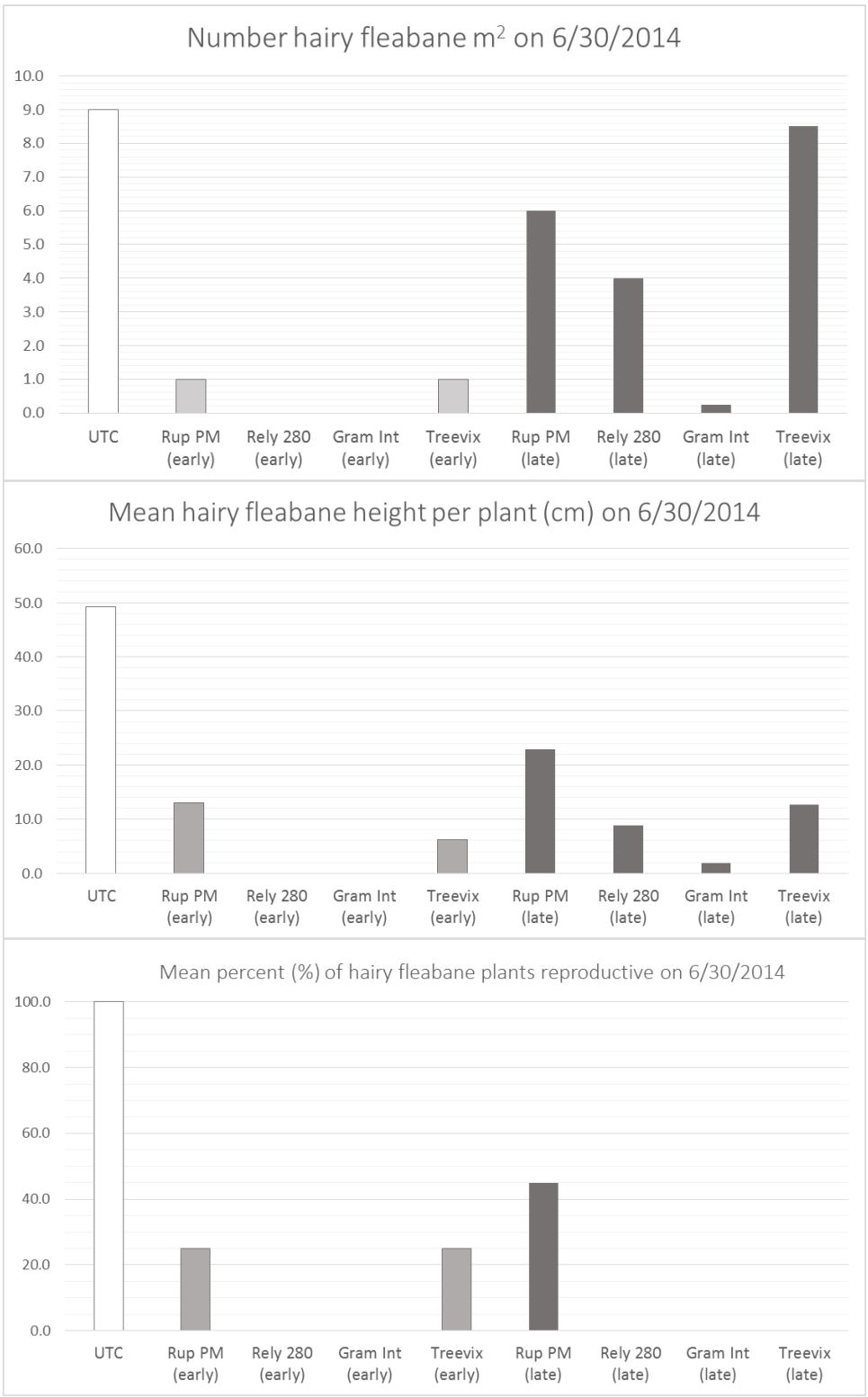


Figure 3. Effects of POST herbicide and weed growth stage on hairy fleabane control at the preharvest timing stage in an almond orchard trial near Arbuckle, CA in 2014. (RupPM = Roundup Powermax, Gram Int – Gramoxone Inteon. Early = fleabane approx. 3 inches tall, Late = fleabane 10 inches tall and flowering). (Sosnoskie and Hanson)