Orchard Weed Management Research

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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 Advisors, and the UC Cooperative Extension network. The almond industry is one of the key stakeholder groups for this program; however, the majority of our research is broadly applicable to, and partially supported by, other orchard and vineyard commodities in the state as well as the pest control industry.

The specific objectives of this ongoing project (14Hort12.Hanson – Weed Management) mirror the major research areas in our program:

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

Numerous field and greenhouse experiments were conducted in 2013/2014 to support grower, Pest Control Advisor, and Farm Advisor weed and herbicide research needs. Because a more thorough presentation of these projects is available in the annual reports to the Almond Board and in various online venues, this poster presents only a few representative results. Data from related projects are routinely presented at cooperative extension meetings as well as scientific presentations by members of the research team.

Herbicide performance

Several field trials were conducted to evaluate weed control efficacy in commercial almond orchards. In these experiments, research personnel applied replicated, small-plot treatments using CO2 pressurized backpack or ATV-mounted spray equipment. Weed control was visually assessed several times during the growing season and, in some cases, biomass or other quantitative data were collected. A few representative data are shown in Tables 1-5 below; a full accounting is available in the Almond Board Research Report. Many of these data are also presented online at the UC Weed Science blog (http://ucanr.edu/blogs/UCDWeedScience/index.cfm) and the Almond Doctor blog (http://thealmonddoctor.com/)

Table1. Selected weed control evaluations from 2014-15 large plot demonstration conducted in an almond orchard near Escalon, CA; second year treatments. (Watkins and Hanson)

	Treatment	Rate			28 DAT-A Annual bluegrass	28 DAT-A Hairy fleabane	28 DAT-A 3 spike goose grass	28 DAT-A Malva	59 DAT-A Hairy fleabane	59 DAT-A Filaree	59 DAT-A Shep-herds purse
					% control						
1	Untreated check				-	-	-		-	-	-
2	Roundup PowerMax	1	lb ae/a	A	100	95	90	93	100	100	100
	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	90	100	73	100	100
	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	90	98	93	100	98
	AMS	2	qt/100 gal	A							
	Pindar GT	3	pt/a	A							
5	Roundup PowerMax	1	lb ae/a	A	100	87	90	93	63	100	73
	AMS	2	qt/100 gal	A							
	Prowl H20	4	qt/a	A							
6	Roundup PowerMax	1	lb ae/a	A	99	95	90	97	77	100	100
	AMS	2	qt/100 gal	A							
	Chateau	10	oz/a	A							
7	Roundup PowerMax	1	lb ae/a	A	98	98	90	97	77	100	100
	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	93	90	96	83	100	100
	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	93	90	77	73	100	100
	AMS	2	qt/100 gal	A							
	Alion	6.5	oz/a	A							
10	Roundup PowerMax	1	lb ae/a	A	98.3	93	87	50	67	100	98
	AMS	2	qt/100 gal	A							
	Trellis	1.3	lb/a	A							
11	Roundup PowerMax	1	lb ae/a	A	100	87	83	83	100	100	100
	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	90	87	100	100	100	100
	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)				***6***	***13***	***7***	***18***	***14***	***0***	***8***

"A" timing was applied on January 21, 2015 and the "B" timing on March 5, 2015. The same treatments were applied to these plots in 2014/15.
Note: the large-plot trials did not include an untreated control and, thus, had only 11 treatments.

Table 2. Postemergence weed control in an almond orchard trial conducted near Wasco, CA in spring 2014. (Moretti, Watkins, and Hanson)

	Treatment	Rate		15 DAT Annual bluegrass	15 DAT Hairy fleabane	28 DAT Jungle-rice	28 DAT Annual bluegrass	28 DAT Hairy fleabane	28 DAT Total biomass
				%					g/m sq
1	untreated control			0	0	0	0	0	137.1
2	Roundup Powerrmax	1	lb ae/a	100	30	65	100	67	23.8
	AMS	2	pt/a						
	NIS	0.25	% v/v						
3	Roundup Powerrmax	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 Powerrmax	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 Powerrmax	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 Powerrmax	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 Powerrmax	1	lb ae/a						
	AMS	2	pt/a						
14	Roundup Powerrmax	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 Powerrmax	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 3. Selected weed control evaluations from 2014-15 Broadworks and Alion tankmix trial near Arbuckle, CA (Brunharo and Hanson)

	Treatment	Rate		56 DAT-A Filaree	56 DAT-A Hairy fleabane	56 DAT-A Chick weed	56 DAT-A Rye grass	103 DAT-A Hairy fleabane	103 DAT-A Bind weed	103 DAT-A Rye grass
				% control						
1	Rely 280	2	qt/a	0	0	0	0	15	8	0
2	Alion	3.5	fl oz/a	93	88	96	88	81	99	98
	Rely 280	2	qt/a							
3	Alion	5	fl oz/a	99	99	99	40	83	47	98
	Rely 280	2	qt/a							
4	Matrix	4	oz/a	95	100	85	90	76	95	96
	Rely 280	2	qt/a							
5	Alion	3.5	fl oz/a	97	93	90	53	99	76	100
	Matrix	2	oz/a							
	Rely 280	2	qt/a							
6	Alion	3.5	fl oz/a	99	95	85	48	79	100	100
	Matrix	4	oz/a							
	Rely 280	2	qt/a							
7	Broadworks	6	fl oz/a	66	75	50	18	99	55	25
	Rely 280	2	qt/a							
8	Alion	3.5	fl oz/a	99	90	83	70	83	96	75
	Broadworks	6	fl oz/a							
	Rely 280	2	qt/a							
9	Alion	5	fl oz/a	98	98	97	96	92	87	100
	Broadworks	6	fl oz/a							
	Rely 280	2	qt/a							
10	Alion	5	fl oz/a	99	75	92	55	93	78	100
	Broadworks	3	fl oz/a							
	Rely 280	2	qt/a							
11	Broadworks	6	fl oz/a	72	95	95	30	99	98	53
	Prowl H2O	4	qt/a							
	Rely 280	2	qt/a							
12	Broadworks	6	fl oz/a	85	65	85	53	93	87	88
	Surflan	4	qt/a							
	Rely 280	2	qt/a							
13	Broadworks	6	fl oz/a	82	88	81	53	96	92	50
	GoalTender	3	pt/a							
	Rely 280	2	% v/v							
14	Broadworks	6	fl oz/a	87	93	74	55	96	92	74
	Matrix	2	oz/a							
	Rely 280	2	qt/a							
15	Broadworks	6	fl oz/a	94	100	91	64	99	78	95
	Matrix	4	oz/a							
	Rely 280	2	qt/a							
16	Pindar GT	2.5	pt/a	95	73	58	20	65	45	70
	Rely 280	2	qt/a							
	LSD (0.05)			***23***	***32***	***39***	***50***	***27***	***29***	***41***

*"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 4. Selected weed control evaluations from 2014-15 comparison of Alion and other preemergence tankmix 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)

	Treatment	Rate			92 DAT Hairy fleabane	92 DAT 3 spike goose grass	128 DAT Hairy fleabane	128 DAT 3 spike goose grass	156 DAT Hairy fleabane	156 DAT 3 spike goose grass	156 DAT Overall
					% control						
1	Untreated Check				0	0	0	0	0	0	0
2	Alion	2.5	oz/a	A	55	75	58	80	53	83	58
3	Alion	3.5	oz/a	A	73	78	71	88	65	85	75
4	Alion	5	oz/a	A	85	93	84	93	85	90	91
5	Chateau	10	oz wt/a	A	78	65	73	73	68	70	68
6	Matrix	4	oz wt/a	A	98	63	99	55	95	20	58
7	Pindar GT	2.5	pt/a	A	85	60	80	55	70	60	48
8	Goaltender	4	pt/a	A	73	85	65	68	60	85	58
9	Alion	5	oz/a	A	97	98	93	93	90	90	93
	Chateau	6	oz wt/a								
10	Alion	5	oz/a	A	90	95	95	95	93	90	94
	Matrix	2	oz wt/a								
11	Alion	5	oz/a	A	100	96	99	91	100	93	95
	Pindar GT	1.5	pt/a								
12	Alion	5	oz/a	A	93	98	90	96	90	98	94
	Goaltender	2	pt/a								
13	Chateau	10	oz wt/a	A	92	98	90	100	85	98	92
	Alion	3.5	oz/a	B							
14	Chateau	12	oz wt/a	A	97	99	96	100	94	96	96
	Alion	5	oz/a	B							
15	Matrix	4	oz wt/a	A	100	100	97	99	100	100	99
	Alion	5	oz/a	B							
16	Alion	5	oz/a	A	94	100	90	100	90	100	93
	Alion	5	oz/a	B							
17	Alion	3.5	oz/a	B	85	98	65	95	43	95	75
18	Alion	5	oz/a	B	93	98	83	95	73	95	88
	LSD (P=.05)				**10**	**13**	**11**	**14**	**16**	**12**	**10**

The "A" timing was applied on January 13, 2015 and the "B" timing on March 5, 2015. *All treatments at both timings included Roundup Powermax plus Rely 280 and AMS for control of emerged weeds.* The same treatments were applied to these plots in 2014/15.

Identification and verification of herbicide-resistant weeds

Weed management in California tree and vine crops is currently dominated by problems with glyphosate–resistant and glyphosate–tolerant species. To date, six species resistant to glyphosate have been confirmed: hairy fleabane, horseweed (aka marestail), Italian and rigid ryegrass, and junglerice, and annual bluegrass. Several other species of concern have been identified and are under evaluation; these include three-spike goosegrass, Palmer amaranth and a suite of summer annual grasses. Research being conducted on herbicide-resistant weeds incudes confirmation of resistance (photo at left), determining distribution of the resistant populations evaluation of alternative control measures, and determining the underlying physiological and genetic causes of resistance.

Dose-response screening of suspected glyphosate-resistant shepherd's purse

Fleabane biology and control

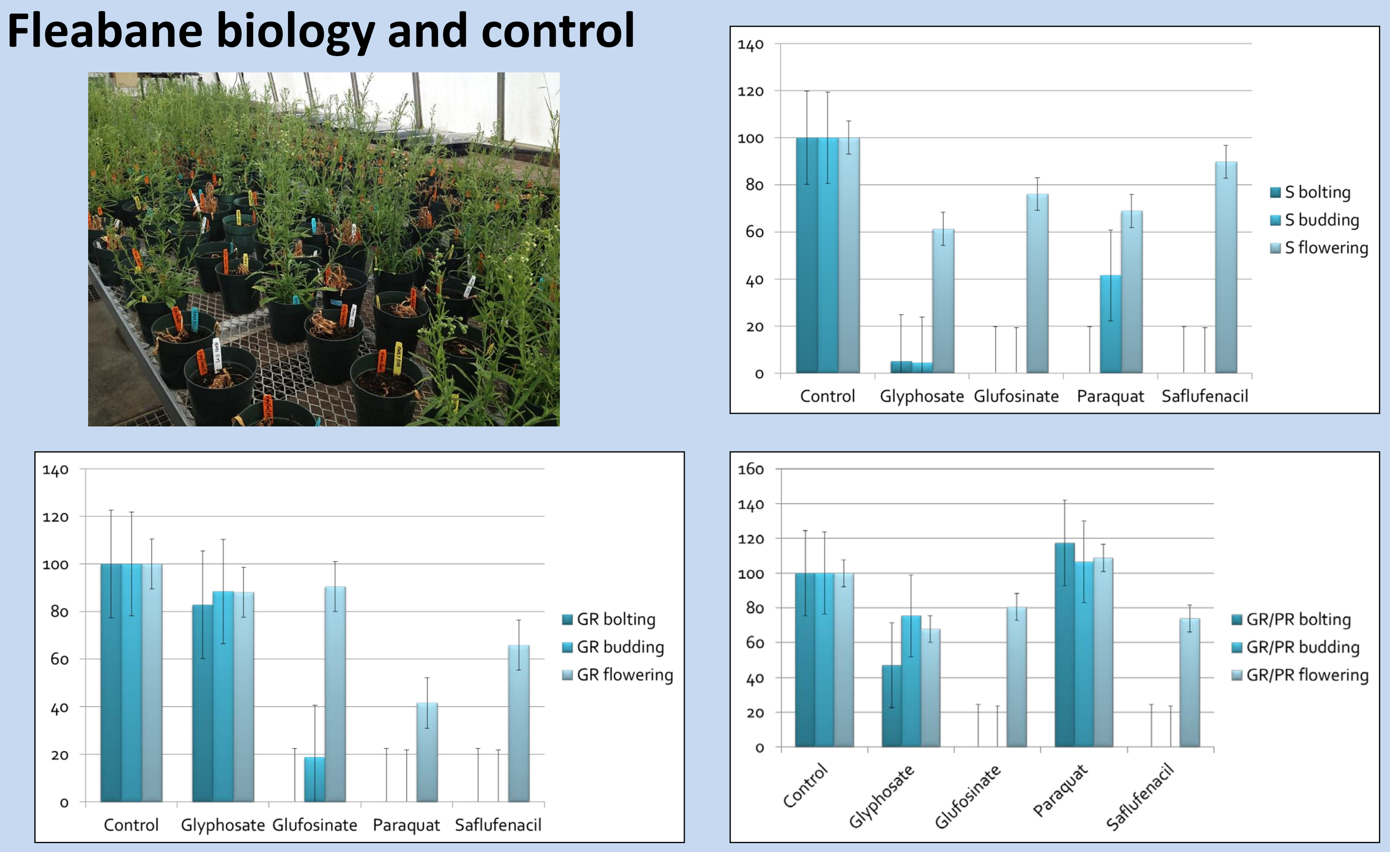


Figure 1. Biomass production (regrowth) of glyphosate susceptible (S), glyphosate-resistant (GR) and glyphosate-paraquat-resistant (GR/PR) hairy fleabane to four POST herbicides applied at early bolting, budding, or flowering growth stages. Once hairy fleabane reaches the flowering stage, none of the herbicides provided full control of any biotype (Sosnoskie and Hanson).

Junglerice biology and genetics

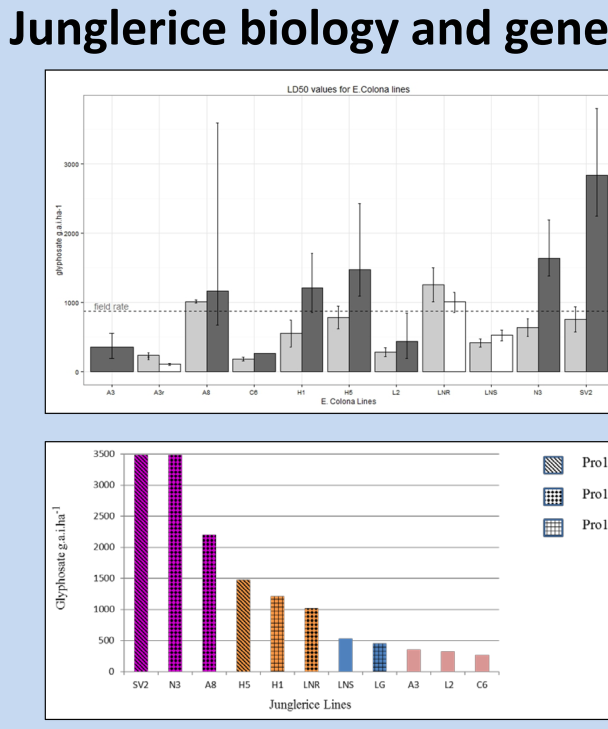


Figure 2. Glyphosate-resistant junglerice plants from the Central Valley have different EPSPS mutations that are associated with varying levels of glyphosate resistance at the whole plant level. Data indicate GR50 levels in greenhouse experiments on populations derived from previous field collections (Morran, Moretti, Fischer, and Hanson)

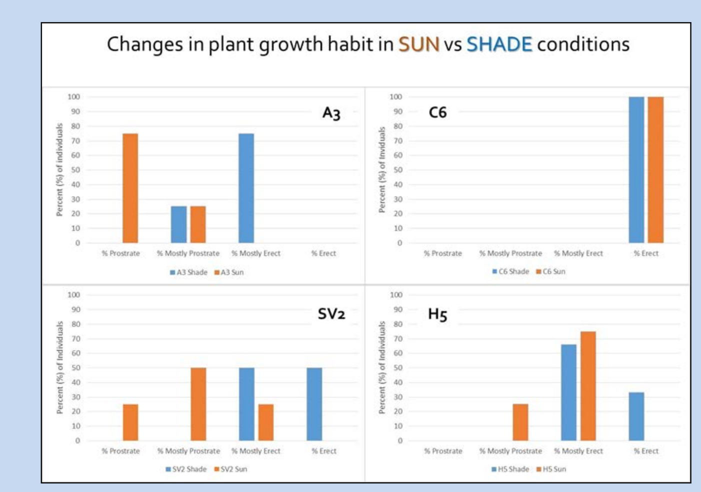


Figure 3 Glyphosate-resistant junglerice populations from various regions of California have different growth habits and responses to environmental cues (e.g. shade). Current research is ongoing to determine if or how this may be related to resistance to herbicides or other stresses and if the resistant populations are also more invasive than the wild types. (Sosnoskie, Morran, and Hanson).

Dose-response screening of glyphosate-resistant junglerice from the Sacramento Valley

Multiple-resistant Conyza spp.

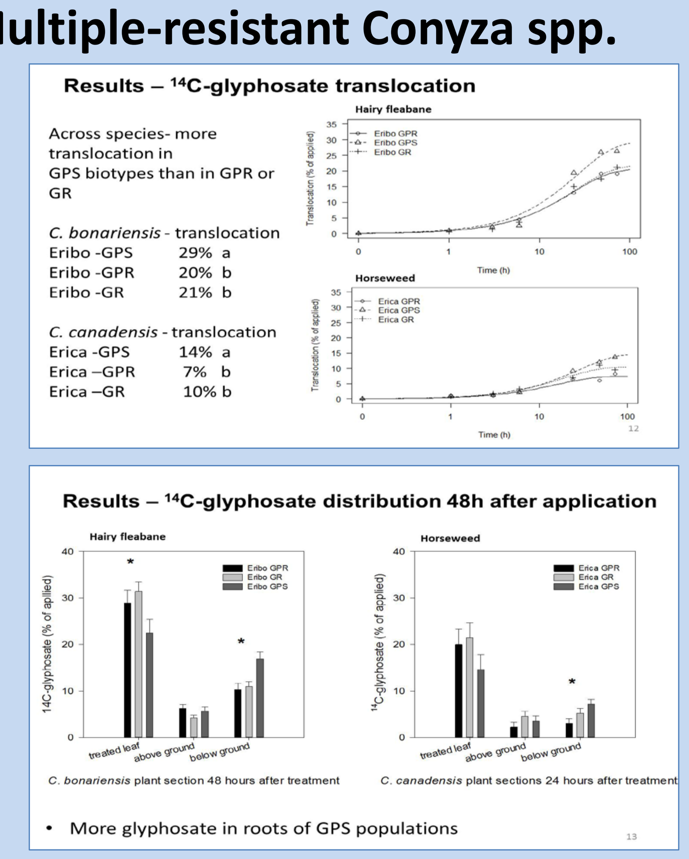


Figure 4. Evaluation of glyphosate translocation in glyphosate-susceptible (GPS), glyphosate-resistant (GR) and glyphosate-paraquat-resistant (GPR) hairy fleabane using radio-labeled glyphosate (Moretti and Hanson).

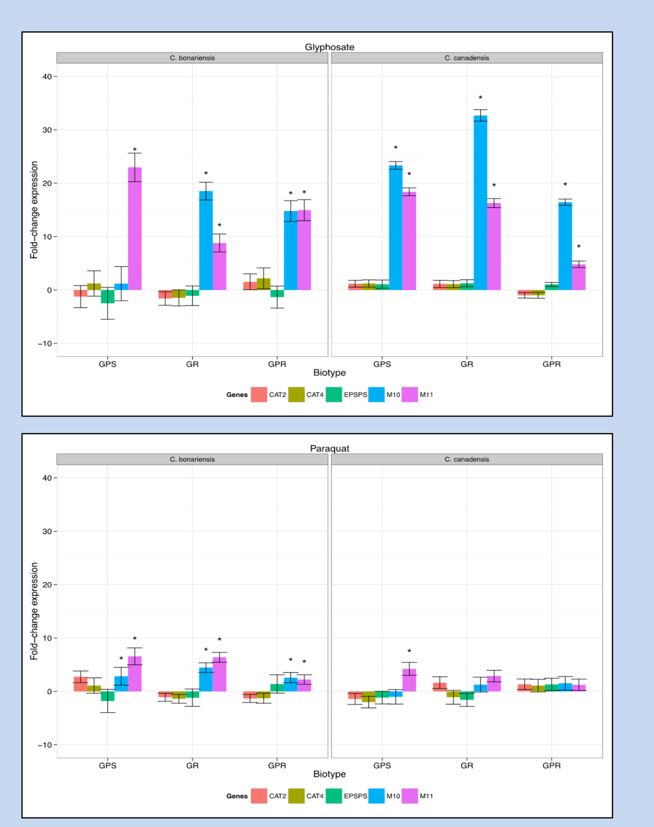
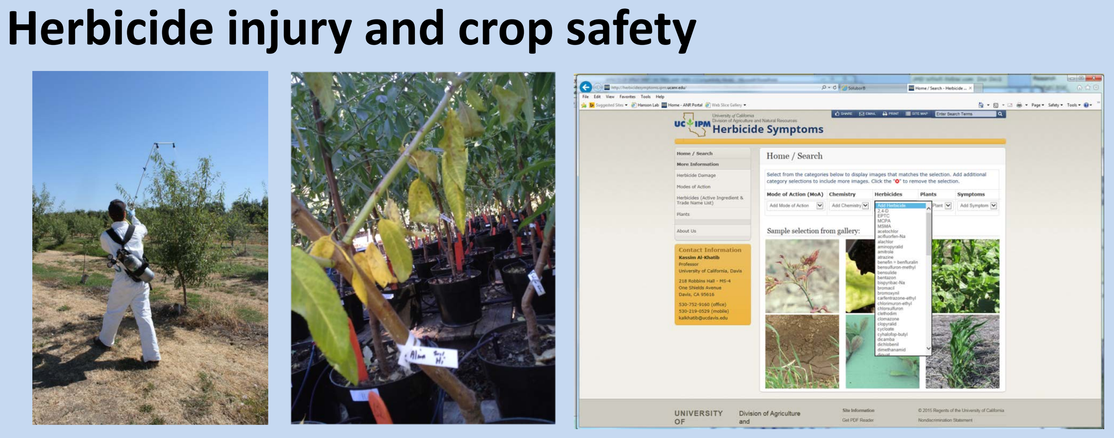


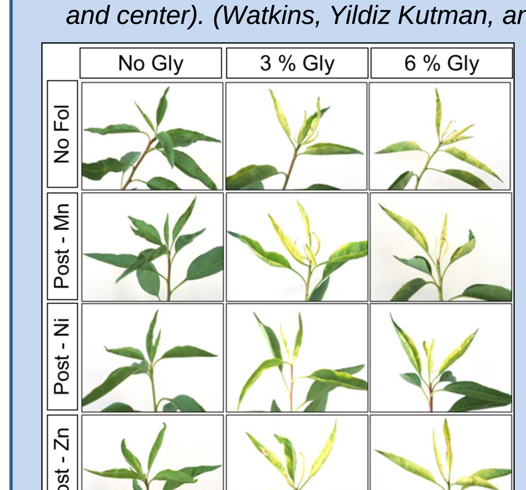
Figure 5. Evaluation of transcription of ABC transporter genes in response to glyphosate or paraquat in GPS, GR, or GPR hairy fleabane (C. bonariensis) and horseweed (C. canadensis) (Moretti, Morran, and Hanson).

Herbicide injury and crop safety



Images are also being used to in online support tools such as the UC-IPM Herbicide Symptoms database http://herbicidesymptoms.ipm.ucanr.edu/index.cfm (Al-Khatib)

Figure 6. Field and greenhouse herbicide symptomology demonstrations use to help troubleshoot crop injury issues (left and center). (Watkins, Yildiz Kutman, and Hanson)



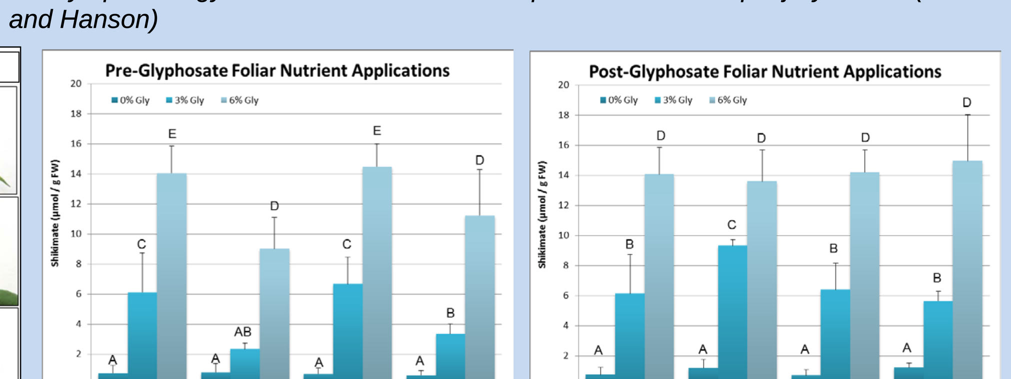


Figure 7. Greenhouse evaluation of micronutrient and glyphosate interactions. Glyphosate was applied at 0.03X and 0.06X of a normal use rate and trees were treated with micronutrient solutions either before or after glyphosate exposure. (Yildiz Kutman and Hanson).

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 55:173-184
- Hanson, B., S. Wright, L. Sosnoskie, A. Fisher, M. Jasieniuk, J. Roncoroni, K. Hembree, S. Orloff, A. Shrestha, and K. Al-Khatib. 2014. Herbicide resistant weeds challenge signature California cropping systems. California Agriculture 68:142-152
- Hanson, B.D., A.J. Fischer, A. McHughen, M. Jasieniuk, A. Shrestha, and A.J. Jhala. 2014. Herbicide-resistant weeds and crops. In S.A. Fennimore and C. Bell (eds). Principles of Weed Control. California Weed Science Society, Salinas CA (ISBN: 978-0-692-30482-2).
- Hanson, B.D., J. Roncoroni, K.J. Hembree, R. Molinar. and C.L. Elmore. 2014. Tree, vine, and soft-fruit crops. In S.A. Fennimore and C. Bell (eds). Principles of Weed Control. California Weed Science Society, Salinas CA (ISBN: 978-0-692-30482-2).
- Hanson, B.D. and T.W. Miller. 2015. The importance of 2,4-D in orchard, vineyard, and berry crops in the United States. Chapter in Phenoxy Herbicide task force report book (in press).
- Nguyen, T.T., D.C. Slaughter, B.D. Hanson, A. Barber, A. Freitas, D. Robles, and E. Whelan. 2015. Automated mobile system for accurate outdoor tree crop enumeration using an uncalibrated camera. Sensors 15:18427-18422.
- Moretti, M., A. Shrestha, K.J. Hembree, and B.D. Hanson. 2015. Postemergence control of glyphosate-paraquat resistant hairy fleabane (*Conyza bonariensis*) in tree nut orchards in the Central Valley of California. Weed Technol. 29:501-508.
- Moretti, M.L., L.M. Sosnoskie, A. Shrestha, S.D. Wright, K.J. Hembree, M. Jasieniuk, and B.D. Hanson. 2015. Distribution of *Conyza* sp. In orchards of California and response to glyphosate and paraquat. Weed Technol. (in press)

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