Determining the Yield Effects of Simulated Glyphosate or Propanil Drift on Dried Plum

B.D. Hanson, Franz Niederholzer, and W.T. Lanini

Dried plum growers have occasionally seen leaf spotting or mottling, poor tree growth and poor flower set and these symptoms have been increasing in recent years. In previous work conducted by the California Dried Plum Board, glyphosate and propanil were found in measureable amounts in dried plum leaf tissue. The source of the propanil is rice fields, but the source of the glyphosate is not clear. Glyphosate may be coming from outside sources, but also may be from applications made within the orchard. What is also not clear is what effects these sub-lethal rates are having on dried plum production. If one or both of these herbicides are impacting dried plum productivity, it may be necessary to modify the way they are applied or the timing of the application.

With funding from the California Dried Plum Board in 2009, a research trial was conducted at the Wolfskill Farm near Winters (Lanini 2009 report to DPB). Two additional trials were conducted in 2010 at the Wolfskill Farm (same orchard as in 2009) and in a commercial orchard near Yuba City to follow up on the earlier experiment.

OBJECTIVES

1. Evaluate the effects of propanil and glyphosate on dried plum production
2. Determine the symptoms associated with these herbicides.

PROCEDURES

The experiments were conducted in established French prune orchards to evaluate the effects of several low-rate (simulated drift) applications of propanil and glyphosate on canopy injury, flower and fruit set, fresh yield, and prune dry weight. Herbicides were applied using a CO_2-powered backpack sprayer, with 80015 nozzles, delivering 10 gal/ac total spray volume. In contrast to the earlier study, treatments were applied above the tree canopy by researchers using an orchard ladder (Figure) rather than from the ground. Each tree was sprayed with two-passes of a 3-nozzle spray boom from opposite sides of the tree and approximately 80% of the upper canopy was treated using this approach. Glyphosate (Roundup WeatherMax) was applied at 0.015, 0.15, and 0.3 lb ae/A and propanil (Stam 80DF) was applied at 0.04, 0.2, and 0.4 lb ai/A which are about $1/100^{th}$, $1/10^{th}$, and $1/5^{th}$ of the normal use rates, respectively.

Number of flower buds was counted on two representative branches about mid-canopy on each tree prior in April or May prior to the first herbicide application and fruit set was evaluated on the same branches in mid-summer. Visual injury estimates were made on the representative branches and on the overall tree canopy several times during the growing season. At maturity, fruit on each marked branch was counted and weighed. A 4 to 6 lb subsample from each plot was weighed before and after drying in a commercial dehydrator (Sunsweet Growers; Winters,

and Yuba City). After drying, the prunes in each subsample were counted and weighed to determine final yield and quality.

At the Wolfskill site, treatments were replicated three times to single-tree plots. Due to limitations on the number of trees available, the 0.3 lb ae/A glyphosate treatment and the 0.2 lb ai/A propanil treatment were not included in the first application timing. Additionally, the untreated trees were not randomized within the experiment due to logistical limitations. The trees at this site had also been treated with similar propanil and glyphosate rates in 2009; thus these results represent the cumulative effects of two years of simulated drift. Treatments were applied at the Wolfskill site on May 24, July 16, and August 10, 2010. All fruit was harvested from each tree from August 26-28, 2010.

The experimental layout at the Yuba City site was a randomized complete block and had larger plots due to the availability of more trees for the study. At this site, each treatment was applied to three replicate plots consisting of two adjacent trees and a full set of untreated control plots was randomized within this experiment. Each tree canopy was sprayed as previously explained with the exception that a few relatively small trees were sprayed with only one pass of the spray boom. At the Yuba City site, treatments were applied on June 1, July 8, and August 10, 2010. Fruit subsamples were harvested from each tree August 31 to September 2, 2010. Total fruit yield on each tree was not determined because of an obvious lack of tree uniformity in the orchard.

RESULTS

In the 2010 experiments, the application of herbicides to the tree canopy resulted in a more uniform application to the trees compared to 2009. However, overall rates of injury were still relatively minor – especially on leaf tissue below the top of the canopy.

At Winters, glyphosate injury was less than 7% and was not consistent among replicates (Table 1a). Propanil caused slightly more injury (up to 18%) but this injury typically did not extend below the treated leaves in the upper canopy and also was not consistent among replicates. No clear trends due to herbicide rate or application timing were apparent in the yield parameters fruit set per flower (Table 1a) or harvested fruit per flower (Table 1b) at Winters. Similarly, total fresh fruit yield (lb/tree), 100-fruit weight (fresh or dry) and dry weight percentage of the fruit were not statistically different among treatments. When averaged over all rates and application timings, few differences were noted among treatments for any yield parameters at the Winters site even though these trees were treated in both 2009 and 2010 (Table 3).

Results were similar at the Yuba City site except that visual injury (canopy top) was more pronounced from the June applications of both glyphosate and propanil (Table 2a). Flowering and fruit set on marked branches were not significantly affected by simulated drift treatments nor were fruit set per flower (Table 2a) or harvested fruit per flower (Table 2b). Fruit quality as measured by 100-fruit weight (fresh or dry) and percent dry matter also was not affected by herbicide rate or application timing. Averaged over all rates and timings, propanil tended to have slightly fewer flowers and fruit per branch but these differences were not statistically significant (Table 4).

CONCLUSIONS:

Based on three field experiments in 2009 and 2010, no clear reductions in dried plum yield or yield parameters were noted with simulated glyphosate and propanil drift. There often herbicide symptoms on French prune foliage and branch tips; especially at the highest rate ($1/10^{th}$ of conventional use rate) tested. Injury was typical of these herbicides; glyphosate caused slight chlorosis and stunting of individual leaves and shortened internodes at branch tips (witch's brooming). Propanil injury at low rates or minor exposure ranged from chlorotic spots to chlorotic and necrotic leaves with tissue damage beginning at the margins and advancing inward. Propanil injury did not appear to extend beyond leaves that were not directly exposed (not translocated through the canopy).

In the field, glyphosate and propanil drift are likely to occur at even lower rates than in these studies suggesting that little impact is likely to be observed on yield and vigor of established prune orchards. However, drift on young orchards or repeated exposure in established orchards could have difficult-to-measure impacts on prune production not noted in these studies.

FUTURE WORK:

The Winters site will be monitored in 2011 to evaluate the effects of simulated drift applications in 2009 and 2010 on affect buds and flower initiation. At the beginning of this project, we planned to continue the evaluations at the Yuba City site as well; however, the cooperating grower changed his schedule and removed this orchard after the 2010 harvest.

Figure. Simulated drift rates of glyphosate or propanil ($1/100^{th}$,$1/10^{th}$, and $1/5^{th}$ x rates) were applied above the canopy of established French prunes near Winters and Yuba City, CA in two field trials in 2010.

BUDGET SUMMARY:

The Dried Plum Board granted $11,978 for this work in 2009-10. The funding has been used to pay a portion of student worker salaries, contract labor (Wolfskill prune harvest and pruning), and a $3000 payment for crop destruction in the commercial orchard operation near Yuba City. As part of our overall perennial crops weed research program, this work has also supported (and been supported by) funding from weed research projects in other fruit and nut commodities.

Table 1a. Effect of simulated glyphosate and propanil drift on French prune yield components – Winters, CA 2010.

	Rate	Application date		
	lb ae or ai/A	June	July	August
		---- Visual injury of treated branches (%) ----		
Glyphosate (lb ae/A)	0.015	6.7	0	2.5
Rate*date: P=0.0001	0.15	0	2.5	3.8
	0.3	-	5	0
Propanil (lb ai/A)	0.04	5	3.8	0
Rate*date: P=0.0001	0.2	-	10	2.5
	0.4	8.3	17.5	3.7
		---- Flowers per marked branch ----		
Glyphosate (lb ae/A)	0.015	17.7	17.4	17.5
Rate*date: P=NS	0.15	21.3	13.3	22.5
	0.3	-	18	14.6
Propanil (lb ai/A)	0.04	15.2	16.3	17.1
Rate*date: P=NS	0.2	-	14.1	16.3
	0.4	17.3	13.5	16.5
		---- Fruit set per marked branch ----		
Glyphosate (lb ae/A)	0.015	5.3	7.4	4.6
Rate*date: P=NS	0.15	9.8	5.1	8.4
	0.3	-	6.4	4.9
Propanil (lb ai/A)	0.04	4.8	5.4	3
Rate*date: P = NS	0.2	-	5.9	5
	0.4	4.3	4	5
		---- Fruit set per flower ----		
Glyphosate (lb ae/A)	0.015	0.3	0.4	0.3
Rate*date: P=NS	0.15	0.5	0.4	0.4
	0.3	-	0.4	0.3
Propanil (lb ai/A)	0.04	0.3	0.3	0.2
Rate*date: P = NS	0.2	-	0.4	0.3
	0.4	0.3	0.3	0.3
		---- Fruit harvested per marked branch ----		
Glyphosate (lb ae/A)	0.015	4.8	7.5	4
Rate*date: P=NS	0.15	9.8	6.5	7.9
	0.3	-	5.8	5
Propanil (lb ai/A)	0.04	3.7	5.6	3.5
Rate*date: P = NS	0.2	-	5.3	4.9
	0.4	4.5	5.4	5.9

Table 1b. Effect of simulated glyphosate and propanil drift on French prune yield - Winters, CA 2010.

	Rate	Application date		
	lb ae or ai/A	June	July	August
			--- Fruit harvested per flower ---	
Glyphosate (lb ae/A)	0.015	0.29	0.42	0.25
Rate*date: P=0.0001	0.15	0.48	0.48	0.35
	0.3	-	0.33	0.33
Propanil (lb ai/A)	0.04	0.24	0.28	0.22
Rate*date: P=0.0001	0.2	-	0.40	0.30
	0.4	0.27	0.40	0.34
			---- 100 fruit fresh weight (g) ----	
Glyphosate (lb ae/A)	0.015	2283	1978	2179
Rate*date: P=NS	0.15	2081	2025	2151
	0.3	-	2146	2217
Propanil (lb ai/A)	0.04	2272	2078	2072
Rate*date: P=NS	0.2	-	2147	2252
	0.4	2253	2230	2181
			---- 100 fruit dry weight (g) ----	
Glyphosate (lb ae/A)	0.015	892	748	965
Rate*date: P=NS	0.15	844	869	892
	0.3	-	799	889
Propanil (lb ai/A)	0.04	996	803	792
Rate*date: P = NS	0.2	-	812	915
	0.4	914	844	818
			---- Fruit dry weight (%) ----	
Glyphosate (lb ae/A)	0.015	39	37.9	45
Rate*date: P=NS	0.15	40.6	44.3	41.4
	0.3	-	37.3	40.1
Propanil (lb ai/A)	0.04	44	38.6	38.2
Rate*date: P = NS	0.2	-	37.6	40.8
	0.4	40.6	37.7	37.5
			---- Fruit yield per tree (lbs) ----	
Glyphosate (lb ae/A)	0.015	193.5	175.6	143.3
Rate*date: P=NS	0.15	133.1	146.4	140.4
	0.3	-	176.2	132.7
Propanil (lb ai/A)	0.04	146.7	147.5	165.9
Rate*date: P = NS	0.2	-	134.9	113.4
	0.4	105	163.5	215.7

Table 2a. Effect of simulated glyphosate and propanil drift on French prune yield components - Yuba City, CA 2010.

	Rate	Application date		
	lb ae or ai/A	June	July	August
		---- Visual injury of treated branches (%) ----		
Glyphosate (lb ae/A)	0.015	2	0	0
Rate*date: P=0.0001	0.15	4.5	0	0
	0.3	5	0	0
Propanil (lb ai/A)	0.04	3.5	0	0
Rate*date: P=0.0001	0.2	26.3	0	0
	0.4	38.8	0	0
		---- Flowers per marked branch ----		
Glyphosate (lb ae/A)	0.015	20	25.5	31.6
Rate*date: P=NS	0.15	17.1	22.7	16.3
	0.3	18.6	20.4	21.4
Propanil (lb ai/A)	0.04	20.4	19.6	17.8
Rate*date: P=NS	0.2	20.8	21.1	18.8
	0.4	16.4	24.5	16.4
		---- Fruit set per marked branch ----		
Glyphosate (lb ae/A)	0.015	14.9	26.8	27.5
Rate*date: P=NS	0.15	12.1	18.3	12.4
	0.3	13.9	15	16.5
Propanil (lb ai/A)	0.04	15.5	15.4	14.8
Rate*date: P = NS	0.2	16.8	16.7	13.9
	0.4	14.2	19.3	12.5
		---- Fruit set per flower ----		
Glyphosate (lb ae/A)	0.015	0.72	0.75	0.82
Rate*date: P=NS	0.15	0.67	0.8	0.76
	0.3	0.75	0.76	0.76
Propanil (lb ai/A)	0.04	0.78	0.76	0.84
Rate*date: P = NS	0.2	0.79	0.79	0.77
	0.4	0.86	0.8	0.78
		---- Fruit harvested per marked branch ----		
Glyphosate (lb ae/A)	0.015	14.9	18.9	26.8
Rate*date: P=NS	0.15	12.1	18.3	12.4
	0.3	13.9	15	16.5
Propanil (lb ai/A)	0.04	15.5	15.4	14.8
Rate*date: P = NS	0.2	16.8	16.9	13.9
	0.4	14.2	19.3	12.5

Table 2b. Effect of simulated glyphosate and propanil drift on French prune yield - Yuba City, CA 2010.

	Rate	Application date		
	lb ae or ai/A	June	July	August
			--- Fruit harvested per flower ---	
Glyphosate (lb ae/A)	0.015	0.8	0.8	0.9
Rate*date: P=0.0001	0.15	1.2	0.8	1.1
	0.3	0.9	0.7	0.8
Propanil (lb ai/A)	0.04	0.8	0.6	1.1
Rate*date: P=0.0001	0.2	1.1	0.8	1
	0.4	1.3	0.9	0.9
			---- 100 fruit fresh weight (g) ----	
Glyphosate (lb ae/A)	0.015	2115	2151	2018
Rate*date: P=NS	0.15	2281	1961	2319
	0.3	2144	2176	2171
Propanil (lb ai/A)	0.04	2174	2357	2171
Rate*date: P=NS	0.2	1991	1967	2299
	0.4	1901	2082	2273
			---- 100 fruit dry weight (g) ----	
Glyphosate (lb ae/A)	0.015	817	831	749
Rate*date: P=NS	0.15	791	755	906
	0.3	824	807	771
Propanil (lb ai/A)	0.04	826	950	791
Rate*date: P = NS	0.2	741	771	896
	0.4	719	792	871
			---- Fruit dry weight (%) ----	
Glyphosate (lb ae/A)	0.015	38.6	38.1	36.8
Rate*date: P=NS	0.15	34.8	38.4	38.7
	0.3	38.2	37	35.5
Propanil (lb ai/A)	0.04	38	40.1	36.3
Rate*date: P = NS	0.2	37	39.1	38.8
	0.4	36.2	37.8	38

Table 3. Summary statistics for the effects of simulated glyphosate and propanil drift on French prune- Winters, CA 2010 (averaged over 3 application rates and 3 application timings).

	Visual injury	Flower set	Fruit set	Harvested fruit	100 fruit fresh wt	100 fruit dry wt	Dehyd. fruit wt	Fresh fruit yield* 2009	2010
	%	#/branch	#	#/flower	g	g	%	lb/tree	lb/tree
Untreated	-	15.8	0.3	0.32	2067	843	41.1	194.9	126.3
Glyphosate	2.5	17.7	0.36	0.36	2123	863	40.9	159	154.6
Propanil	6.5	15.8	0.3	0.31	2179	855	39.2	152.3	150.6

* The untreated trees were not incorporated within the experimental design; edge effects or cultural practices may have impacted yield differently than the herbicide-treated plots.

Table 4. Summary statistics for the effects of simulated glyphosate and propanil drift on French prune- Yuba City, CA 2010 (averaged over 3 application rates and 3 application timings).

	Visual injury	Flower set	Fruit set	Harvested fruit	100 fruit fresh wt	100 fruit dry wt	Dehydrated fruit wt
	%	#/branch	#	#/flower	g	g	%
Untreated*	0	21.3	0.79	0.82	2172	839	38.5
Glyphosate	1.2	21.9	0.76	0.87	2137	807	37.6
Propanil	7.6	19.5	0.8	0.94	2135	816	38