Weed control with glyphosate tank mixed with indaziflam or penoxsulam in California orchards and vineyards

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Introduction

California is the largest producer of walnuts and grapes in the USA. In California, walnut is grown on more than 200,000 acres by more than 4,000 growers contributing to the state's $540 million walnut industry. Grapes are grown on more than 1 million acres in California for wine, table, and raisin markets. Weed management is an annual challenge for perennial crop producers in order to reduce weed competition as well as minimize weed interference with horticultural operations. Most walnut and grape growers in California use herbicides as part of their weed management program. Due to its broad weed spectrum, relatively low cost, and favorable environmental profile, glyphosate is used extensively in California orchards and vineyards. The occurrence of weed shifts and selection of glyphosate resistant biotypes in some areas has led to an increased need for alternative herbicide programs. Fortunately, several new herbicides are in the process of registration or have recently been registered for weed control in perennial crops. For example, indaziflam (Alion 200) is a new herbicide (federal registration pending) for a pre-emergence weed control in perennial fruit, nut and vine crops. Penoxsulam (Pindar GT, Tangent) is a selective herbicide for pre-emergence and post-emergence residual control of certain broadleaf and grass weeds in tree nut crops. Indaziflam and penoxsulam may be applied alone or in a tank mix with other herbicides. It is expected that when applied with a post-emergence herbicide such as glufosinate or glyphosate, these herbicides will provide burndown effects in addition to extended residual weed control. However, relatively little information is available on weed control with a tank mixes of glyphosate with indaziflam or penoxsulam in California orchards and vineyards.

Objective

To evaluate efficacy of tank mix of glyphosate with indaziflam or penoxsulam applied at various rates for weed control in established orchards and vineyards in California.

Materials and Methods

Field Experiments: Field experiments were conducted in an established walnut orchard and a vineyard in Yolo County, CA in 2010. At both sites, treatments included glyphosate alone (2 lb ae/acre) and glyphosate tank mixed with penoxsulam (0.015 or 0.03 lb/acre), indaziflam (0.065 or 0.085 lb/acre), flumioxazin (0.255 or 0.383 lb/acre) or rimsulfuron (0.063 lb/acre). An untreated control was included for comparison. Both the experiments were conducted in randomized complete block design with four replications. In the walnut trial, 8 x 30 ft plots were arranged between the tree rows (middles). Herbicides were applied on April 22, 2010 at the walnut site in a spray volume of 20 gallons per acre (gpa). In the vineyard trial, herbicides were applied in a spray volume of 30 gpa to 6 x 20 ft plots centered on the vine row on March 30, 2010.

Data Collection: Visual ratings of broadleaf and grass weeds (based on 0 to 100% scale) were taken several times during the crop season. In mid-summer, all weeds from a random 0.25 m^2 area in each plot were cut at the soil surface, placed in paper bags, dried for 72 h at 60 ºC and total weed biomass was recorded.

Statistical Analysis: All data were subjected to analysis of variance (ANOVA) using the Proc GLM procedure of SAS (SAS Institute, NC). The weed density data were square root transformed for homogenous variance prior to analysis; however, data presented here are the means of actual values for comparison.

Table 1. Visual weed control evaluations in a glyphosate plus residual herbicides trial in a walnut orchard in Yolo County, CA.

	Treatment[a]	Rate lb ae or ai/acre	% Control[c]									Weed Biomass (g m^{-2})
			May 10 (2.5 WAT[b])			June 2 (7.5 WAT)			July 27 (15.5)			
			Filaree	Burclover	Mallow	Bermuda grass	Mallow	Bindweed	Lambsquarters	Bindweed	Bermuda grass	
1	Untreated		0 c	0 c	0 c	0 b	0 b	0 c	0 e	0 d	0 c	187 a
2	Glyphosate	2	90 ab	93 ab	69 b	79 b	83 b	64 b	19 d	76 a	26 b	101 b
3	Glyphosate + Penoxsulam	2 + 0.015	93 ab	94 a	87 ab	67 b	91 b	73 ab	95 ab	76 a	84 a	57 cd
4	Glyphosate + Penoxsulam	2 + 0.030	94 a	96 a	91 a	79 b	78 b	79 ab	95 ab	74 a	98 a	48 cd
5	Glyphosate + Indaziflam	2 + 0.065	92 ab	92 ab	95 a	86 b	88 b	74 ab	56 cd	56 ab	89 a	79 bc
6	Glyphosate + Indaziflam	2 + 0.085	87 b	89 b	89 a	83 b	93 b	85 a	97 a	79 a	98 a	32 d
7	Glyphosate + Flumioxazin	2 + 0.255	92 ab	92 ab	93 a	84 b	93 b	89 a	68 bc	39 bc	45 b	112 b
8	Glyphosate + Flumioxazin	2 + 0.383	90 ab	93 ab	91 a	83 b	90 b	76 ab	86 abc	28 c	93 a	77 bc
9	Glyphosate + Rimsulfuron	2 + 0.063	93 ab	93 ab	91 a	85 b	89 b	83 ab	73 abc	71 a	97 a	52 cd

Glyphosate + penoxsulam 0.03 lb ai/A at 7.5 WAT

Glufosinate + flumioxazin at 0.383 lb ai/acre at 7.5 WAT

Table 2. Visual weed control evaluations in a glyphosate plus residual herbicides trial in a vineyard in Yolo County, CA.

	Treatment[a]	Rate lb ae or ai/acre	% Control[c]									Weed Biomass (g m^{-2})
			April 15 (2 WAT[b])			June 2 (9 WAT)			August 17 (20 WAT)			
			Willowherb	Filaree	Burclover	Willowherb	Filaree	Hare barley	Willowherb	Burclover	Fluvellin	
1	Untreated		0 d	0 c	0 c	0 e	0 c	0 d	0 d	0 b	0 c	150 a
2	Glyphosate	2	3 cd	68 b	41 b	26 d	92 ab	91 abc	12 cd	99 a	74 b	57 b
3	Glyphosate + Penoxsulam	2 + 0.015	12 cd	95 a	91 a	86 ab	94 ab	93 a	58 b	99 a	99 a	29 bc
4	Glyphosate + Penoxsulam	2 + 0.030	7 cd	93 ab	97 a	96 a	97 b	90 bc	97 a	99 a	89 ab	5 bc
5	Glyphosate + Indaziflam	2 + 0.065	11 cd	96 a	98 a	44 bcd	90 ab	91 abc	61 b	99 a	94 ab	24 bc
6	Glyphosate + Indaziflam	2 + 0.085	8 cd	97 a	96 a	41 cd	96 a	90 bc	41 bc	99 a	97 a	23 bc
7	Glyphosate + Flumioxazin	2 + 0.255	68 ab	92 ab	97 a	79 abc	85 b	90 bc	97 a	99 a	98 a	6 bc
8	Glyphosate + Flumioxazin	2 + 0.383	78 a	94 ab	88 a	76 abc	97 a	92 ab	98 a	99 a	94 ab	4 c
9	Glyphosate + Rimsulfuron	2 + 0.063	31 bc	95 a	90 a	63 abcd	97 a	88 c	74 ab	99 a	98 a	10 bc

[a]All treatments with glyphosate included ammonium sulfate at 10 lb/100 gallon spray solution; All treatments with penoxsulam, flumioxazin and rimsulfuron included a nonionic surfactant at 0.25% v/v. [b]WAT, weeks after treatment; [c]Least square means within columns with no common letters are significantly different according to Fisher's Protected LSD test where $P < 0.05$.

Untreated on June 2, 2010

Glyphosate 2 lb ae/A + flumioxazin at 0.383 lb ai/A at 9 WAT

Results and Discussion

The objective of present study was to investigate the efficacy of tank mixes of glyphosate with indaziflam, penoxsulam, flumioxazin or rimsulfuron for weed control in walnut and vineyard in California. The results suggested that there were few weed control differences among residual herbicides tank mixed with glyphosate although most were slightly better than glyphosate applied alone in early summer. For example, little mallow (*Malva parviflora*) and California burclover (*Medicago polymorpha*) control was significantly reduced when glyphosate was applied alone compared to other tank mix partners at 2 WAT. Late summer weed control evaluations usually revealed better weed control in all treatments compared to untreated plots with some differences among tank mix partners. For example, willowherb (*Epilobium ciliatum*) was better controlled with a tank mix of glyphosate with penoxsulam (0.03 lb ai/acre), flumioxazin or rimsulfuron compared to glyphosate applied alone or in a tank mix with penoxsulam at 0.015 lb ai/acre or indaziflam at 20 WAT in a vineyard trial. All treatments reduced weed biomass compared to untreated plots at both sites with only minor differences among tank mix partners. Herbicides were applied later (March/April) than recommended time (December/January); therefore earlier application timing likely would have improved weed control.