HERBICIDE COMBINATIONS AND ADJUVANTS FOR YELLOW NUTSEDGE CONTROL IN GLYPHOSATE-RESISTANT SUGAR BEET

Joel Felix and Joey Ishida, Malheur Experiment Station, Oregon State University, Ontario, OR, 2012

Introduction

Weed control in sugar beet improved after the introduction of glyphosate-resistant hybrids for commercial production in 2008. Growers are now able to control most annual broadleaf and grassy weeds better compared to the micro-rate herbicide program era. However, control for yellow nutsedge (*Cyperus esculentus*) remains a challenge for sugar beet growers in the Treasure Valley of eastern Oregon and southwestern Idaho.

The predominant use of glyphosate as the herbicide of choice for weed control in glyphosate-resistant crops has resulted in the selection of resistant weed biotypes in many states. It is important for growers in the Treasure Valley to be aware of the selection pressure exerted on weeds by the continuous use of glyphosate alone to manage weeds.

Growers need to be proactive in their approach to weed management in glyphosate-resistant sugar beets. The ideal weed management program needs to include herbicides with different modes of action. The weed management research program at the Malheur Experiment Station strives to develop herbicide combinations for effective management of weeds. Extra effort is devoted to develop herbicide programs for effective management of yellow nutsedge. We also need to develop herbicide combinations for the management of kochia in sugar beet to avert selection for glyphosate resistance. Glyphosate-resistant kochia populations have been confirmed in Kansa, Nebraska, South and North Dakota, Colorado, and southern Alberta in Canada.

Materials and Methods

Field studies were established in 2012 at the Malheur Experiment Station, Ontario, Oregon to evaluate herbicide combinations, adjuvants, and application timing to improve yellow nutsedge control in glyphosate-resistant sugar beets. Fertilizer was applied during fall 2011 to provide 50, 40, and 60 lb/acre of nitrogen, phosphate, and sulfur, respectively. The field was moldboard plowed, groundhogged, and 22-inch-wide beds formed. The beds were harrowed and reshaped on April 10, 2012. Two trials had treatments arranged in randomized complete block designs with four replications. Individual plots were 7.33 ft wide (4 rows) by 27 ft long. Soil was Owyhee silt loam (pH 6.9, 1.75 percent organic matter, and cation exchange capacity [CEC] 21 meq/kg). The treatments are listed in Tables 1 and 4.

Roundup Ready® sugar beet hybrid BTS 27RR20 was planted on April 11, 2012, using tractor-mounted flexi-planter units with double-disc furrow openers and cone seeders fed from a spinner divider that uniformly distributed the seeds within the row. Sugar beet seeds were dropped at 5-inch spacing within the row. Terbufos at 1.11 lb ai/acre (Counter® 15G at 7.4 lb/acre) was applied on April 13. Plants were sidedressed with urea on May 30, 2012 to supply 200 lb nitrogen/acre. The study was furrow irrigated on a calendar schedule to maintain moisture in the top 12 inches of the soil profile. Irrigation scheduling began on May 9 and ended on August 30, 2012 with each event lasting 24 hours. Preventative sprays for powdery mildew were done on July 9 and August 28 using Inspire™ (difenoconazole) fungicide at 7 oz/acre plus sulfur at 5 lbs/acre.

Herbicide treatments were applied using a CO_2-pressurized backpack sprayer with a boom equipped with four 8002EVS Teejet nozzles calibrated to deliver 12 gal/acre of spray solution at 35 psi and 3 mph. Early POST treatments (sugar beet at 2-leaf stage) were applied on May 9 followed by a second POST application (sugar beet at 6-leaf stage) on May 31, 2012. Plants within each plot were evaluated visually for crop injury and weed control on June 21 and August 10, 2012. Evaluations were based on a scale of 0 percent (no crop injury or no weed control) to 100 percent (complete crop kill or complete weed control). Sugar beets were harvested by hand on October 2 from 10 ft of the two center rows. Sugar beet weight from each plot was corrected for tare to estimate yield. Sugar content and other sugar yield variables were determined in a laboratory at the Amalgamated Sugar Factory in Paul, Idaho. Data were subjected to analysis of variance using SAS and means compared using LSD at $P = 0.05$ percent.

Results and Discussion

Herbicide Combination Study

There was no sugar beet injury observed from any of the evaluated treatment combinations in these studies (Tables 1 and 4). Early season yellow nutsedge control was evaluated on June 21 (21 days after the last herbicide application) and ranged from 73 to 97 percent (Table 1). The highest control (91 to 97%) was obtained with treatments that included Dual Magnum® at 1.27 lb ai/acre or Outlook® at 0.98 lb ai/acre applied in tank mixtures with glyphosate. These results are consistent with our findings in 2011. The tank mix of Nortron® at 0.5 lb ai/acre plus glyphosate at 0.77 lb ae/acre applied at the two-leaf stage followed by glyphosate at 0.77 lb ae/acre when sugar beet plants were at the six-leaf stage provided 88 percent control. The lowest yellow nutsedge control was observed when standalone glyphosate at 0.77 lb ae/acre was applied at the two- and six-leaf stages. Control for common lambsquarters and kochia at 21 days after the last herbicide application was greater than 97 percent across treatments. The treatments provided complete control of pigweed species.

Estimates of late season weed control was made 71 days after the last herbicide application (Table 2). The control of yellow nutsedge followed a similar trend as that obtained at 21 days after herbicide application. Yellow nutsedge control was consistently highest for treatments that included Dual Magnum or Outlook at the two- and six-leaf application timings. Late season control for common lambsquarters, pigweed species, hairy nightshade, and barnyardgrass ranged from 94 to 100 percent across herbicide treatments.

The treatments did not affect sugar beet plant stand (Table 3). Sugar beet root yield ranged from 29.1 to 50 tons/acre. The lowest root yield and estimated recoverable sugar was obtained when glyphosate at 0.77 lb ae/acre was applied alone to plants that were at the two- and six-leaf stages. Percent sucrose content was similar across herbicide treatments. Once again these results are consistent with our findings in 2011 when treatments that included soil-active herbicides provided the highest yellow nutsedge control and root yield.

Adjuvants Study

Tank mixes of glyphosate at 1.13 lb ae/acre with either ammonium sulfate (AMS), Zenith, Array, or AMS plus nonionic surfactant (NIS) provided the highest early season yellow nutsedge control (Table 4). Application of glyphosate at 0.77 lb ae/acre provided the lowest yellow nutsedge control among the herbicide treatments. The treatments provided complete control for common lambsquarters, kochia, and barnyardgrass.

Late season yellow nutsedge control ranged from 71 to 89 percent with glyphosate applied at 0.77 lb ae/acre providing the lowest control (Table 5). Control for common lambsquarters, kochia, and barnyardgrass at 71 days after the last herbicide application ranged from 86 to 98 percent. The root yield was similar across treatments and ranged from 38.3 to 48.4 tons/acre (Table 6). Percent sucrose content and the estimated recoverable sugar was similar across herbicide treatments. The results suggested that control for yellow nutsedge was influenced more by the glyphosate rate than the adjuvants. Previous results had indicated improved yellow nutsedge control with the tank mixes that included AMS and NIS.

Table 1. Early season (June 21, 2012) weed control in Roundup-resistant sugar beet with and without soil active herbicides at the Malheur Experiment Station, Ontario, OR, 2012.

Treatment*	Rate	Timing	Crop injury	Weed control**			
				Yellow nutsedge	Common lambsquarters	Kochia	Pigweed species
			---------- % ----------				
Untreated			0 a	0 e	0 c	0 c	0 b
Nortron	0.5 lb ai/a	2-leaf	0 a	88 c	98 b	98 ab	100 a
Roundup PowerMax	0.77 lb ae/a	2-leaf					
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Nortron	1 lb ai/a	2-leaf	0 a	83 c	100 a	100 a	100 a
Roundup PowerMax	0.77 lb ae/a	2-leaf					
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Roundup PowerMax	0.77 lb ae/a	2-leaf	0 a	73 d	97 b	97 b	100 a
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Roundup PowerMax	1.13 lb ae/a	2-leaf	0 a	84 bc	100 a	100 a	100 a
Roundup PowerMax	1.13 lb ae/a	6-leaf					
Roundup PowerMax	0.77 lb ae/a	2-leaf	0 a	97 a	100 a	100 a	100 a
Dual Magnum	1.27 lb ai/a	2-leaf					
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Dual Magnum	1.27 lb ai/a	6-leaf					
Roundup PowerMax	0.77 lb ae/a	2-leaf	0 a	91 abc	100 a	100 a	100 a
Sustain	1.04 lb ai/a	2-leaf					
Dual Magnum	1.27 lb ai/a	6-leaf					
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Sustain	1.04 lb ai/a	6-leaf					
Roundup PowerMax	1.13 lb ae/a	2-leaf	0 a	93 ab	100 a	100 a	100 a
Outlook	0.98 lb ai/a	6-leaf					
Roundup PowerMax	1.13 lb ae/a	6-leaf					
Roundup PowerMax	1.13 lb ae/a	2-leaf	0 a	97 a	100 a	100 a	100 a
Outlook	0.98 lb ai/a	2-leaf					
Roundup PowerMax	1.13 lb ae/a	6-leaf					
Outlook	0.98 lb ai/a	6-leaf					

* All treatments included ammonium sulfate (AMS) at 2.5 percent v/v.

**Means within a column followed by same letter do not significantly differ (*P* = 0.05, Student-Newman-Keuls).

Table 2. Late season (August 10, 2012) weed control in Roundup-resistant sugar beet with and without soil-active herbicides at the Malheur Experiment Station, Ontario, OR, 2012.

Treatment*	Rate	Timing	Weed control**				
			Yellow nutsedge	Common lambsquarters	Pigweed species	Hairy nightshade	Barnyardgrass
			%				
Untreated			0 e	0 d	0 c	0 b	0 b
Nortron	0.5 lb ai/a	2-leaf	81 c	96 bc	97 ab	100 a	94 a
Roundup PowerMax	0.77 lb ae/a	2-leaf					
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Nortron	1 lb ai/a	2-leaf	78 c	100 a	100 a	100 a	95 a
Roundup PowerMax	0.77 lb ae/a	2-leaf					
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Roundup PowerMax	0.77 lb ae/a	2-leaf	66 d	95 c	97 b	94 a	99 a
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Roundup PowerMax	1.13 lb ae/a	2-leaf	80 c	100 a	100 a	99 a	93 a
Roundup PowerMax	1.13 lb ae/a	6-leaf					
Roundup PowerMax	0.77 lb ae/a	2-leaf	98 a	98 ab	98 ab	100 a	100 a
Dual Magnum	1.27 lb ai/a	2-leaf					
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Dual Magnum	1.27 lb ai/a	6-leaf					
Roundup PowerMax	0.77 lb ae/a	2-leaf	93 ab	100 a	100 a	100 a	98 a
Sustain	1.04 lb ai/a	2-leaf					
Dual Magnum	1.27 lb ai/a	6-leaf					
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Sustain	1.04 lb ai/a	6-leaf					
Roundup PowerMax	1.13 lb ae/a	2-leaf	89 b	100 a	100 a	99 a	95 a
Outlook	0.98 lb ai/a	6-leaf					
Roundup PowerMax	1.13 lb ae/a	6-leaf					
Roundup PowerMax	1.13 lb ae/a	2-leaf	99 a	100 a	100 a	100 a	100 a
Outlook	0.98 lb ai/a	2-leaf					
Roundup PowerMax	1.13 lb ae/a	6-leaf					
Outlook	0.98 lb ai/a	6-leaf					

* All treatments included ammonium sulfate (AMS) at 2.5 percent v/v.

**Means within a column followed by same letter do not significantly differ (*P* = 0.05, Student-Newman-Keuls).

Table 3. Late season (August 10, 2012) weed control in Roundup-resistant sugar beet with and without soil-active herbicides at the Malheur Experiment Station, Ontario, OR, 2012.

			Root and sugar yield**				
Treatment*	Rate	Timing	Roots no./acre	Root yield tons/acre	Sugar content %	Gross sugar lbs/acre	ER Sugar lbs/acre
Untreated			35311 b	5.3 c	4.16 b	394.5 c	337.1 c
Nortron	0.5 lb ai/a	2-leaf	54895 a	45.4 a	18.43 a	16,668.1 a	14,315.0 a
Roundup PowerMax	0.77 lb ae/a	2-leaf					
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Nortron	1 lb ai/a	2-leaf	65281 a	40.8 a	18.47 a	15,038.0 a	12,942.2 a
Roundup PowerMax	0.77 lb ae/a	2-leaf					
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Roundup PowerMax	0.77 lb ae/a	2-leaf	62017 a	29.1 b	18.55 a	10,786.4 b	9,354.8 b
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Roundup PowerMax	1.13 lb ae/a	2-leaf	62610 a	41.7 a	18.51 a	15,339.1 a	13,126.6 a
Roundup PowerMax	1.13 lb ae/a	6-leaf					
Roundup PowerMax	0.77 lb ae/a	2-leaf	57269 a	45.7 a	18.15 a	16,530.6 a	14,248.6 a
Dual Magnum	1.27 lb ai/a	2-leaf					
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Dual Magnum	1.27 lb ai/a	6-leaf					
Roundup PowerMax	0.77 lb ae/a	2-leaf	62017 a	49.0 a	18.46 a	18,065.5 a	15,518.2 a
Sustain	1.04 lb ai/a	2-leaf					
Dual Magnum	1.27 lb ai/a	6-leaf					
Roundup PowerMax	0.77 lb ae/a	6-leaf					
Sustain	1.04 lb ai/a	6-leaf					
Roundup PowerMax	1.13 lb ae/a	2-leaf	55192 a	46.1 a	17.94 a	16,549.9 a	14,174.1 a
Outlook	0.98 lb ai/a	6-leaf					
Roundup PowerMax	1.13 lb ae/a	6-leaf					
Roundup PowerMax	1.13 lb ae/a	2-leaf	64984 a	50.0 a	17.86 a	17,861.7 a	15,196.9 a
Outlook	0.98 lb ai/a	2-leaf					
Roundup PowerMax	1.13 lb ae/a	6-leaf					
Outlook	0.98 lb ai/a	6-leaf					

* All treatments included ammonium sulfate (AMS) at 2.5 percent v/v.

**Means within a column followed by same letter do not significantly differ (*P* = 0.05, Student-Newman-Keuls).

Table 4. Early season (June 21, 2012) weed control in Roundup-resistant sugar beet with glyphosate tank-mixed with different adjuvants at the Malheur Experiment Station, Ontario, OR, 2012.

Treatment	Rate	Timing	Crop injury	Weed control*			
				Yellow nutsedge	Common lambsquarters	Barnyardgrass	Kochia
			---------- % ----------				
Untreated			0a	0 e	0 b	0 b	0b
Roundup Weathermax	0.77 lb ae/a	2-leaf	0a	78 cd	100 a	100 a	100 a
AMS	2.5 % v/v	2-leaf					
Roundup Weathermax	0.77 lb ae/a	6-leaf					
AMS	2.5 % v/v	6-leaf					
Roundup Weathermax	1.13 lb ae/a	2-leaf	0a	91 ab	100 a	100 a	100 a
AMS	2.5 % v/v	2-leaf					
Roundup Weathermax	1.13 lb ae/a	6-leaf					
AMS	2.5 % v/v	6-leaf					
Roundup Weathermax	0.77 lb ae/a	2-leaf	0a	73 d	100 a	100 a	100 a
Sustain	1.04 lb ai/a	2-leaf					
Roundup Weathermax	0.77 lb ae/a	6-leaf					
Sustain	1.04 lb ai/a	6-leaf					
Roundup Weathermax	0.77 lb ae/a	2-leaf	0a	78 cd	100 a	100 a	100 a
Zenith	2.25 lb ai/a	2-leaf					
Roundup Weathermax	0.77 lb ae/a	6-leaf					
Zenith	2.25 lb ai/a	6-leaf					
Roundup Weathermax	0.77 lb ae/a	2-leaf	0a	80 bcd	100 a	100 a	100 a
Array	1.08 % v/v	2-leaf					
Roundup Weathermax	0.77 lb ae/a	6-leaf					
Array	1.08 % v/v	6-leaf					
Roundup Weathermax	1.13 lb ae/a	2-leaf	0a	91 ab	100 a	100 a	100 a
Zenith	2.25 lb ai/a	2-leaf					
Roundup Weathermax	1.13 lb ae/a	6-leaf					
Zenith	2.25 lb ai/a	6-leaf					
Roundup Weathermax	1.13 lb ae/a	2-leaf	0a	93 a	100 a	100 a	100 a
Array	1.08 % v/v	2-leaf					
Roundup Weathermax	1.13 lb ae/a	6-leaf					
Array	1.08 % v/v	6-leaf					
Roundup Weathermax	0.77 lb ae/a	2-leaf	0a	88 abc	100 a	100 a	100 a
AMS	2.5 % v/v	2-leaf					
NIS (R-11)	0.25 % v/v	2-leaf					
Roundup Weathermax	0.77 lb ae/a	6-leaf					
AMS	2.5 % v/v	6-leaf					
NIS (R-11)	0.25 % v/v	6-leaf					

*Means within a column followed by same letter do not significantly differ (P = 0.05, Student-Newman-Keuls).

Table 5. Late season (August 10, 2012) weed control in Roundup-resistant sugar beet with glyphosate tank-mixed with different adjuvants at the Malheur Experiment Station, Ontario, OR, 2012.

Treatment	Rate	Timing	Weed control*			
			Yellow nutsedge	Common lambsquarters	Pigweed species	Barnyardgrass
			%			
Untreated			0 c	0 b	0 b	0 b
Roundup Weathermax	0.77 lb ae/a	2-leaf	71 b	95 a	90 a	95 a
AMS	2.5 % v/v	2-leaf				
Roundup Weathermax	0.77 lb ae/a	6-leaf				
AMS	2.5 % v/v	6-leaf				
Roundup Weathermax	1.13 lb ae/a	2-leaf	80 a	98 a	98 a	96 a
AMS	2.5 % v/v	2-leaf				
Roundup Weathermax	1.13 lb ae/a	6-leaf				
AMS	2.5 % v/v	6-leaf				
Roundup Weathermax	0.77 lb ae/a	2-leaf	74 b	95 a	88 a	91 a
Sustain	1.04 lb ai/a	2-leaf				
Roundup Weathermax	0.77 lb ae/a	6-leaf				
Sustain	1.04 lb ai/a	6-leaf				
Roundup Weathermax	0.77 lb ae/a	2-leaf	84 a	98 a	96 a	99 a
Zenith	2.25 lb ai/a	2-leaf				
Roundup Weathermax	0.77 lb ae/a	6-leaf				
Zenith	2.25 lb ai/a	6-leaf				
Roundup Weathermax	0.77 lb ae/a	2-leaf	83 a	98 a	86 a	95 a
Array	1.08 % v/v	2-leaf				
Roundup Weathermax	0.77 lb ae/a	6-leaf				
Array	1.08 % v/v	6-leaf				
Roundup Weathermax	1.13 lb ae/a	2-leaf	81 a	94 a	89 a	88 a
Zenith	2.25 lb ai/a	2-leaf				
Roundup Weathermax	1.13 lb ae/a	6-leaf				
Zenith	2.25 lb ai/a	6-leaf				
Roundup Weathermax	1.13 lb ae/a	2-leaf	84 a	96 a	96 a	95 a
Array	1.08 % v/v	2-leaf				
Roundup Weathermax	1.13 lb ae/a	6-leaf				
Array	1.08 % v/v	6-leaf				
Roundup Weathermax	0.77 lb ae/a	2-leaf	89 a	98 a	95 a	96 a
AMS	2.5 % v/v	2-leaf				
NIS (R-11)	0.25 % v/v	2-leaf				
Roundup Weathermax	0.77 lb ae/a	6-leaf				
AMS	2.5 % v/v	6-leaf				
NIS (R-11)	0.25 % v/v	6-leaf				

* Means within a column followed by same letter do not significantly differ (*P* = 0.05, Student-Newman-Keuls)

Table 6. Sugar beet root yield and sugar content in response to glyphosate tank-mixed with different adjuvants at the Malheur Experiment Station, Ontario, OR, 2012.

			Root and sugar yield*				
			Roots	Yield	Sugar content	Gross sugar	ERS
Treatment	Rate	Timing	no./acre	ton/acre	%	lbs/acre	lbs/acre
Untreated			1,7210 b	6.7 b	13.85 a	1,934.1 b	1,660.6 b
Roundup Weathermax	0.77 lb ae/a	2-leaf	63,204 a	45.5 a	18.39 a	16,743.8 a	14,405.6 a
AMS	2.5 % v/v	2-leaf					
Roundup Weathermax	0.77 lb ae/a	6-leaf					
AMS	2.5 % v/v	6-leaf					
Roundup Weathermax	1.13 lb ae/a	2-leaf	63,204 a	48.4 a	18.27 a	17,675.0 a	15,220.5 a
AMS	2.5 % v/v	2-leaf					
Roundup Weathermax	1.13 lb ae/a	6-leaf					
AMS	2.5 % v/v	6-leaf					
Roundup Weathermax	0.77 lb ae/a	2-leaf	63,204 a	39.8 a	18.63 a	14,807.4 a	12,738.2 a
Sustain	1.04 lb ai/a	2-leaf					
Roundup Weathermax	0.77 lb ae/a	6-leaf					
Sustain	1.04 lb ai/a	6-leaf					
Roundup Weathermax	0.77 lb ae/a	2-leaf	67,951 a	44.2 a	18.27 a	16,150.1 a	13,794.2 a
Zenith	2.25 lb ai/a	2-leaf					
Roundup Weathermax	0.77 lb ae/a	6-leaf					
Zenith	2.25 lb ai/a	6-leaf					
Roundup Weathermax	0.77 lb ae/a	2-leaf	56,675 a	38.3 a	18.57 a	14,223.1 a	12,207.6 a
Array	1.08 % v/v	2-leaf					
Roundup Weathermax	0.77 lb ae/a	6-leaf					
Array	1.08 % v/v	6-leaf					
Roundup Weathermax	1.13 lb ae/a	2-leaf	61,423 a	44.1 a	17.908a	15,806.7 a	13,561.6 a
Zenith	2.25 lb ai/a	2-leaf					
Roundup Weathermax	1.13 lb ae/a	6-leaf					
Zenith	2.25 lb ai/a	6-leaf					
Roundup Weathermax	1.13 lb ae/a	2-leaf	56,675 a	42.6 a	17.855a	14,630.6 a	12,623.1 a
Array	1.08 % v/v	2-leaf					
Roundup Weathermax	1.13 lb ae/a	6-leaf					
Array	1.08 % v/v	6-leaf					
Roundup Weathermax	0.77 lb ae/a	2-leaf	58,159 a	45.5 a	18.013a	16,394.6 a	14,019.6 a
AMS	2.5 % v/v	2-leaf					
NIS (R-11)	0.25 % v/v	2-leaf					
Roundup Weathermax	0.77 lb ae/a	6-leaf					
AMS	2.5 % v/v	6-leaf					
NIS (R-11)	0.25 % v/v	6-leaf					

* Means within a column followed by same letter do not significantly differ (*P* = 0.05, Student-Newman-Keuls).