HERBICIDE COMBINATIONS FOR GENERAL WEED AND YELLOW NUTSEDGE CONTROL IN SUGAR BEET IN THE TREASURE VALLEY

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Introduction

Weed control in sugar beet improved after the introduction of glyphosate-resistant sugar beet hybrids in the Treasure Valley of eastern Oregon and southwestern Idaho in 2008. Now growers are 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. Also, the predominant use of glyphosate as the sole herbicide of choice for weed control in glyphosate-resistant crops has resulted in a selection of resistant weed biotypes in some states. It is important for growers in the Treasure Valley to be aware of the selection pressure exerted on weeds by continuously using glyphosate alone to manage weeds.

A proactive approach in developing effective and better weed management practices in glyphosate-resistant sugar beets is the key to avoiding selection pressure that results in development of herbicide-resistant weeds. The ideal weed management program needs to include herbicides with different modes of action. The weed management research program at Malheur Experiment Station, Ontario, Oregon strives to develop herbicide combinations for effective management of weeds. Development of herbicide combinations for the management of kochia to avert selection for glyphosate resistance is of paramount importance. Glyphosate-resistant kochia populations have been confirmed in Kansas, Nebraska, South and North Dakota, Colorado, and southern Alberta in Canada. The objectives of this study were to evaluate herbicide combinations for effective weed control and application timing to improve yellow nutsedge control in glyphosate-resistant sugar beets.

Materials and Methods

Field studies were established in 2013 at Malheur Experiment Station and along Highway 201 near Ontario, Oregon in fields previously planted to wheat. The wheat stubble was flailed and the fields were disked. Details of soil type and properties are listed in Table 1. Based on soil test, fertilizer was applied during fall 2012 as indicated in Table 1. Thereafter, fields were moldboard plowed, groundhogged, and 22-inch-wide beds formed. The beds were harrowed and reshaped on April 3. Treatments were arranged in randomized complete block design with four replications. Individual plots were 7.33 ft wide (4 rows) by 27 ft long. The treatments are listed in Tables 2 and 5.

Roundup Ready® sugar beet hybrid BTS 27RR20 was used in both studies. Sugar beet seeds were dropped every 5 inches within the row.

Table 1. Soil type, properties, and herbicide spray details for fields along Highway 201 and field C-2 on Malheur Experiment Station, Oregon State University, Ontario, OR, 2013.

	Along Oregon Hwy 201	**Field C2 on station**
Soil type	Greenleaf silt loam	Owyhee silt loam
pH	6.9	7.2
organic matter	1.75%	1.83%
Fall fertilizer (per acre)	100 lb N, 100 lbs phosphate, 2 lb zinc, and 1 lb boron	150 lbs phosphate and 100 lbs sulfur
Planting date	April 3, 2013	April 4, 2013
Herbicide application		
Preemergence	4/10/2013	4/10/2013
2-leaf stage	5/3/2013	5/2/2013
6-leaf stage	5/24/2013	5/10/2013

Terbufos at 1.11 lb ai/acre (Counter® 15G at 6 oz/1,000 ft of row) was applied immediately after planting. Studies were furrow irrigated on a calendar schedule to maintain moisture in the top 12 inches of the soil profile. Irrigation scheduling began on April 10 and ended on August 27 with each event lasting 24 hours. Preventive sprays for powdery mildew were done on June 29 and July 31 using Inspire™ (difenaconazole) fungicide at 7 oz/acre plus sulfur at 5 lbs/acre. Gem® and Proline® were aerially sprayed in July and August.

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. Preemergence, early postemergence treatments (sugar beet at the 2-leaf stage) and a second postemergence application (sugar beet at the 6-leaf stage) were applied on dates shown in Table 1. Plants within each plot were visually evaluated for crop injury and weed control on May 24, July 28, and yellow nutsedge control on July 2 and July 28. Evaluations were based on a scale of 0% (no crop injury or no weed control) to 100% (complete crop kill or complete weed control). Sugar beets were harvested September 23 and 25 from the two center rows. Sugar beet weight from each plot was corrected for tare to determine 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 $P = 0.05$%.

Results and Discussion

Sugar beet injury was observed on treatments that included Betamix® regardless of the application timing (Table 2). Injury ranged from 8 to 18% across herbicide treatments that contained Betamix. Application of Nortron® prior to sugar beet emergence did not cause injury.

Early-season common lambsquarters control on May 24 varied across treatments and ranged from 98 to 100% (Table 2). Evaluations on July 28 indicated common lambsquarters control was more than 94% across herbicide treatments. Control for pigweed species on May 24 ranged from 89 to 98% and was 88 to 95% on July 28. Kochia control on May 24 was almost complete at over 98% across herbicide treatments. Mid-season kochia control on July 28 was reduced slightly to 91 to 96% across herbicide treatments.

There was no sugar beet injury on July 28 (Table 3). Control for hairy nightshade on May 24 ranged from 88 to 98% and was 83 to 91% across herbicide treatments on July 28. Barnyardgrass control on May 24 was over 96% and ranged from 90 to 93% across herbicide treatments on July 28. These results suggest a need for improvement in control of pigweeds, kochia, hairy nightshade, and barnyardgrass in glyphosate-resistant sugar beets. Mid-season control for hairy nightshade and barnyardgrass was particularly low compared to control for common lambsquarters.

Plant stand was uniform across herbicide treatments and ranged from 136,199 to 141,837 plants/acre (Table 4). Consequently, the sugar beet root yield was similar across herbicide treatments ranging from 39.7 to 42.2 tons/acre. Percent sugar content was also similar across treatments and ranged from 15.24 to 15.77%. In turn, the gross sugar yield and estimated recoverable sugar were similar across herbicide treatments, ranging from 11,821 to 13,091 and 9,980 to 11,156 lbs/acre, respectively. These results suggested that the application of Betamix plus Nortron as tank-mix partners with glyphosate did not affect sugar beet root yield or sugar content. Future studies will be designed to confirm these results.

Yellow Nutsedge Control

Mid-season yellow nutsedge control ranged from 90 to 97% across herbicide treatments (Table 5). The lowest control (90%) was observed when Nortron was applied preemergence once at 16 or 32 fl oz/acre. Late-season control was 83 to 91% across herbicide treatments. Root yield ranged from 39.8 to 56.7 tons/acre across herbicide treatments. Sugar content was similar across herbicide treatments and ranged from 16 to 16.4%. Gross sugar was 12,813 to 18,548 lbs/acre and estimated recoverable sugar yield ranged from 10,798 to 15,926 lbs/acre.

The results suggested that control for yellow nutsedge was relatively better when Dual Magnum® and Outlook® were used as tank mixes with glyphosate at 32 fl oz/acre. Preemergence application of Nortron did not improve yellow nutsedge control, probably because of poor soil incorporation due to lack of moisture after application. The droughty conditions during winter and spring did not allow effective activation of Nortron**.**

Table 2. Injury, early and mid-season common lambsquarters, pigweed species, and kochia control in Roundup®-resistant sugar beet sprayed with various herbicide tank mixes at Malheur Experiment Station, Oregon State University, Ontario, OR, 2013.

				Weed control[c]					
			Injury	common lambsquarters		pigweed species		kochia	
Treatment[a]	Rate	Timing[b]	5/16	5/24	7/28	5/24	7/28	5/24	7/28
			%						
Untreated			0 d	0 c	0 d	0 c	0 c	0 c	0 d
Betamix	1.54 pt/a	2 leaf	9 c	98 b	94 c	94 ab	90 ab	100 a	93 bc
Glyphosate	21.3 fl oz/a	2 leaf							
Glyphosate	21.3 fl oz/a	6 leaf							
Glyphosate	32.0 fl oz/a	2 leaf	8 c	100 a	95 bc	93 ab	90 ab	100 a	94 abc
Glyphosate	21.3 fl oz/a	6 leaf							
Betamix	1.54 pt/a	6 leaf							
Betamix	2.03 pt/a	2 leaf	10 bc	98 b	95 bc	92 ab	90 ab	98 b	91 c
Glyphosate	21.3 fl oz/a	2 leaf							
Glyphosate	21.3 fl oz/a	6 leaf							
Glyphosate	21.3 fl oz/a	2 leaf	13 b	99 ab	97 abc	94 ab	90 ab	100 a	95 ab
Glyphosate	21.3 fl oz/a	6 leaf							
Betamix	2.03 pt/a	6 leaf							
Betamix	3.7 pt/a	2 leaf	16 a	100 ab	95 bc	89 b	88 b	100 a	91 c
Glyphosate	21.3 fl oz/a	2 leaf							
Glyphosate	21.3 fl oz/a	6 leaf							
Glyphosate	21.3 fl oz/a	2 leaf	18 a	100 a	98 abc	96 a	95 a	100 a	94 abc
Glyphosate	21.3 fl oz/a	6 leaf							
Betamix	3.7 pt/a	6 leaf							
Betamix	2.03 pt/a	2 leaf	8 c	100 a	98 abc	98 a	95 a	100 a	95 ab
Nortron	1.0 pt/a	2 leaf							
Glyphosate	21.3 fl oz/a	2 leaf							
Nortron	1.0 pt/a	6 leaf							
Glyphosate	21.3 fl oz/a	6 leaf							
Betamix	1.54 pt/a	2 leaf	10 bc	100 ab	98 abc	96 a	95 a	100 a	94 abc
Glyphosate	21.3 fl oz/a	2 leaf							
Nortron	1.0 pt/a	2 leaf							
Betamix	1.54 pt/a	6 leaf							
Glyphosate	21.3 fl oz/a	6 leaf							
Nortron	1.0 pt/a	6 leaf							
Glyphosate	32.0 fl oz/a	2 leaf	9 c	100 a	99 ab	94 ab	93 ab	100 a	96 a
Betamix	2.03 pt/a	2 leaf							
Nortron	32.0 fl oz/a	2 leaf							
Glyphosate	32.0 fl oz/a	6 leaf							
Betamix	2.03 pt/a	6 leaf							
Nortron	32.0 fl oz/a	6 leaf							
Nortron	1.0 pt/a	PRE	0 d	100 a	98 abc	94 ab	93 ab	100 a	95 ab
Glyphosate	21.3 fl oz/a	2 leaf							
Glyphosate	21.3 fl oz/a	6 leaf							
Glyphosate	21.3 fl oz/a	2 leaf	0 d	100 a	100 a	94 ab	94 ab	100 a	94 abc
Glyphosate	21.3 fl oz/a	6 leaf							

[a]All treatments included ammonium sulfate (AMS) at 2.5% v/v.
[b]Herbicide application timing: PRE = preemergence on 4/10/2013; 2 leaf = postemergence on 5/2/2013; 6 leaf = postemergence on 5/10/2013.
[c]Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD).

Table 3. Injury, early and mid-season hairy nightshade and barnyardgrass control in Roundup®-resistant sugar beet sprayed with various herbicide tank mixes at Malheur Experiment Station, Oregon State University, Ontario, OR, 2013.

				Control[c]			
			Injury	hairy nightshade		barnyardgrass	
Treatment[a]	Rate	Timing[b]	7/28	5/24	7/28	5/24	7/28
			%				
Untreated			0 d	0 c	0 b	0 c	0 b
Betamix	1.54 pt/a	2 leaf	0 c	94 ab	90 a	97 ab	90 a
Glyphosate	21.3 fl oz/a	2 leaf					
Glyphosate	21.3 fl oz/a	6 leaf					
Glyphosate	32.0 fl oz/a	2 leaf	0 c	88 b	81 a	97 ab	90 a
Glyphosate	21.3 fl oz/a	6 leaf					
Betamix	1.54 pt/a	6 leaf					
Betamix	2.03 pt/a	2 leaf	0 bc	94 ab	89 a	98 ab	90 a
Glyphosate	21.3 fl oz/a	2 leaf					
Glyphosate	21.3 fl oz/a	6 leaf					
Glyphosate	21.3 fl oz/a	2 leaf	0 b	92 ab	86 a	96 b	93 a
Glyphosate	21.3 fl oz/a	6 leaf					
Betamix	2.03 pt/a	6 leaf					
Betamix	3.7 pt/a	2 leaf	0 a	91 ab	86 a	100 a	93 a
Glyphosate	21.3 fl oz/a	2 leaf					
Glyphosate	21.3 fl oz/a	6 leaf					
Glyphosate	21.3 fl oz/a	2 leaf	0 a	88 b	83 a	98 ab	91 a
Glyphosate	21.3 fl oz/a	6 leaf					
Betamix	3.7 pt/a	6 leaf					
Betamix	2.03 pt/a	2 leaf	0 c	98 a	91 a	96 b	93 a
Nortron	1.0 pt/a	2 leaf					
Glyphosate	21.3 fl oz/a	2 leaf					
Nortron	1.0 pt/a	6 leaf					
Glyphosate	21.3 fl oz/a	6 leaf					
Betamix	1.54 pt/a	2 leaf	0 bc	95 ab	89 a	96 b	91 a
Glyphosate	21.3 fl oz/a	2 leaf					
Nortron	1.0 pt/a	2 leaf					
Betamix	1.54 pt/a	6 leaf					
Glyphosate	21.3 fl oz/a	6 leaf					
Nortron	1.0 pt/a	6 leaf					
Glyphosate	32.0 fl oz/a	2 leaf	0 c	94 ab	90 a	96 b	93 a
Betamix	2.03 pt/a	2 leaf					
Nortron	32.0 fl oz/a	2 leaf					
Glyphosate	32.0 fl oz/a	6 leaf					
Betamix	2.03 pt/a	6 leaf					
Nortron	32.0 fl oz/a	6 leaf					
Nortron	1.0 pt/a	PRE	0 d	95 ab	91 a	96 ab	89 a
Glyphosate	21.3 fl oz/a	2 leaf					
Glyphosate	21.3 fl oz/a	6 leaf					
Glyphosate	21.3 fl oz/a	2 leaf	0 d	96 ab	91 a	98 ab	93 a
Glyphosate	21.3 fl oz/a	6 leaf					

[a]All treatments included ammonium sulfate (AMS) at 2.5% v/v.
[b]Herbicide application timing: PRE = preemergence on 4/10/2013; 2 leaf = postemergence on 5/2/2013; 6 leaf = postemergence on 5/10/2013.
[c]Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD).

Table 4. Plant stand, sugar beet root yield, and sugar content in response to various herbicide tank mixes at Malheur Experiment Station, Oregon State University, Ontario, OR, 2013.

Treatment[a]	Rate	Timing[b]	Plant stand[c]	Yield	Sugar content	Nitrate	Gross sugar	Estimated recoverable sugar
			no./acre	tons/acre	%	ppm	lbs/acre	lbs/acre
Untreated			145,695 a	8.4 b	15.31 a	175.0 a	2,547 b	2,148 b
Betamix Glyphosate Glyphosate	1.54 pt/a 21.3 fl oz/a 21.3 fl oz/a	2 leaf 2 leaf 6 leaf	136,199 a	39.7 a	15.24 a	173.3 a	12,139 a	10,391 a
Glyphosate Glyphosate Betamix	32.0 fl oz/a 21.3 fl oz/a 1.54 pt/a	2 leaf 6 leaf 6 leaf	142,134 a	39.2 a	15.32 a	161.5 a	11,982 a	10,147 a
Betamix Glyphosate Glyphosate	2.03 pt/a 21.3 fl oz/a 21.3 fl oz/a	2 leaf 2 leaf 6 leaf	139,463 a	37.4 a	15.77 a	161.5 a	11,821 a	9,980 a
Glyphosate Glyphosate Betamix	21.3 fl oz/a 21.3 fl oz/a 2.03 pt/a	2 leaf 6 leaf 6 leaf	140,057 a	38.1 a	15.77 a	146.0 a	12,025 a	10,236 a
Betamix Glyphosate Glyphosate	3.7 pt/a 21.3 fl oz/a 21.3 fl oz/a	2 leaf 2 leaf 6 leaf	140,650 a	39.0 a	15.72 a	155.8 a	12,294 a	10,537 a
Glyphosate Glyphosate Betamix	21.3 fl oz/a 21.3 fl oz/a 3.7 pt/a	2 leaf 6 leaf 6 leaf	141,837 a	39.3 a	15.90 a	169.0 a	12,520 a	10,612 a
Betamix Nortron Glyphosate Nortron Glyphosate	2.03 pt/a 1.0 pt/a 21.3 fl oz/a 1.0 pt/a 21.3 fl oz/a	2 leaf 2 leaf 2 leaf 6 leaf 6 leaf	140,650 a	41.0 a	15.51 a	182.8 a	12,734 a	10,687 a
Betamix Glyphosate Nortron Betamix Glyphosate Nortron	1.54 pt/a 21.3 fl oz/a 1.0 pt/a 1.54 pt/a 21.3 fl oz/a 1.0 pt/a	2 leaf 2 leaf 2 leaf 6 leaf 6 leaf 6 leaf	143,024 a	40.3 a	15.17 a	150.0 a	12,245 a	10,550 a
Glyphosate Betamix Nortron Glyphosate Betamix Nortron	32.0 fl oz/a 2.03 pt/a 32.0 fl oz/a 32.0 fl oz/a 2.03 pt/a 32.0 fl oz/a	2 leaf 2 leaf 2 leaf 6 leaf 6 leaf 6 leaf	140,947 a	42.4 a	15.43 a	159.3 a	13,091 a	11,156 a
Nortron Glyphosate Glyphosate	1.0 pt/a 21.3 fl oz/a 21.3 fl oz/a	PRE 2 leaf 6 leaf	141,837 a	39.5 a	15.10 a	155.8 a	11,909 a	10,185 a
Glyphosate Glyphosate	21.3 fl oz/a 21.3 fl oz/a	2 leaf 6 leaf	140,650 a	41.2 a	15.16 a	178.5 a	12,472 a	10,566 a

[a]All treatments included ammonium sulfate (AMS) at 2.5% v/v.
[b]Herbicide application timing: PRE = preemergence on 4/10/2013; 2 leaf = postemergence on 5/2/2013; 6 leaf = postemergence on 5/10/2013.
[c]Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD).

Table 5. Yellow nutsedge control and sugar yield in Roundup®-resistant sugar beet at Malheur Experiment Station, Oregon State University, Ontario, OR, 2013.

Treatment	Rate	Timing[a]	Control[b] yellow nutsedge 7/2	Control[b] yellow nutsedge 8/28	Root yield	Sugar content	Gross sugar	Estimated recoverable sugar
			--------- % ---------		ton/acre	%	lbs/acre	lbs/acre
Untreated			0 d	0 e	7.9 c	14.1 a	4,218 c	1,783 c
Nortron	16 fl oz/a	PRE	90 c	83 d	42.0 ab	16.0 a	13,384 b	11,437 b
Glyphosate	22 fl oz/a	POST1						
AMS	4 pt/a	POST1						
Glyphosate	32 fl oz/a	POST2						
AMS	4 pt/a	POST2						
Nortron	32 fl oz/a	PRE	90 c	84 cd	48.2 ab	15.6 a	15,035 ab	12,705 ab
Glyphosate	32 fl oz/a	POST1						
Sustain	1 pt/a	POST1						
AMS	4 pt/a	POST1						
Glyphosate	22 fl oz/a	POST2						
AMS	4 pt/a	POST2						
AMS	4 pt/a	POST1	91 bc	86 a-d	39.8 b	16.2 a	12,813 b	10,798 b
Glyphosate	22 fl oz/a	POST1						
Nortron	16 fl oz/a	POST1						
AMS	4 pt/a	POST2						
Glyphosate	22 fl oz/a	POST2						
Nortron	16 fl oz/a	POST2						
AMS	4 pt/a	POST1	92 abc	86 a-d	43.3 ab	16.0 a	13,943 ab	11,885 ab
Glyphosate	22 fl oz/a	POST1						
Nortron	32 fl oz/a	POST1						
AMS	4 pt/a	POST2						
Glyphosate	22 fl oz/a	POST2						
Nortron	32 fl oz/a	POST2						
AMS	4 pt/a	POST1	95 abc	89 abc	45.8 ab	16.4 a	15,024 ab	12,980 ab
Sequence	2.5 pt/a	POST1						
AMS	4 pt/a	POST2						
Sequence	2.5 pt/a	POST2						
AMS	4 pt/a	POST1	91 bc	85 bcd	47.6 ab	16.3 a	15,500 ab	13,325 ab
Glyphosate	22 fl oz/a	POST1						
AMS	4 pt/a	POST2						
Sequence	2.5 pt/a	POST2						
AMS	4 pt/a	POST1	97 a	91 a	50.9 ab	16.4 a	16,686 ab	14,252 ab
Dual Magnum	1.33 pt/a	POST1						
Glyphosate	22 fl oz/a	POST1						
AMS	4 pt/a	POST2						
Glyphosate	32 fl oz/a	POST2						
Dual Magnum	1.33 pt/a	POST2						
AMS	4 pt/a	POST1	96 ab	90 ab	56.7 a	16.4 a	18,549 a	15,926 a
Outlook	21 fl oz/a	POST1						
Glyphosate	32 fl oz/a	POST1						
AMS	4 pt/a	POST2						
Glyphosate	32 fl oz/a	POST2						
Outlook	21 fl oz/a	POST2						

[a]Herbicide application timing: PRE = preemergence on 4/10/2013; POST1 = postemergence on 5/3/2013; POST2 = postemergence on 5/24/2013.

[b]Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD).