TIMING OF WEED REMOVAL IN ROUNDUP READY® SUGAR BEET

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Introduction

Weed competition is one of the yield-limiting factors in most crop production systems. Weed species compete with sugar beet for light, nutrients, and water. Sugar beets are especially vulnerable to weeds because of their poor competitiveness at early stages of growth before canopy closure. Sugar beet tolerance of weeds will vary depending on the predominant weed species, planting date, time of weed emergence relative to the crop, and environmental conditions. Newly emerged sugar beet seedlings are small, lack vigor, and require approximately 60-90 days of growth for total canopy closure. Annual weeds that germinate within 2 weeks after sugar beet planting or in a 4-week period after the 2-leaf stage can reduce sugar beet root yield by 26 to 100 percent. Sugar beet growers have traditionally used preplant or pre-emergence (PRE) herbicides to control weeds that emerge simultaneously with the crop. The objective of this study was to determine the optimum time for weed control in Roundup Ready® sugar beets.

Materials and Methods

A field experiment was conducted at the Malheur Experiment Station, Ontario, Oregon in 2009 to determine the optimum time for controlling weeds in glyphosate-tolerant sugar beet in order to limit potential yield loss from competition. The experimental design of this study was a randomized complete block design with four replications. Individual plots were 7.33 ft wide (4 rows) by 30 ft. Soil type at this site was Owyhee silt loam (pH 7.4, 1.74 percent organic matter, and cation exchange capacity [CEC] 14 meq/kg). Roundup Ready sugar beet ('BTS 26R14') was planted on April 4, 2009, using tractor-mounted flexi-planter units with double-disc furrow openers and cone seeders fed from a spinner divider that uniformly distributed seeds within the row. Sugar beet seeds were dropped at the rate of 4 seeds/ft of row and later thinned to 8-inch spacing between plants within a row. Sugar beet emergence was observed on April 22. Terbufos at 1.11 lb ai/acre (Counter® 15G at 7.4 lb/acre) was applied on April 17 and aldicarb at 1.5 lb ai/acre (Temik® 15G at 10 lb/acre) on June 4, 2009. Sugar beets were fertilized on June 10 using a custom blended fertilizer to supply 175 lb urea (nitrogen)/acre and 2 lb zinc/acre. The study was irrigated on a calendar schedule to maintain moisture in the top 12 inches of the soil profile. 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 at 35 psi at 3 mph.

Very early POST glyphosate was applied on April 29 (7 days after emergence [DAE]), while early POST treatments (2-leaf stage) were applied on May 13 (21 DAE). Subsequent applications were made on May 21 (39 DAE), May 30 (48 DAE), June 8 (56 DAE), and June 17 (66 DAE). Glyphosate (Roundup PowerMax®) was applied at 0.75 or 1.13 lb ae/acre (22 or 32 fl oz/acre) depending on the treatment timing. Mid-season weed control and sugar beet injury was visually assessed on August 17, while late-season evaluations were made on October 15. Visual 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 on October 20 from 30 ft of the two center rows using a beet harvester. Sugar beet weight from each plot was multiplied by a factor of 0.90 to correct for tare. Sugar content and other sugar yield variables were determined in a laboratory at the Amalgamated Sugar Factory in Nampa, Idaho. Sugar concentrations were determined by multiplying the measured sucrose by 0.98 to estimate the sugar that would have been lost to respiration if the beets had been stored in a pile. The percent sugar extraction was calculated using the formula:

$$Ext = \frac{250 + [(1{,}255.2 * Cond) - (15{,}000 * Sug) - 6{,}185]}{Sug * (98.66 - 7.845 * Cond)}$$

where *Ext* is percent sugar extraction, *Cond* is the electrical conductivity in mmho, and *Sug* is the percent sucrose concentration. The data were subjected to analysis of variance and means compared using the least significant difference (LSD, P = 0.05).

Results and Discussion

Glyphosate treatments caused no injury to glyphosate-tolerant sugar beet. Two or three applications of glyphosate applied at 0.75 lb ae/acre and ending on June 8 (56 DAE) controlled 100 percent of the weed species (Table 1). Similarly, spraying glyphosate at 1.13 lb ae/acre provided complete control of the weeds, regardless of the initial application timing. Mid-season visual evaluations on August 17 indicated poor weed control with a single application of glyphosate (0.75 lb ae/acre) on May 13 (Table 1). Poor control for common lambsquarters, hairy nightshade, barnyardgrass, pigweed species, and smartweed was observed when glyphosate was applied once on May 13 (21 DAE) or twice with the terminal application on May 21 (39 DAE).

Late-season visual weed control on October 15 indicated 100 percent control for common lambsquarters regardless of glyphosate application timing (Table 2). A single application of glyphosate at 21 DAE (May 13) resulted in the least control (60 to 89 percent) of common lambsquarters, hairy nightshade, barnyardgrass, pigweed species, and smartweed. Two applications of glyphosate at 0.75 kg ae/acre each with the last application on May 21 (39 DAE) also resulted in poor control of the previously mentioned weeds.

Delaying the first herbicide application to June 8 (56 DAE) or June 17 (66 DAE) resulted in a substantial sugar beet yield penalty. For example, sugar beet root yield was 42.6 and 41.3 tons/acre, respectively, compared to 50.7 tons/acre when the initial glyphosate

was applied May 13 (21 DAE). Similarly, a single application of glyphosate at 0.75 lbs ae/acre on May 13 (21 DAE) resulted in reduced sugar beet root yield (47.5 compared to 50.7 tons/acre when multiple glyphosate applications were used).

There was no clear response pattern between treatments for root percent sugar content. However, the estimated recoverable sugar was influenced most by the root yield. The highest (13,094 lbs/acre) estimated recoverable sugar was obtained with two applications of glyphosate with the initial timing at 21 DAE. Results suggest application of glyphosate starting when sugar beets are at the 2-leaf stage and delaying the last application until sugar beets are at the 10-leaf stage may be the best strategy to preserve sugar beet root yield and corresponding sugar yield.

Table 1. Weed control in Roundup Ready sugar beet on August 17 in response to different herbicides at the Malheur Experiment Station, Ontario, OR, 2009.

Treatment[a]	Rate	Timing	Weed control[b]				
			Common lambsquarters	Hairy nightshade	Barnyard-grass	Pigweed species	Pennsylvania smartweed
			%				
Glyphosate	22 fl oz/a	4/29	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/13, 6/21					
Glyphosate	22 fl oz/a	5/13	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/21, 6/21					
Glyphosate	22 fl oz/a	5/21	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/30, 6/21					
Glyphosate	22 fl oz/a	5/30	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	6/8, 6/21					
Glyphosate	32 fl oz/a	6/8	100 a	100 a	100 a	100 a	100 a
Glyphosate	32 fl oz/a	6/17					
Glyphosate	32 fl oz/a	6/17	100 a	100 a	100 a	100 a	100 a
Glyphosate	32 fl oz/a	6/21					
Glyphosate	32 fl oz/a	4/29	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/13, 6/21					
Glyphosate	32 fl oz/a	5/13	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/21					
Glyphosate	32 fl oz/a	5/21	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/30					
Glyphosate	32 fl oz/a	5/30	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	6/17					
Glyphosate	22 fl oz/a	5/13	100 a	84 b	65 b	75 c	58 c
Glyphosate	22 fl oz/a	5/13	100 a	91 ab	71 b	85 b	63 b
Glyphosate	22 fl oz/a	5/21					
Glyphosate	22 fl oz/a	5/13	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/30					
Glyphosate	22 fl oz/a	5/13	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	6/8					
Glyphosate	22 fl oz/a	5/13	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	6/17					
Untreated		--	0 b	0 c	0 c	0 d	0 d

[a]All treatments included ammonium sulfate at 2.5% V/V.
[b]Means within a column followed by same letter do not significantly differ (P = 0.05, LSD).

Table 2. Weed control in Roundup Ready sugar beet on October 15 in response to different herbicides at the Malheur Experiment Station, Ontario, OR, 2009.

Treatment	Rate	Timing[a]	Weed control[b]				
			Common lambsquarters	Hairy nightshade	Barnyard-grass	Pigweed species	Pennsylvania smartweed
			%				
Glyphosate	22 fl oz/a	4/29	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/13, 6/21					
Glyphosate	22 fl oz/a	5/13	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/21, 6/21					
Glyphosate	22 fl oz/a	5/21	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/30, 6/21					
Glyphosate	22 fl oz/a	5/30	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	6/8, 6/21					
Glyphosate	32 fl oz/a	6/8	100 a	100 a	100 a	100 a	100 a
Glyphosate	32 fl oz/a	6/17					
Glyphosate	32 fl oz/a	6/17	100 a	100 a	100 a	100 a	100 a
Glyphosate	32 fl oz/a	6/21					
Glyphosate	32 fl oz/a	4/29	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/13, 6/21					
Glyphosate	32 fl oz/a	5/13	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/21					
Glyphosate	32 fl oz/a	5/21	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/30					
Glyphosate	32 fl oz/a	5/30	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	6/17					
Glyphosate	22 fl oz/a	5/13	100 a	89 c	71 c	79 c	60 c
Glyphosate	22 fl oz/a	5/13	100 a	95 b	83 b	90 b	68 b
Glyphosate	22 fl oz/a	5/21					
Glyphosate	22 fl oz/a	5/13	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	5/30					
Glyphosate	22 fl oz/a	5/13	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	6/8					
Glyphosate	22 fl oz/a	5/13	100 a	100 a	100 a	100 a	100 a
Glyphosate	22 fl oz/a	6/17					
Untreated		--	0 b	0 d	0 d	0 d	0 d

[a]All treatments included ammonium sulfate at 2.5% V/V.
[b]Means within a column followed by same letter do not significantly differ (P = 0.05, LSD).

Table 3. Sugar beet yield and sugar components in response to different herbicides at the Malheur Experiment Station, Ontario, OR, 2009.

Treatment	Rate	Timing[a]	Sugar beet yield	Sugar components[b]			
				sugar content	Conductivity	Extractable sugar	Estimated rec'ble sugar
			t/acre	%			lbs/acre
Glyphosate	22 fl oz/a	4/29	47.7 a-d	15.5 abc	0.933 abc	82.2 bcd	12182.8 bcd
Glyphosate	22 fl oz/a	5/13, 6/21					
Glyphosate	22 fl oz/a	5/13	50.7 ab	15.5 abc	0.870 cd	83.1 ab	13001.4 ab
Glyphosate	22 fl oz/a	5/21, 6/21					
Glyphosate	22 fl oz/a	5/21	46.5 cd	15.6 abc	0.883 bcd	82.9 abc	12065.3 cd
Glyphosate	22 fl oz/a	5/30, 6/21					
Glyphosate	22 fl oz/a	5/30	48.1 a-d	15.2 c	0.953 ab	81.9 cd	11976.7 cd
Glyphosate	22 fl oz/a	6/8, 6/21					
Glyphosate	32 fl oz/a	6/8	42.6 e	16.0 ab	0.845 d	83.5 a	11389.3 de
Glyphosate	32 fl oz/a	6/17					
Glyphosate	32 fl oz/a	6/17	41.3 e	15.9 ab	0.893 bcd	82.9 abc	10868.8 e
Glyphosate	32 fl oz/a	6/21					
Glyphosate	32 fl oz/a	4/29	46.9 cd	15.4 bc	0.878 cd	83.0 ab	11962.8 cd
Glyphosate	22 fl oz/a	5/13, 6/21					
Glyphosate	32 fl oz/a	5/13	49.5 abc	15.4 bc	0.878 cd	82.9 abc	12615.4 abc
Glyphosate	22 fl oz/a	5/21					
Glyphosate	32 fl oz/a	5/21	47.0 bcd	15.6 abc	0.895 bcd	82.8 abc	12106.6 cd
Glyphosate	22 fl oz/a	5/30					
Glyphosate	32 fl oz/a	5/30	44.4 de	15.8 abc	0.938 abc	82.2 bcd	11498.0 de
Glyphosate	22 fl oz/a	6/17					
Glyphosate	22 fl oz/a	5/13	47.5 bcd	15.7 abc	0.868 cd	83.2 ab	12420.3 abc
Glyphosate	22 fl oz/a	5/13	51.3 a	15.4 bc	0.898 bcd	82.7 abc	13094.0 a
Glyphosate	22 fl oz/a	5/21					
Glyphosate	22 fl oz/a	5/13	49.0 abc	15.7 abc	0.895 bcd	82.8 abc	12728.5 abc
Glyphosate	22 fl oz/a	5/30					
Glyphosate	22 fl oz/a	5/13	49.0 abc	15.7 abc	0.870 cd	83.1 ab	12748.5 abc
Glyphosate	22 fl oz/a	6/8					
Glyphosate	22 fl oz/a	5/13	47.9 a-d	16.1 a	0.880 cd	83.1 ab	12820.0 abc
Glyphosate	22 fl oz/a	6/17					
Untreated		--	8.0 f	15.2 c	0.995 a	81.3 d	1965.2 f

[a]All treatments included ammonium sulfate at 2.5% V/V.
[b]Means within a column followed by same letter do not significantly differ (P = 0.05, LSD).