EVALUATION OF STRIP TILLAGE IN SUGAR BEETS UNDER FURROW IRRIGATION

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

Introduction

Sugar beet growers in eastern Oregon and southwestern Idaho have expressed interest in adopting strip tillage in their production operations. Strip tillage, also known as zone tillage or conservation tillage, has been adopted and is widely used in the rainfed areas of the U.S. Midwest and other parts of the world. However, the practice has been largely restricted to large seeded crops like corn and soybeans (Al-Kaisi and Licht 2004). Strip tillage is a system combining the benefits of no-till and full tillage to produce row crops. It has been reported that strip tillage maintains about two-thirds to three-quarters as much residue as no-till systems. With fall strip tillage, narrow strips, typically 5 to 9 inches deep and 7 to 9 inches wide, are tilled in the center of the crop row to incorporate the stubble into the soil, while the area between rows is left undisturbed. Since the tilled strips correspond to planter row width, the crop is subsequently planted into the cleared areas during spring.

Strip tillage addresses a common concern of conservation tillage related to soil warm-up in the spring by clearing stubble in the row while maintaining high residue levels overall. Besides many environmental benefits, strip tillage can yield economic benefits as well. Fuel costs can be reduced as field operations (trips across the field) are decreased and fertilizer costs can be decreased with banding instead of broadcasting. Fertilizer banding is a key feature of strip tillage and allows for nutrient placement in the strip zone and may reduce surface nitrogen loss and underground water contamination.

For small-seeded crops like sugar beet, strip tillage has not been nearly as successful, primarily due to poor seed-to-soil contact. Older strip tillage equipment did not make a seedbed firm enough and tended to leave air pockets, largely due to their inability to break and incorporate the stubble within strips. Recent improvements in strip tillage equipment have created an interest for growers of small-seeded crops to adopt strip tillage. In fact, strip tillage for sugar beets has been evaluated and partly adopted by growers in Montana and Nebraska. Recently, sugar beet growers in Idaho and eastern Oregon have expressed a desire to use strip tillage as a goal towards environmental stewardship and reducing the cost of production. Adoption of strip tillage for sugar beets has largely been restricted to growers who exclusively use overhead irrigation (sprinklers and center pivots) for irrigation. There is a need to evaluate the usefulness of strip tillage for furrow-irrigated fields in the Treasure Valley.

Materials and Methods

A field study was conducted at the Malheur Experiment Station, Ontario, Oregon during 2010 in a field previously planted to wheat on 30-inch bed centers. Wheat stubble was cut to 6-inch height on August 4, 2009. The field was irrigated to encourage volunteer wheat emergence. Glyphosate at 22 fl oz/acre (0.77 lb ae/acre) was applied on October 18 to control all volunteer wheat and weeds. The strip-cat tiller was used to create 7- to 9-inch-wide strips on November 23, 2009. On April 15, 2010, Saber Cat row cleaners were used to prepare the strips before planting. The study followed a split-plot design with nitrogen (N) level as main plots and herbicide treatments as subplots. The plot size was 7.33 ft (4 rows wide) by 27 ft. The study had four replications. Sugar beet hybrid 'Betaseed 27RR10' was planted on April 16, 2010 using a John Deere 71 flex planter. The first furrow irrigation was delivered on April 27 and lasted for 24 hours. Soil samples were pulled from 1-inch, 2-inch, and 3-inch depth to determine soil fertility. Based on soil analyses and estimated crop needs, plots were fertilized to supply 267, 200, 134, and 0 lb N/acre, which corresponded to 1x, 0.75x, 0.5x, and 0x of the recommended N rate. The field was later corrugated and furrow irrigated for 24 hours.

Herbicide treatments were applied sequentially when sugar beets were at the 2-leaf (May 14) and at 4-leaf stage (May 25) using a backpack CO_2 sprayer. Treatments included; sequential glyphosate at 22 fl oz/acre; glyphosate 22 fl oz/acre followed by glyphosate at 22 fl oz/acre + Nortron at 12 fl oz/acre (ethofumesate at 0.38 lb ai/acre); glyphosate at 22 fl oz/acre followed by glyphosate at 22 fl oz/acre + Outlook at 18 fl oz/acre (dimethenamid-p at 0.98 lb ai/acre); glyphosate at 22 fl oz/acre followed by glyphosate at 22 fl oz/acre + Stinger® at 12 fl oz/acre (chlopyralid at 0.28 lb ae/acre).

A tank mixture of Proline® fungicide at 5 oz/acre (prothioconazole at 0.156 lb ai/acre) plus sulfur 5 lb/acre was applied on June 26 as a preventive measure against powdery mildew. Subsequent tank mixture of Proline fungicide at 12 fl oz/acre plus sulfur at 5 lb/acre was applied on July 18. The field was furrow irrigated for 24 hours each on June 28, 30, July 8, 14, 23, 29, August 4, 13, 20, September 1, and 14, 2010. Soil sampling to estimate nitrate and ammonium levels at 1-ft and 2-ft depth was done on July 27. Soil samples at each depth were comprised of 10 subsamples per plot.

Visual plant injury and weed control was performed on June 14 and August 9 based on a scale of 0 to 100 percent (0 percent = no weed control or crop injury and 100 percent = complete weed control or crop damage).

Sugar beet foliage was flailed and the crowns removed with rotating disks on October 18. Roots were hand harvested from 10 ft of the 2 center rows of each plot on October 18 and 19, 2010. The roots were counted, weighted, and samples transported daily to the Snake River Sugar factory in Nampa, Idaho for laboratory analysis to determine percentage sucrose content, nitrate, and root conductivity. Sugar concentrations were adjusted 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.

Data were subjected to statistical analysis and means compared with the use of the least significant difference (LSD) at $P \leq 0.05$.

Results and Discussion

There was an N level and herbicide treatment interaction for the level of weed control. Visual evaluation on June 14 indicated that sugar beet injury across herbicide treatments and N rates ranged from 0 to 10 percent (Table 1). The injury was characterized by transient yellowing of the leaves. Crop injury in the untreated treatment ranged from 4 to 11 percent mainly due to excessive competition with weeds. Control of common lambsquarters (*Chenopodium album*) ranged from 90 to 100 percent and was generally reduced in plots that did not receive N. Pigweed (*Amaranthus* spp.) control ranged from 46 to 100 percent and was lowest in plots without N application and when glyphosate at 22 fl oz/acre was applied sequentially without soil active herbicides. All treatments provided 100 percent control for kochia (*Kochia scoparia*) and annual sowthistle (*Sonchus oleraceus*). Control for hairy nightshade (*Solanum sarrachoides*) ranged from 95 to 100 percent across N rates and herbicide treatments. Barnyardgrass (*Echinochloa crus-galli*) control ranged from 95 to 100 percent.

Late season crop injury and weed control was evaluated on August 9. Crop injury ranged from 3 to 54 percent (Table 2). The highest injury was observed in plots that did not receive N fertilizer, regardless of the herbicides used. Sugar beet plants in the untreated treatment were greatly stunted. Common lambsquarters control ranged from 85 to 100 percent across N rates and herbicide treatments. Control of pigweed ranged from 9 to 100 percent. Plots that were not fertilized had the lowest pigweed control, regardless of the herbicide treatment used. Late season kochia control was still high at 95 to 100 percent. Control of hairy nightshade was 100 percent across treatments. Annual sowthistle control ranged from 73 to 100 percent. Control for barnyardgrass ranged from 55 to 100 percent.

There was no statistical difference among treatments for sugar beet plant stand, which ranged from 32,370 to 46,031 plants/acre (Table 3). Root yield ranged from 18.2 to 62.8 ton/acre across treatments. The highest yield was observed when N was applied at 267 lb/acre and weeds controlled by glyphosate at 22 fl oz/acre followed by a tank mixture of glyphosate at 22 fl oz/acre + Outlook at 18 fl oz/acre. Sucrose content ranged from 16.4 to 19.5 percent. The estimated recoverable sugar ranged from 5,479 to 18,253 lb/acre. Mid-season soil nitrate content (July 27) ranged from 5.7 to 48.8 ppm and 2.5 to 22.2 ppm at the 1-ft and 2-ft depth, respectively. The corresponding ammonium content ranged from 3.3 to 21.6 and 1.6 to 8 ppm. The soil nitrate and ammonium content directly reflected N rates used.

References

Al-Kaisi, M., and M.A. Licht. 2004. Effect of strip tillage on corn nitrogen uptake and residual soil nitrate accumulation compared with no tillage and chisel plow. Agronomy Journal 96:1164-1171.

Table 1. Effect of nitrogen levels on weed control on June 14, 2011 in sugar beets under a furrow-irrigation system at Malheur Experiment Station, Ontario, OR, 2010.

	Treatment	Rate	Timing[a]	Nitrogen rate	Crop injury	Weed control					
						Common lambsquarters	Pigweed	Kochia	Hairy nightshade	Barnyardgrass	Annual sowthistle
				lb N/acre		%					
1	Untreated control			0	10	0	0	0	0	0	0
2	Untreated control			134	6	0	0	0	0	0	0
3	Untreated control			200	11	0	0	0	0	0	0
4	Untreated control			267	4	0	0	0	0	0	0
5	Glyphosate	0.77 lb ae/a	A; B	0	10	93	46	100	100	96	100
6	Glyphosate	0.77 lb ae/a	A; B	134	1	100	90	100	100	95	100
7	Glyphosate	0.77 lb ae/a	A; B	200	0	95	91	100	100	100	100
8	Glyphosate	0.77 lb ae/a	A; B	267	0	100	85	100	100	100	100
9	Glyphosate Glyphosate Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	0	10	95	85	100	100	100	100
10	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	134	0	100	90	100	100	95	100
11	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	200	0	100	100	100	100	100	100
12	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	267	0	90	95	100	100	95	100

Table 1. Continued……

	Treatment	Rate	Timing[a]	Nitrogen rate	Crop Injury	Weed control					
						Common lambsquarters	Pigweed	Kochia	Hairy nightshade	Barnyardgrass	Annual sowthistle
				lb N/acre		%					
13	Glyphosate	0.77lb ae/a	A	0	4	100	100	100	100	100	100
	Glyphosate	0.77lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
14	Glyphosate	0.77lb ae/a	A	134	0	100	98	100	100	100	100
	Glyphosate	0.77lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
15	Glyphosate	0.77lb ae/a	A	200	5	95	95	100	100	100	100
	Glyphosate	0.77lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
16	Glyphosate	0.77lb ae/a	A	267	0	100	85	100	100	100	100
	Glyphosate	0.77lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
17	Glyphosate	0.77lb ae/a	A	0	13	96	95	100	100	0	100
	STINGER	0.28lb ae/a	B								
	Glyphosate	0.77lb ae/a	B								
18	Glyphosate	0.77lb ae/a	A	134	1	96	100	100	100	100	100
	STINGER	0.28lb ae/a	B								
	Glyphosate	0.77lb ae/a	B								
19	Glyphosate	0.77lb ae/a	A	200	0	100	95	100	100	95	100
	STINGER	0.28lb ae/a	B								
	Glyphosate	0.77lb ae/a	B								
20	Glyphosate	0.77lb ae/a	A	267	0	100	75	100	100	100	100
	STINGER	0.28lb ae/a	B								
	Glyphosate	0.77lb ae/a	B								
	LSD (*P*=0.05)				5	4	2	NS	NS	1	NS

[a] A = glyphosate applied when sugar beets were at the 2-leaf stage; B = glyphosate applied when sugar beets were at the 4-leaf stage. Glyphosate application at each time included ammonium sulfate at 5% v/v. Roundup PowerMax® was the brand of glyphosate used.

Table 2. Effect of nitrogen levels on weed control on August 9, 2011 in sugar beets under a furrow-irrigation system at Malheur Experiment Station, Ontario, OR, 2010.

	Treatment	Rate	Timing [a]	Nitrogen rate	Crop injury	Weed control					
						Common lambsquarters	Pigweed	Kochia	Hairy nightshade	Barnyardgrass	Annual sowthistle
				lb N/acre				%			
1	Untreated control			0	46	0	0	0	0	0	0
2	Untreated control			134	21	0	0	0	0	0	0
3	Untreated control			200	33	0	0	0	0	0	0
4	Untreated control			267	13	0	0	0	0	0	0
5	Glyphosate	0.77 lb ae/a	A; B	0	50	85	9	100	100	96	73
6	Glyphosate	0.77 lb ae/a	A; B	134	9	98	56	95	100	98	100
7	Glyphosate	0.77 lb ae/a	A; B	200	3	96	70	100	100	100	100
8	Glyphosate	0.77 lb ae/a	A; B	267	5	95	46			99	100
9	Glyphosate Glyphosate Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	0	48	95	23	100	100	98	98
10	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	134	3	98	90	100	100	98	100
11	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	200	3	99	90	100	100	100	100
12	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	267	3	93	91	100	100	95	100

Table 2. Continued……

	Treatment	Rate	Timing[a]	Nitrogen rate	Crop injury	Weed control					
						Common lambsquarters	Pigweed	Kochia	Hairy nightshade	Barnyardgrass	Annual sowthistle
				lb N/acre	%						
13	Glyphosate	0.77lb ae/a	A	0	43	100	45	100	100	98	100
	Glyphosate	0.77lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
14	Glyphosate	0.77lb ae/a	A	134	3	100	93	100	100	99	100
	Glyphosate	0.77lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
15	Glyphosate	0.77lb ae/a	A	200	0	99	98	100	100	99	100
	Glyphosate	0.77lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
16	Glyphosate	0.77lb ae/a	A	267	0	100	100	100	100	100	100
	Glyphosate	0.77lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
17	Glyphosate	0.77lb ae/a	A	0	54	100	58	100	100	55	100
	STINGER	0.28lb ae/a	B								
	Glyphosate	0.77lb ae/a									
18	Glyphosate	0.77lb ae/a	A	134	8	100	80	95	100	98	100
	STINGER	0.28lb ae/a	B								
	Glyphosate	0.77lb ae/a									
19	Glyphosate	0.77lb ae/a	A	200	5	100	88	98	100	96	100
	STINGER	0.28lb ae/a	B								
	Glyphosate	0.77lb ae/a									
20	Glyphosate	0.77lb ae/a	A	267	3	100	80	100	100	93	100
	STINGER	0.28lb ae/a	B								
	Glyphosate	0.77lb ae/a									
	LSD (*P*=0.05)				8	NS	28	NS	NS	17	NS

[a] A = glyphosate applied when sugar beets were at the 2-leaf stage; B = glyphosate applied when sugar beets were at the 4-leaf stage. Glyphosate application at each time included ammonium sulfate at 5% v/v. Roundup PowerMax® was the brand of glyphosate used.

Table 3. Sugar beet root yield and yield components as affected by nitrogen levels and weed control under a furrow-irrigation system at Malheur Experiment Station, Ontario, OR, 2010.

						Root yield and yield components				Soil N content[b]			
	Treatment	Rate	Timing[a]	Nitrogen rate	Plant stand	Yield	Sugar content	Nitrate	ERS[c]	NO_3 (1 ft)	NO_3 (2 ft)	NH_4 (1 ft)	NH_4 (2 ft)
				lb N/acre	plants/a	tons/a	%	ppm	lb/a	ppm	ppm	ppm	ppm
1	Untreated control			0	40,388	24.3	19.4	75.3	8,114	6.6	2.5	3.3	1.6
2	Untreated control			134	44,546	32.7	18.7	169.5	10,391	5.7	3.6	4.2	2.0
3	Untreated control			200	32,370	18.2	17.8	174.8	5,479	23.0	7.6	16.6	4.9
4	Untreated control			267	42,764	41.3	16.4	559.8	11,362	15.9	6.7	8.1	3.5
5	Glyphosate	0.77 lb ae/a	A; B	0	36,825	41.6	19.5	100.0	13,695	9.3	5.8	3.4	4.1
6	Glyphosate	0.77 lb ae/a	A; B	134	38,903	49.9	17.6	247.8	14,716	10.0	8.1	4.0	4.8
7	Glyphosate	0.77 lb ae/a	A; B	200	41,576	51.1	17.3	398.0	14,709	15.8	6.0	6.0	2.2
8	Glyphosate	0.77 lb ae/a	A; B	267	38,310	48.9	16.6	463.5	13,285	21.7	9.9	9.6	3.1
9	Glyphosate Glyphosate Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	0	40,388	44.6	18.5	154.0	13,824	6.8	5.3	3.6	2.7
10	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	134	45,140	55.6	18.9	109.5	17,738	17.5	9.1	4.4	2.2
11	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B	200	42,467	57.3	17.7	273.0	16,915	21.0	13.4	18.2	8.0
12	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	267	46,031	58.7	17.6	284.8	16,982	52.3	10.6	16.9	3.6

Table 3. Continued……

	Treatment	Rate	Timing[a]	Nitrogen rate	Plant stand	Root yield and yield components				Soil N content[b]			
						Yield	Sugar content	Nitrate	ERS[c]	NO_3 (1 ft)	NO_3 (2 ft)	NH_4 (1 ft)	NH_4 (2 ft)
				lb N/a	plants/a	tons/a	%	ppm	lb/a	ppm	ppm	ppm	ppm
13	Glyphosate	0.77 lb ae/a	A	0	43,655	52.3	17.9	198.3	15,418	7.6	6.7	5.1	2.6
	Glyphosate	0.77 lb ae/a	B										
	OUTLOOK	0.84 lb ai/a	B										
14	Glyphosate	0.77 lb ae/a	A	134	38,903	59.5	18.0	288.5	17,701	11.1	7.6	4.5	1.9
	Glyphosate	0.77 lb ae/a	B										
	OUTLOOK	0.84 lb ai/a	B										
15	Glyphosate	0.77 lb ae/a	A	200	43,952	58.5	18.0	257.5	17,512	26.6	22.2	9.5	8.0
	Glyphosate	0.77 lb ae/a	B										
	OUTLOOK	0.84 lb ai/a	B										
16	Glyphosate	0.77 lb ae/a	A	267	40,685	62.8	17.4	375.0	18,253	25.1	17.4	5.7	2.9
	Glyphosate	0.77 lb ae/a	B										
	OUTLOOK	0.84 lb ai/a	B										
17	Glyphosate	0.77 lb ae/a	A	0	43,061	43.5	18.8	248.0	13,217	10.0	5.5	4.5	2.1
	Glyphosate	0.77 lb ae/a	B										
	STINGER	0.28 lb ae/a	B										
18	Glyphosate	0.77 lb ae/a	A	134	40,091	49.5	17.8	199.8	14,506	9.7	10.8	3.6	2.5
	Glyphosate	0.77 lb ae/a	B										
	STINGER	0.28 lb ae/a	B										
19	Glyphosate	0.77 lb ae/a	A	200	45,734	60.6	17.3	361.3	17,314	48.8	17.5	21.6	5.6
	Glyphosate	0.77 lb ae/a	B										
	STINGER	0.28 lb ae/a	B										
20	Glyphosate	0.77 lb ae/a	A	267	39,200	54.2	16.9	444.3	14,860	18.1	8.2	7.5	3.2
	Glyphosate	0.77 lb ae/a	B										
	STINGER	0.28 lb ae/a	B										
	LSD (*P*=0.05)				NS	13	NS	NS	1,858	13.2	5.6	9.8	3.9

[a] A = glyphosate applied when sugar beets were at the 2-leaf stage; B = glyphosate applied when sugar beets were at 4-leaf stage. Glyphosate application at each time included ammonium sulfate at 5% v/v. Roundup PowerMax® was the brand of glyphosate used.
[b] NO_3 = nitrate; NH_4 = ammonium. Soil nitrate and ammonium at 1-ft and 2-ft depth was determined on July 27, 2010.
[c] ERS = estimated recoverable sugar.