STRIP TILLAGE IN SUGARBEET ROTATIONS – FINAL REPORT

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Introduction

2010 was the final year of the 4-year strip tillage study reported here. High costs and volatility of fuel and fertilizer inputs and wind erosion concerns have motivated many growers to be keenly interested in converting from a conventional tillage system to strip-tillage. An additional consideration that improved yield and management of reduced tillage operations was the arrival of Roundup Ready™ (RR) sugarbeet varieties in 2008. Additionally, autosteer technology is becoming more common on sugarbeet farms in ND and MN and is particularly beneficial in strip tillage systems because it assures that growers can plant seed directly into the middle of the strips created the preceding fall.

To date, no reduced tillage systems have been found acceptable for sugarbeet production throughout the sugarbeet production regions of ND and MN. Ridge tillage has been used on a limited number of acres (<1000 acres) in the northern Red River Valley. Strip tillage and no-till are rarely conducted for sugarbeet production. A review of previous research conducted in this region indicates that the low rate of adoption of strip-tillage is largely due to equipment that is not adapted for these soils and cropping systems. More specific issues cited as the cause for low adoption rates of reduced tillage in sugarbeet systems include cooler soil temperatures, root deformation of sugarbeet seedlings, seeding delays, wetter soils, inability to cultivate, and harvest issues (Franzen et al., 2005). Another complaint with strip-tillage is that most strip-till machines do not cultivate enough rows at a time and must be operated at slower speeds. However, companies producing strip tillers have recently begun constructing 24-row strip till machines.

In strip-tillage, narrow strips, usually 7-10 inches wide, are tilled and then planted with standard planting equipment, sometimes modified slightly. The area between rows remains undisturbed throughout the growing season. Strip-tillage is optimal in areas that are well-drained, prone to soil erosion, have compacted soils or plow pans, and/or for small-seeded crops, root crops, or high-value transplants that require a finely cultivated seed/root bed. Strip-tillage allows the cultivated strips of soil to warm up quickly in the spring for early-seeded crops, and may provide better drainage during wet springs compared to other reduced tillage methods. During dry years, the inter-row areas retain moisture, which is available for crop use. These properties of strip-tillage make this a well-suited reduced tillage method for the soils of the RRV, which are frequently cold and wet early in the planting season and are also susceptible to wind and flood-water induced soil erosion in the spring. Advantages that growers will experience directly by implementing strip-tillage are reduced fuel expenditures, less labor, time, and machinery use, improved soil structure, and the potential for conservation payments through federal programs and carbon credit trading boards.

Although many growers considering strip-tillage in this region are primarily interested in it for sugarbeet production, associated rotation crops may also benefit from strip tillage. Strip-tillage has been shown to result in corn and soybean yields similar to conventional tillage while also providing the benefits of wind protection and accurate placement of N, P, and K beneath the soil surface (unlike no-till). Additionally, banding fertilizer with strip-tillage may provide enhanced plant availability of P in P-fixing soil environments, which are common in ND and MN. **The objective of this study was to evaluate three regionally-important crops (sugarbeet, corn, and soybean) through a full crop rotation using strip-tillage and conventional tillage systems.**

Materials and Methods

This study is located at two locations: The Prosper research station and a grower-cooperator's farm near Moorhead, MN. Both sites are relatively well-drained and are located on regionally representative soil types with no history of major disease issues. The study was designed as a randomized complete split plot with two whole plot treatment factors: strip tillage vs. conventional chisel plow tillage. Split plot treatment factors are each of the four crops used in the rotation. The rotation sequence for this study is wheat/sugarbeet/soybean/corn. According to the design of this study, each crop is present in each year of the study. Tillage treatments were initiated in the fall of the preceding growing season with the exception of fall 2008, which was an exceptionally wet period that prevented fall tillage operations throughout the Red River Valley. Specific tillage, cultivars, and planting and harvest dates are provided in each yearly report for years 2007-2009. Corn, soybean, and sugarbeet were planted on April 30, 2010 at both locations. In 2010, Roundup Ready sugarbeet variety Crystal 658RR, corn variety Pioneer Hybrid 39D85RR, soybean variety Peterson 1002RR, and wheat variety Glenn were seeded in this study. All row crops were seeded to stand at 4 9/16 inches in-row spacing and 22 inches between row centers. Fertilizer application rates were the same for both tillage treatments. Three gallon/a of 10-34-0 were applied as starter fertilizer at planting for corn, soybean, and sugarbeet. The target corn population was 33,500 plants per acre and the target soybean population was at 163,500 plants per acre. Wheat was drilled at 100 lb of grain per acre. In 2010, wheat was harvested on August 6th, soybeans on September 30th, and corn October 7th at both locations. Sugarbeets were harvested on September 22nd at Prosper and September 29th at Glyndon.

Results

Review of previous years' results: **2007:** Despite wet conditions in early spring 2007, sugarbeet root yield did not differ between tillage treatments. Averaged over both locations, net sugar averaged 14.5% for both treatments (Table 1). In 2007, soybean yield differed between locations but not treatments; strip tillage yields averaged 49 and 30 bu a^{-1} and chisel plow averaged 52 and 32 bu a^{-1} from ND and MN (Table 4). This was the only year that conventional tillage out-yielded strip tillage for corn production at both locations (Table 2).

2008: Sugarbeet stand was poor at the Prosper location for both tillage treatments in 2008, but strip tillage stand was about 20% lower than conventional tillage (Table 1). As a result, yield parameters were 5-15% lower for strip tillage compared to conventional tillage at Prosper. These results reflected the importance of properly setting the planter depth gauge wheels in strip tillage systems since the gauge wheels are often spaced so that they ride on the elevated berm that forms along the edges of the strip; this can result in seed placement that is 0.5-1.0 inches too shallow in the center of the strip. We also found that creating a fall berm that was either too high or uneven in height results in related planter seeding depth issues. Root yields at the Moorhead location were statistically the same between tillage treatments in 2008, but net sugar was 0.42% lower in strip tillage relative to conventional tillage. This has been a recurring issue for sugarbeet grown in strip tillage systems and is probably the most serious concern for strip tillage in sugarbeet production systems. Since there was no difference in impurity levels (%slm) between tillage treatments at this location, the reason for lower sugar was the result of lower gross sugar content in the strip till treatment. Although final stand counts were high at the Moorhead location for both tillage treatments, the stand evenness was inconsistent in the strip till treatment. It is possible that this, too, was the result of non-optimal planter setting issues and/or too high or uneven berm creation during fall strip tillage operations. When sugarbeet are seeded at a non-optimal depth some seeds don't germinate, others germinate but don't emerge, and still others emerge but die quickly or don't grow as well as their neighbors. The final result is that beet sizes are non-uniform and overall sugar content for the area is reduced.

Soybean yields at the Prosper location were very good for both tillage treatments and corn yields were exceptional for both tillage treatments in 2008 (Table 2). Soybean yields were above average and corn yields were very good for both tillage treatments at the Moorhead location. High corn yields were observed in many parts of the U.S. in 2008 and were partially due to cooler night temperatures. Yields were significantly greater at the Prosper location compared to the Moorhead location for both corn and soybean. There was a period of no rainfall for several weeks following planting which resulted in uneven corn germination and emergence in conventionally tilled vs. strip tilled treatments. Favorable soil moisture in the strip tilled treatments was due to residue between strips which reduced evaporation and increased water-holding capacity of surface soil.

2009: Despite wet conditions that prevented fall strip tillage in 2008 and consequently produced very poor seedbeds when strips were established in 2009, sugarbeet root yields did not differ as a result of tillage system (Table 1). However, there was significantly less sucrose content in roots produced with strip tillage compared to conventional tillage. There was also significantly greater sucrose loss to molasses at one location for strip tillage compared to conventional tillage. Reduced sucrose content and increased loss to molasses in strip tillage are probably due to a combination of three factors: 1) reduced and/or uneven sugarbeet stand, 2) higher than optimal nitrogen fertilizer rate, and 3) increased tare due to more soil remaining on roots at harvest and/or uneven defoliation. Reduced final sugarbeet stand in strip tilled plots was probably the result of seeding sugarbeet into a poor seedbed in the spring. Defoliation issues can be remedied with proper defoliater settings. Greater soil tare results from higher soil moisture content in strip tillage systems and may be a concern during wet harvest years.

Considering the poor seedbeds created in spring 2009, corn and soybean yields for strip tillage were very competitive compared to conventional tillage (Table 2). Soybean yields were significantly less at Glyndon compared to Prosper, but the tillage effect was inconsistent; strip tillage resulted in about 8 bu/a less soybean grain yield at Prosper and 6 bu/a greater yield at Moorhead. Corn yields were 19 bu/a and 26 bu/a greater in strip tillage than in conventional tillage at Prosper and Moorhead, respectively.

Results of current year: Due to the early planting season and favorable rainfall and temperatures, 2010 was a remarkably good growing season throughout the Red River Valley. In 2010, we were also able to achieve a very good strip tillage seedbed, being sure that fall tillage activities created even berms and the sugarbeet planter was adjusted correctly for the strip tillage conditions. The result was good sugarbeet plant stand and evenness at both locations and consistently high root yields that were equivalent or greater than conventional tillage yields (Table 1). Net sugar content was higher for strip tillage at the Moorhead location, but lower at the Prosper location. The higher root yield at Moorhead resulted in greater RSA and RST for strip tillage; however, at the Prosper location the lower net sugar resulted in lower RSA and RST for strip tillage compared to conventional tillage. Soybean yields were equal at Prosper for both tillage treatments, but strip tillage out-yielded conventional tillage at the Moorhead location (Table 2). For the third year in a row, strip tillage produced greater corn grain yield than conventional tillage at both study locations (Table 2).

Conclusions

This is one of the longest-running strip tillage projects in the Red River Valley region examining tillage effects on three major row crops at multiple locations. The data produced from the study has proven that strip-tillage can produce sugarbeet, soybean, and corn yields that are equal or exceed those obtained using conventional tillage. Reduced sugar and greater loss to molasses observed in strip tillage systems are the greatest concern for strip tillage use in sugarbeet production systems. These issues can be largely overcome by paying special attention to the following issues: assure that fall berms are both even and not too tall; during planting, periodically check that the sugarbeet planter is seeding at the correct depth especially if planter depth gauge wheels ride on the edges of the berms; do not over-apply nitrogen if applying fertilizer in a band with the strip tiller. It is also helpful to evenly distribute harvested residue of the previous crop before creating strips to prevent planting the strips into swaths of residue that can create a mat that prevents even seed emergence and immobilizes N for the following crop.

During the 4 years of this study, corn consistently (6 out of 8 site-years) produced higher yields with strip tillage than conventional tillage. Averaged over all site-years, soybean produced statistically equal yields under the two tillage systems. A non-quantifiable but consistently observed advantage to strip tillage for soybean production is a marked reduction in soybean iron chlorosis symptoms. The Moorhead location frequently produces iron chlorosis symptoms in soybean and in 3 out of 4 years (the only years in which symptoms were noted), strip tillage treatments showed either no symptoms or greatly reduced symptoms compared to conventional tillage treatments and to conventionally tilled soybean fields nearby. We determined that even when strips could not be established in the fall, corn and soybean yields did not decline as a result of spring strip tillage compared to spring chisel plowing for seedbed preparation. Although spring strip tillage did not affect final root yield, it did reduce final sugarbeet stand and increased molasses content, resulting in lower net sugar content. Based on the data of this study, we do not recommend spring strip tillage for sugarbeet production on moderate- to poorly-drained soils in the Red River Valley. Otherwise, we believe that strip tillage can be an effective, productive, and cost-saving tillage alternative to conventional full-width tillage for sugarbeet, corn, and soybean production in the Red River Valley.

References

Franzen, D.; N. Cattanach, R. Utter, J. Giles. 2005. Tillage System Study-Initial Year. Sugarbeet Research and Education Board of MN and ND, 36:144.

Acknowledgement-

Funding for this project was provided by the Sugarbeet Research and Education Board of Minnesota and North Dakota.

SUMMARY STATISTICS OF MULTI-CROP STRIP-TILLAGE STUDY, ALL YEARS COMBINED

Table 1. Sugarbeet Yield and Quality Parameters – Combined Analysis, All Years. Least significant difference (LSD) values provided for P<0.05.

YEAR	LOC	TILLAGE	YIELD (ton a^{-1})	NET SUGAR (%)	STAND Beets $(100ft)^{-1}$	RSA (lb a^{-1})	RST (lb ton^{-1})
2007	PROSPER	STRIP	28.62	14.00	116.7	8014.04	280.08
		CONV	27.84	14.82	102.9	8247.29	296.49
	MOORHEAD	STRIP	30.02	14.75	142.5	8837.11	295.01
		CONV	31.14	14.28	133.8	8906.94	285.57
2008	PROSPER	STRIP	29.25	13.59	97.0	7946.58	271.87
		CONV	32.10	14.29	121.8	9190.76	285.78
	MOORHEAD	STRIP	25.50	14.78	177.5	7550.66	295.60
		CONV	26.02	15.20	167.5	7912.68	304.00
2009	PROSPER	STRIP	32.17	12.72	186.7	8183.61	254.45
		CONV	32.01	13.86	211.3	8876.73	277.25
	MOORHEAD	STRIP	35.52	12.77	128.3	9067.62	255.40
		CONV	35.51	14.49	200.4	10296.84	289.80
2010	PROSPER	STRIP	37.08	13.47	200.0	10007.11	269.39
		CONV	38.87	14.35	210.8	11151.87	286.95
	MOORHEAD	STRIP	29.96	14.26	220.8	8537.23	285.14
		CONV	26.74	13.70	235.0	7299.76	273.97
LSD (P<0.05)			2.00	0.3098	11.4	602.32	6.18

Table 2. Soybean and Corn Yields – Combined Analysis, All Years. Least significant difference (LSD) values provided for P<0.05.

YEAR	**LOC**	**TILLAGE**	**SOYBEAN YIELD (bu a^{-1})**	**CORN YIELD (bu a^{-1})**
2007	PROSPER	STRIP	48.98	150
		CONV	52.20	167
	MOORHEAD	STRIP	29.74	146
		CONV	31.66	157
2008	PROSPER	STRIP	53.25	230
		CONV	55.61	205
	MOORHEAD	STRIP	44.23	197
		CONV	36.46	163
2009	PROSPER	STRIP	39.66	203
		CONV	47.74	184
	MOORHEAD	STRIP	30.19	194
		CONV	24.19	168
2010	PROSPER	STRIP	51.73	209
		CONV	51.37	179
	MOORHEAD	STRIP	45.60	164
		CONV	37.01	154
LSD (P<0.05)			3.67	8.85