Strip-Tillage in Sugarbeet Rotations

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Introduction

High energy costs and wind erosion concerns have motivated many growers to be keenly interested in converting from conventional tillage to a strip-tillage system. An additional consideration that should improve yield and ease management of reduced tillage operations is the arrival of Roundup Ready™ (RR) sugarbeet varieties in 2008. With this new technology, weed management in sugarbeet will be dramatically changed. If sugarbeet follows the trend seen in soybean and other row crops, the availability of RR varieties will provide additional motivation for interested growers to actively pursue the implementation of strip-tillage on their farms

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, usually only under special circumstances. 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.

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 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 cultivated seed/root bed. Additionally, 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 method well-suited for the soils of the RRV, which are frequently cold and wet early in the planting season and are also highly 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. The objective of this study is to help develop a strip-tillage program for sugarbeet and associated rotation crops (22-inch row spacing) in the RRV and Southern Minnesota. Strip-tillage has been shown to result in corn 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, strip-tillage provides enhanced use of P by optimizing placement, while offering cost savings for P fertilizer.

Materials and Methods

<u>Production practices:</u>

In 2006, a 6-row strip-tiller was designed and built by Wil-Rich Manufacturers in Wahpeton, ND, according to input from researchers and representatives of the sugarbeet cooperatives. Funding was provided by NDSU and American Crystal Sugar Co. and Wil-Rich provided a discount on the total price of the equipment to support research efforts.

An initial strip-tillage study was designed with the objective of determining if strip-tillage can be modified to become a suitable, cost-effective means of producing sugarbeet and associated rotation crops in ND and MN. The study was designed as a randomized complete split plot with two whole plot treatments: strip-tillage vs. conventional tillage. Split plot treatments are each of the four crops used in the rotation. This four-year study was designed so that each crop will be present in each year of the study. The rotation sequence for this study is wheat/sugarbeet/soybean/corn.

On Sept. 8th, 2006, strips were implemented at two site locations, the NDSU Prosper Research Station and with a grower cooperator east of Moorhead, MN. Both sites were established into wheat stubble. A conventional chisel treatment was included as a standard comparison or control. At the same time that strips were applied, N fertilizer was placed according to soil test recommendations using UAN. Soil P and K levels were determined to be sufficient at both sites. The rows at the Moorhead location were oriented east-west, while rows were oriented north-south at the Prosper station. It is believed that row orientation differences are the best explanation for differing soil temperatures measured prior to planting. On May 2nd, 2007, strips were planted to sugarbeet, wheat, corn, and soybean at both locations. Sugarbeet was planted to stand with Betaseed variety 1305R. Sugarbeet and corn emergence counts were taken early in the growing season at both sites.

Wheat, soybean, sugarbeet, and corn plots were harvested on August 8, September 14th, September 27th, and October 3, respectively.

Temperature and Moisture Monitoring:

On April 24th and April 27th, thermocouple wire was installed to monitor soil temperatures at the Moorhead and Prosper locations, respectively. Monitors were installed at one-inch and three-inch depths to characterize the soil temperatures in the sugarbeet seedling placement zone. The monitoring equipment was removed on May 1st and May 3rd from the Moorhead and Prosper sites, respectively, so that the area could be prepared for planting. Soil moisture was determined on two occasions early in the growing season, first (May 21st) after heavy rains in the previous two weeks had resulted in flooding conditions in the study locations, and the second time (June 3rd) after the field had dried out and plots had no standing water. Moisture content was determined using a Theta probe to measure electrical conductance, which was related to volumetric soil moisture content by using a calibration technique based on measurements of soil bulk density.

Results and Discussion

May 4th, 5th, and 6th experienced very heavy rainfalls in excess of 2 inches. The months of May and June experienced about nine inches of precipitation at the experiment sites, almost 50% greater rainfall than average. Consequently, flooding and the resulting damage of poor stand establishment and denitrification may have reduced the final yield potential in both the conventional and strip-tillage treatments in this study. Because strip-tillage has the effect of maintaining a higher soil water-holding capacity, the detriment of flooding can be more pronounced under strip-tillage management compared to conventional tillage. As a result of the high precipitation, it was determined in June that the Moorhead location was affected by *Fusarium* species in the wetter areas of the field, particularly in the strip-tilled treatments. The conventionally tilled plots, and to a lesser extent, the strip-tilled plots at Prosper were observed to have developed crusts on the soil surface up to 0.5 inches thick, reducing seedling emergence and resulting in poor stand at the Prosper site (see Table 3, Beet/100'). Crusting was minimal in the crop rows of strip-tilled plots due to the extra surface residue and improved aggregate stability resulting from strip-tillage. The higher emergence rate of beet and corn at the Prosper location is partially credited to the absence of a soil crust present in the strip-tilled plots. Residue cover was measured at Moorhead on May 15th and at Prosper on June 11th. At Moorhead, the strip-tilled plots had 45% surface residue cover and the conventionally-tilled plots had 14% residue cover. At Prosper, the strip-tilled plots had 41% surface residue cover and the conventionally-tilled plots had 17% surface residue cover.

Regarding sugarbeet yield and quality, strip-tillage resulted in essentially equivalent yields and sugar content for all parameters measured: tonnage, net sucrose content, recoverable sugar per acre, recoverable sugar per ton, stand, and profit (Table 1). It should be noted that the high tonnage values indicated for both strip-till and conventional tillage are partially the result of the low stand counts present at Prosper. The low stand counts at Prosper were primarily due to crusting after heavy rainfall in May and June, which reduced stand establishment. This data indicates that, given the fuel savings due to fewer passes across the field, strip-tillage has the potential to result in cost savings for sugarbeet farmers.

Soil temperature data is represented in Table 2 below. Results were surprising, since it is generally accepted that soil temperatures are lower in strip tilled plots compared to conventionally tilled plots, especially in early spring. What was found, however, was that in the north-south oriented plots at Prosper, the soil temperatures were warmer at the one-inch depth in strip-tilled treatments compared to conventionally-tilled treatments. The differences were greater earlier in the season, with the greatest daily average difference occurring on April 27 and revealing a 4-degree temperature increase in the strip-till versus the conventional-till treatments at the one-inch depth. At the three-inch depth, there was no notable difference in soil temperatures between tillage treatments. At the Moorhead location, where rows were oriented east-west and soils were sandier and better drained, there was no difference between in-row soil temperatures at either soil depth for the strip-tilled and conventionally-tilled treatments. An explanation for the warmer soils observed at Prosper is not fully possible without further research, but possible explanations may be due to row orientation and the fact that standing residue in the inter-row areas (region between the strips) may trap some of the solar heat close to the soil surface, and, by blocking wind movement across wet soils, prevent the surface soil temperature from being reduced as it would be in a more exposed conventionally tilled soil. Also, because of the slight (approximately 4 inch) birm that is created by strip-tillage in the fall, there may be slightly more pore space to allow for better drainage in surface soils in strip tilled plots, thus allowing less temperature buffering (resistance to temperature increases) imposed by water.

Soil moisture data was collected from both experiment locations on June 21st, when soils were near saturation, and again on July 3rd, after soils had been allowed to drain for over a week. Only data for the Prosper site is provided below, but the Moorhead data appears very similar, although differences in moisture content between tillage treatments was smaller in magnitude on both dates at the Moorhead location. This data shows that on June 21st, soils were near saturation after the heavy rainfall that had occurred throughout early May. Moisture contents ranged from 40% to 46.5% during this time at Prosper. A moisture content of 50% would be close to complete saturation of all pore space with water. The strip tillage treatments had 3.5 to 5.5% greater moisture content than the conventional tillage treatments. By July 3rd, soils had drained considerably, but the strip tillage treatments were still holding more water than the conventionally tilled treatments in all cases. In years of excessive moisture, like early 2007, the increased moisture holding capacity of strip-tilled soils can be a disadvantage, however in dry years this can be an advantage.

Table 1. Sugar tonnage and quality parameters. Except for stand (Beet/100'), all parameters were averaged across both study locations because treatment effects did not differ significantly between locations. For Beet/100', values differed significantly between the Prosper and Moorhead site, so values were analyzed individually. Trt = treatment (strip=strip-tillage; conv=conventional chisel plow); Tons=yield (tons/a); sugar=net sucrose (%); RSA=recoverable sugar per acre (lbs sugar/acre); RST=recoverable sugar per ton (lb sugar/ton root); Beet/100'=no. beets per 100 ft. of row; Gross Ton = Gross profit per ton ($/ton root); Gross Acre = Gross profit per acre ($/acre).

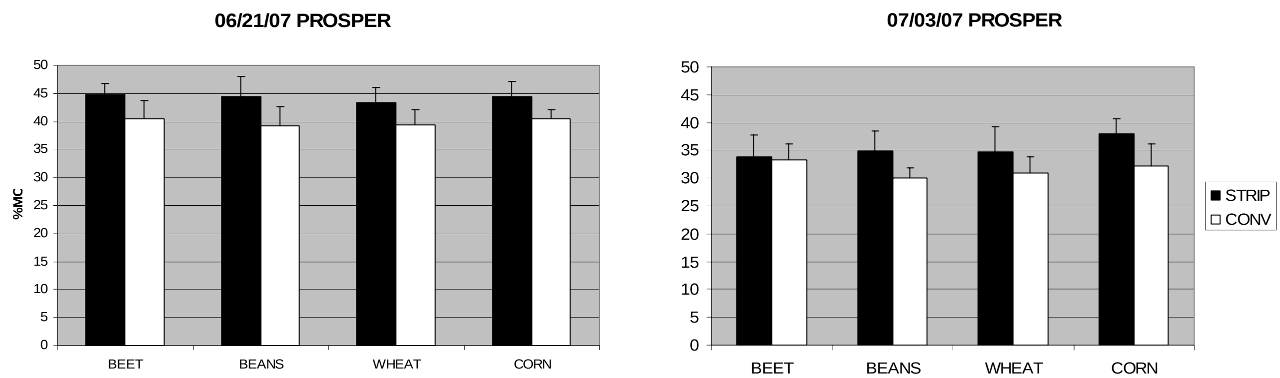
TRT	TONS	SUGAR	RSA	RST	BEET/100' PROSPER	BEET/100' MOORHEAD	GROSS TON	GROSS ACRE
STRIP	29.6 a	14.50 a	8562 a	290.0 a	93 a	143 a	30.89 a	910.89 a
CONV	30.0 a	14.46 a	8687 a	289.2 a	103 a	134 a	30.71 a	922.24 a

Table 2. Soil temperature in degrees Fahrenheit at 1 inch and 3 inch at both study sites. Values are the average of the daily soil temperatures, which were logged and recorded approximately every 30 minutes. DOY = Day of Year.

LOCATION	DOY	STRIP 1 INCH	CONV 1 INCH	STRIP 3 INCH	CONV 3 INCH
MOORHEAD	APRIL 24	52.27	53.06	50.38	51.74
MOORHEAD	APRIL 25	50.49	51.32	48.01	48.93
MOORHEAD	APRIL 26	52.45	53.01	49.78	50.72
MOORHEAD	APRIL 27	55.49	55.58	52.28	52.72
MOORHEAD	APRIL 28	55.22	54.91	53.06	53.01
MOORHEAD	APRIL 29	56.28	55.95	53.62	53.36
MOORHEAD	APRIL 30	58.00	57.92	55.71	55.85
MOORHEAD	MAY 1	53.59	53.04	52.43	51.62
PROSPER	APRIL 27	66.36	62.85	59.95	58.48
PROSPER	APRIL 28	61.20	59.20	57.26	56.40
PROSPER	APRIL 29	61.86	61.38	58.89	58.91
PROSPER	APRIL 30	57.61	57.59	55.82	56.03
PROSPER	MAY 1	58.08	57.47	56.26	56.09
PROSPER	MAY 2	53.01	52.76	51.81	51.98

Table 3. Emergence counts from two study locations (M = Moorhead; P = Prosper) for sugarbeet and corn.

DATE	CROP	STRIP	CONV
15-MAY (M)	BEET	112	128
24-MAY (P)	BEET	138	105
15-MAY (M)	CORN	140	129
24-MAY (P)	CORN	141	130



Figures 1 and 2. Volumetric soil moisture content for strip-tilled (STRIP) and chisel plowed (CONV) tillage treatments for four different crops (BEET BEANS WHEAT and CORN) at the Prosper experiment site. Measurements were taken on June 21 and July 3rd, 2007 at approximately the same time of day. Error bars represent standard deviation of the data set.

Conclusions

In this study, the first year of a four-year strip-tillage experiment, it was found that strip-tillage resulted in similar yield potential for sugarbeet production relative to conventional chisel tillage. Because 2007 experienced a very wet spring, which is not favorable for strip-tillage conditions due to the greater water holding capacity of strip-tilled fields, this was a good year to consider as a “worst case scenario” for testing strip tillage. There was greater moisture in the strip-tilled treatment relative to the conventionally tilled treatment, and that may have resulted in higher levels of *Fusarium* and other root rot diseases observed in this study, but disease pressure was not severe enough to result in lower yields or sugar quality levels than those obtained for conventional tillage under the same adverse conditions. Surprisingly, soil temperature and moisture data revealed that strip-tillage does not necessarily have cooler soil temperatures compared to conventionally tilled soils and may even be slightly warmer than conventionally tilled soils in some instances. Overall, this data indicates that strip-tillage is a promising tillage practice and one that would benefit from continued research efforts as well as grower and industry interest and support.