NITROGEN FERTILITY IN STRIP TILLAGE

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Introduction

In recent years, an increasing number of growers are considering strip tillage as an alternative to full width conventional tillage. High fuel and fertilizer prices as well as Roundup Ready sugarbeet were strong influences in peaking grower interest in strip tillage. Sugarbeet producers who farm silty and sandy soil types prone to wind erosion were among those particularly interested in strip tillage. Spring wind events, common to the Red River Valley, reduce sugarbeet yields on thousands of acres every year causing affected growers to reconsider the importance of reduced tillage, cover crops, and other practices that reduce susceptibility to wind erosion. Additionally, autosteer technology is becoming common on many sugarbeet farms in ND and MN and is particularly beneficial in strip tillage systems because it assures that growers can plant seeds directly into the middle of the strips that were made the preceding fall or earlier in the spring. Roundup Ready sugarbeet varieties reduce grower dependence on cultivation as a weed control method, which also makes weed control in strip tillage more manageable.

In strip-tillage, narrow strips, usually 7-10 inches wide, are tilled and then planted with standard planting equipment, often modified with row cleaners. The area between rows remains undisturbed throughout the growing season. Strip-tillage is optimal for well-drained soils prone to wind erosion. Additionally, strip-tillage allows the cultivated strips of soil to warm up and dry faster than no-till systems in the spring for early-seeded crops. During dry periods, the inter-row areas retain moisture, which is available for crop use. This is a particular benefit in the spring, when dry soil conditions may result in reduced or uneven seedling emergence and consequently poorer stand establishment in conventionally tilled fields. 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, as well as the potential for conservation payments through federal programs and carbon credit trading boards.

Economically, strip tillage provides fuel savings by eliminating primary and secondary tillage operations with chisel plow, field cultivators, etc. Strip tillage also eliminates additional fuel inputs associated with fertilizer application and weed cultivations in conventional tillage systems. Labor costs may also be reduced in association with fewer field operations. Fertilizer savings may be realized if fertilizer banding increases N and/or P uptake efficiency, allowing a fertilizer rate reduction. Planting and harvesting operations are the same for strip till and conventional till systems. Converting to strip-till production requires investment in new equipment associated with equipment cost, insurance, and storage.

One concern of growers and agronomists regarding fall strip tillage is fall nitrogen fertilizer application. Since strip tillage is recommended in fall in this region and one of the principle advantages of strip tillage is the convenience and fuel savings associated with applying fertilizer at the same time as tillage, it is most convenient to apply fall N fertilizer with the strip tillage activity. Fall N fertilizer application is a very common practice among growers in the Red River Valley region and many agronomists consider it an environmentally and economically safe practice provided that fertilizer is not applied until after soil temperatures at the four-inch soil depth are below 50° F. However, it is tempting for growers to establish strips and apply fertilizer soon after harvesting the previous crop in case snow, very cold, or very wet weather creates conditions that preclude field work later in the fall. In this study, we examine the consequences of establishing strips and applying N fertilizer (as urea) early in the fall, soon after wheat harvest, compared to later in the fall when soil conditions are more appropriate for fall N fertilizer application.

This study also investigated the potential of a N placement technique that has proven beneficial in some instances in Michigan. Applying N fertilizer in a 2X2 spatial arrangement (2 inches to the side of the row and 2 inches deep) has provided visibly greater early season sugarbeet biomass and vigor in most years and has translated to a half ton yield advantage in some years in MI (Steven Poindexter, personal communication). In a research study conducted over several years by Steve Poindexter and colleagues in Michigan, higher-than-normal levels of fertilizer (i.e. 7.5 gallons of 10-34-0 + 7.5 gallons of 28% UAN) were applied with the planter in a 2X2 arrangement. Two potential advantages of this system are 1) fertilizer is accessible to the seedling early in the season to provide necessary fertility for early season growth and to encourage early canopy closure, and 2) the fertilizer is placed spatially in an area where the seedling can access it in early spring without risk of fertilizer burn. According to a survey of 17 top Michigan Sugar Company growers representing 9360 acres of sugarbeet production, 77% of the farmers surveyed reported that they used starter fertilizer and 100% of those who used starter fertilizer were applying it with a 2X2 placement (Sugarbeet Advancement report 2006). Since sugarbeet do not associate with mycorrhizal fungi, they have even less access to P than most row crops. Without mycorrhizae, sugarbeet have a greater chance of facing P deficiency than other crops when P is not available early in the growing season and especially under cold, very wet, or very dry early conditions, since root growth and mass flow are reduced under such conditions.

The objectives of this study are to examine 3 important fertility questions specific to nitrogen (N) fertilization in strip tillage systems. 1) Will reducing N rates for sugarbeet production eliminate the problem of higher molasses observed in strip tillage systems without compromising sugarbeet root yield? 2) Can 2x2 starter fertilizer placement increase sugarbeet yield and sugar quality and/or reduce total N fertilization requirement in strip tilled systems? And 3) how much N fertilizer (if any) is lost as a result of applying N with strip tillage soon after wheat harvest, before soil temperature is below 50 degrees F? 2010 was the first year of a three-year study.

Materials and Methods

The study was designed in a randomized complete block design with four replications, near Amenia, ND on a well drained sandy loam soil with no serious history of root rot diseases. Soil samples taken in September 2009 indicated that there was 27 lb. N a^{-1} (to a depth of 4 ft.) and 11 ppm P (0-6 inch depth, Olsen extraction). Fertilizer was applied at the full recommended rate (103 lb. N a^{-1}) or a fraction thereof, as specified in Table 1. All plots were oriented in an east-west orientation and all fertilizer treatments were applied on September 16, 2009 <u>except</u> treatments 13-15 (late application N fertilizer, Table 1). The 0 N added check was a strip tillage treatment; a 0 N added check as a conventional tillage treatment was not included due to space constraints. Nitrogen fertilizer was applied as urea and P_2O_5 as triple super phosphate during the strip tillage operation in all strip tillage treatments. The conventionally tilled treatment was fertilized with urea and triple super phosphate by broadcasting and incorporating twice with a chisel plow in the fall and lightly cultivating in the spring with a harrow/packer combination. Late-application N fertilizer treatments were applied with strip tillage on November 20th, 2009. 2X2 fertilizer application was accomplished using a ferti-placer fertilizer shoe adjusted to place liquid 10-34-0 and UAN fertilizer 2 inches from the crop row and 2 inches below the soil surface during the planting operation. The 2X2 placement provided 31.3 lb of N and 29.6 lb of P_2O_5 for early season sugarbeet seedling uptake. Select soils were sampled to 4 feet for total N content on the following dates: 09/09/09, 12/11/09, 04/15/10, 05/21/10, and 07/12/10.

Individual treatment plots measured 11 feet wide and 30 feet long. Sugarbeet variety Crystal 658RR was planted in a smooth, moist, firm, seedbed on April 19, 2010 with a John Deere MaxEmerge 2 planter. Sugarbeet was placed 1.25 inches deep with 5-inch in-row spacing. Excellent emergence and plant vigor was noted. Roundup Ready herbicide was applied three times; plots were not cultivated and some late hand labor was used as needed for weed control. Quadris fungicide was applied at the four- to six-leaf stage and again three weeks later to help control rhizoctonia root rot. Two fungicide applications, Eminent and Headline were applied for Cercospora leaf spot control. Plots were harvested on September 22, 2010. Yield determinations were made and quality analysis performed at American Crystal Sugar Quality Tare Lab, East Grand Forks, MN.

Results and Discussion

Average root yields ranged from 25.7 tons per acre for the no N added check (Treatment 1) to 39.1 tons per acre for the conventionally tilled/broadcast full rate N plus starter fertilizer (Treatment 9, Table 1). Although treatment 9 produced the greatest root yields, the following treatments were statistically equal to it: Strip tilled full N rate (38.5 t/a, treatment 4), Conventionally tilled/broadcast 80% N rate (37.8 t/a, treatment 3), Strip tilled 70% N Rate (37.7 t/a, treatment 6), Strip tilled 80% N rate (37.4 t/a, treatment 5), Conventionally tilled/broadcast full N Rate (36.7 t/a, Treatment 2), Strip tilled late-Fall application 60% N Rate (36.6 t/a, Treatment 14), and Strip tilled full N rate plus starter fertilizer (36.3 t/a, Treatment 8). Reducing the N fertilizer rate by 40% in strip tillage resulted in a significant yield loss of 5.6 tons per acre, revealing that although N rate reductions may be possible in strip tillage, reducing N rate drastically (more than 40%) is not feasible. Reducing fertilizer rates by 20% and 30% below the recommended rate in strip tilled plots resulted in a statistically non-significant reduction of about 0.85 to 1 ton per acre; this is a 2-3% reduction in root yield relative the full N rate treatment. At an application rate of 100 lb N/a and a fertilizer cost of $0.50/ lb N, the result of reducing fertilizer application rate by 20% would save $10/a; reducing N fertilizer rate by 30% would save $15/a. However, if fertilizer reduction results in consistent loss of 1 ton of beets per acre (without affecting net sugar content) the gross return per acre is correspondingly reduced by $48 (using the payment schedule provided for 2010). Thus, reducing fertilizer at the expense of even just 1 ton yield per acre does not necessarily provide net economic return when beet payments are a record high, as they were in 2010. This may be different when beet payments are lower. It should also be pointed out that this is just considering differences in fertilizer application rate for strip tillage treatments. When compared to full-width tillage, there are additional savings from strip tillage resulting from fuel savings due to fewer passes across the field.

There was an average yield increase of 2.4 ton per acre when starter fertilizer was applied in conventional tillage in addition to the full N fertilizer recommended rate. In strip tillage, however, average tonnage decreased by 2.2 ton per acre when starter fertilizer was applied in addition to the full N rate. This is surprising since starter fertilizer has been observed to improve early season growth in strip tillage systems, presumably by making more N and P available to young seedlings in cooler soil conditions present early in the growing season. Early season conditions in 2010 were highly favorable for growth and probably did not adequately represent the value of starter fertilizer in more typical years.

The 2X2 N placement treatments (treatments 10 and 11) did not rank among the best treatments. The 2X2 treatments displayed poorer vigor and uneven plant stand as early as mid-June. Average root yield for full fall N rate plus 2X2 (Treatment 10) produced lower root yield than 80% N rate plus 2X2 (Treatment 11) and also produced the largest %slm value (due to higher tare, sodium, potassium, and/or amino N values for two of the replicates), but there were no observations that might explain these results and none of the values qualified as outliers. There were no observations to explain why these two replicates of Treatment 10 were so poor. There were several storm events in May and June that saturated soils for several days and which may have resulted in loss of N in the liquid forms (UAN and 10-34-0) used in the 2X2 treatments, perhaps resulting in mild N deficiency. The reason for larger loss-to-molasses values in the 2X2 treatments cannot be fully understood based on this data set. More site years are needed to evaluate the 2X2 N fertilizer placement system.

The effect of applying N fertilizer later in the fall did not increase sugarbeet root yield or improve any yield parameter. The soil test N results from select soil samples taken in early and late fall and in early spring and summer were highly variable even within treatment replicates. The high variability and lack of consistent trends in total N levels along with the incomplete nature of the dataset makes it difficult to draw conclusions regarding fertilizer N fate in the soil and N use efficiency by the crop. Soil test N values taken in late fall and early spring roughly reflected N fertilizer application treatments but the variability among replicates precludes accurate quantification of N loss resulting from early- versus late-fall N fertilizer application. This issue can be addressed more completely in the future if funding is provided for this study again.

The three lowest %slm values were determined for the no-N added check (0.9102%, Treatment 1), Strip tilled 80% N rate (0.9133%, Treatment 5), and conventional tillage/broadcast full rate N (0.9285%, Treatment 2). Strip tillage treatments with 60 and 70% of the full N rate did not result in lower %slm than the full N rate, but net sugar values were similar for all strip tillage treatments regardless of N fertilizer application rate. Root yield was not significantly reduced by reducing the N fertilizer rate in strip tillage from the full rate down to 70% of the full rate. In fact, the highest average RSA value among strip tillage treatments was produced by the Strip Tilled 70% N rate treatment (Treatment 6, Table1). However, more data should be collected over different locations and different growing seasons before recommendations regarding N application rate in strip tillage systems can be made.

Net sugar, recoverable sugar per ton, and gross return per ton did not differ significantly among any of the N rate, placement, or timing treatments. One plot (from Treatment 5) was deleted from the data set because it was unintentionally planted later than other plots.

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Table 1. Nitrogen Rate and Placement Effects on Strip-tilled and Conventionally-tilled Sugarbeet Yields at 2 locations. 2010 Growing Season. Least significant difference (LSD) values provided for P<0.05; n.s. signifies no significant differences.

Treatment	Root Yield (Tons/a)	Gross Sucrose (%)	%SLM* (%)	Net Sucrose (%)	RSA† (lb/a)	RST‡ (lb/ton)	Tare (%)	GrossTon§ ($/Ton)	GrossAcre¶ ($/acre)
1. Strip Till 0 N	25.70	15.7600	0.9102	14.8498	7622.15	297.00	3.67	52.68	1350.55
2. Broadcast Full	36.71	15.7975	0.9285	14.8690	10912.84	297.38	4.37	52.79	1936.96
3. Broadcast 80%	37.82	15.7275	1.0104	14.7171	11145.43	294.34	4.90	51.88	1966.15
4. Strip Till Full	38.48	15.3800	1.0166	14.3634	11051.36	287.27	4.29	49.76	1914.03
5. Strip Till 80%	37.42	15.6833	0.9133	14.7700	11046.12	295.40	4.68	52.20	1951.15
6. Strip Till 70%	37.69	15.8675	1.0193	14.8482	11195.16	296.96	4.05	52.67	1985.88
7. Strip Till 60%	32.86	15.4225	1.0247	14.3978	9488.70	287.96	3.91	49.97	1649.88
8. Strip Till + Starter	36.29	15.6700	1.0279	14.6421	10628.33	292.84	4.00	51.43	1866.90
9. Broadcast + Starter	39.12	15.5675	0.9852	14.5823	11416.65	291.65	4.12	51.07	2000.23
10. Strip Till Full + 2X2	32.83	15.8550	1.0729	14.7821	9731.80	295.64	4.39	52.27	1723.70
11. Strip Till 80% + 2X2	34.63	15.7850	0.9605	14.8245	10256.00	296.49	3.35	52.53	1815.42
12. Strip Till Full Late	34.16	15.5325	1.0404	14.4921	9894.30	289.84	4.44	50.53	1724.25
13. Strip Till 80% Late	35.76	15.4300	0.9987	14.4313	10330.06	288.63	3.36	50.17	1796.75
14. Strip Till 60% Late	36.60	15.6275	0.9913	14.6362	10700.00	292.72	3.66	51.40	1877.07
LSD (P<0.05)	**2.87**	**0.4846**	**0.0966**	**n.s.**	**924.36**	**n.s.**	**0.97**	**n.s.**	**186.67**

*%SLM = Sucrose Loss to Molasses, a measure of impurity content
† RSA = Recoverable Sucrose per Acre
‡ RST = Recoverable Sucrose per Ton
§ GrossTon = Gross Revenue per Ton
¶ GrossAcre = Gross Revenue per Acre