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 or very cold 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. Strips were applied in a north/south row orientation on September 08, 2010. Fertilizer was applied as urea and triple super phosphate during the strip tillage operation in all strip tillage treatments except treatments 13-15 (late application N fertilizer, Table 1). The conventionally tilled treatment was also fertilized with urea and triple super phosphate by broadcasting and incorporating twice with a chisel plow in the fall and lightly cultivated in the spring with a harrow/packer combination. Late-application N fertilizer treatments were applied with strip tillage on October 17th, 2010. 2×2 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 2×2 placement provided 31.3 lb of N and 29.6 lb of P_2O_5 for early season sugarbeet seedling uptake.

Treatments – (ST = Strip Till; CT = Conventional chisel plow tillage)

1. No fertilizer-added check, strip till (ST)
2. N broadcast (full rate) – normal P recommended rate, applied in fall w/ conventional chisel plow tillage (CT) to incorporate (the commercial production standard)
3. N broadcast (20% reduction) – normal P recommended rate, applied in fall w/ CT to incorporate
4. N banded w/ ST (full rate) – normal P recommended rate, applied in fall w/ ST
5. N banded w/ ST (20% reduction) – normal P recommended rate, applied in fall w/ ST
6. N banded w/ ST (30% reduction) - normal P recommended rate, applied in fall w/ ST
7. N banded w/ ST (40% reduction) - normal P recommended rate, applied in fall w/ ST
8. N+P Starter w/ fall ST - 3 gall 10-34-0 applied @ planting, balance of N & P applied in fall w/ ST
9. N+P Starter w/ fall broadcast – 3 gall 10-34-0 applied @ planting, balance of N & P broadcast applied in fall w/ CT to incorporate
10. P-only Starter – equivalent P to 3 gall 10-34-0 applied @ planting, balance of N&P applied w/ ST in fall
11. 2×2 placement in spring – balance of full rate N & P banded in fall w/ ST
12. 2×2 placement in spring - balance of 20% reduced rate banded in fall w/ ST
13. Late strips – Full N rate
14. Late strips – 80% of full N rate
15. Late strips – 60% of full N rate

Individual treatment plots measured 11 feet wide and 30 feet long. Sugarbeet variety Crystal 658RR was planted in a smooth, moist, soft, seedbed on May 12, 2011 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, Supertin/Topsin and Headline were applied for Cercospora leaf spot control. Plots were harvested on September 21, 2011. Yield determinations were made and quality analysis performed at American Crystal Sugar Quality Tare Lab, East Grand Forks, MN.

Results and Discussion

Growing conditions for sugarbeet production in many districts of the Red River Valley were very poor in 2011, resulting in the worst average sugarbeet yields in several years. Excessive rainfall in May, June and July resulted in prolonged and wet soil conditions. In June 2011, the North Dakota State average precipitation was 4.51 inches which is above the 1971-2000 normal of 3.19 inches and ranked 23rd wettest in the last 117 years according to the North Dakota Agricultural Weather Network. The Prosper NADAWN observation site recorded 3.14, 5.17 and 5.91 inches of rainfall in May, June and July respectfully in 2011. Because of the saturated soil, conditions were favorable for disease infection mainly Aphanomyces and Rhizoctonia Root Rot. Because of early season cool temperatures and wet soil conditions spring planting was also delayed in 2011. Poor growth conditions and high disease pressure contributed small yields, poor sugar quality, and great variability in the dataset.

Average root yields ranged from 11.6 tons per acre for the Late-fall ST application (Treatment 13) to 21.8 tons per acre for the Conventional Tillage Full N Rate Broadcast (Treatment 2, Table 1). Although treatment 2 produced the greatest root yields, the following treatments were statistically equal to it: Conventional Tillage Full N Rate Applied 2X2 (20.5 t/a, treatment 11), Conventional Tillage w/ P-Only Starter Fertilizer (19.4 t/a, treatment 8), Conventional Tillage 80% N Rate Broadcast (18.0 t/a, treatment 3), Conventional Tillage w/ N+P Starter Fertilizer (17.7 t/a, treatment 9), Strip Tillage 70% N Rate (17.4 t/a, Treatment 6), Strip Till w/ N+P Starter (17.2 t/a, Treatment 10), Strip Tillage 80% N Rate (16.1 t/a, Treatment 5), Strip Tillage 60% N Rate(15.6 t/a, Treatment 7), and Conventional Tillage 80% N Rate Applied 2×2 (15.3 t/a, Treatment 12). The same 10 treatments provided the best (and statistically equal) recoverable sugar per acre (RSA) and gross return per acre (Gross/Acre).

Since disease and excessive soil moisture were the factors most limiting yield and sugar quality in 2011, it is difficult to assess the value of N rates and tillage systems under such adverse growing conditions. It was clear, however, that strip tillage does not perform as well as conventional tillage under these conditions. The wet, warm weather combined with the high surface residue in strip tillage systems created a particularly good environment for a variety of fungal diseases. The Strip Tillage with 60%, 70%, and 80% of N applied (Treatments 7, 6, and 5, respectively) provided yields statistically the same as the Conventional Tillage Full and 80% of N Rate (Treatments 2 and 3), but this is probably reflective of the high variability in yield data. The late-fall applied strip tillage treatments (Treatments 13, 14, and 15) gave particularly poor root yields and higher levels of sugar loss to molasses. Average root yield for the Late Strip Tillage Full N Rate (Treatment 13) was lower than the 80% N Rate and 60% N Rate (Treatments 14 and 15) and even lower than the No-N Check Plot (Treatment 1). Among all treatments tested in this study, Treatment 13 produced the lowest root yield, net sucrose, RSA, and Gross/Acre. The poor results for Treatment 13 and, to a lesser extent, 14 and 15 were strongly influenced by the location of these plots which coincided with low areas of the field and greater disease pressure. It is not possible to determine, based on these results, whether later fall application of N fertilizer might reduce N losses due to leaching and denitrification in a year with more average in-season precipitation.

In terms of starter fertilizers, no starter treatment resulted in greater yields than the conventionally tilled non-starter treatments with full N rate applied either broadcast or 2X2 (Treatments 2 and 11). Among starter treatments, the P-only Starter (Treatment 8) provided the greatest yield benefit resulting in 19.4 t/a, about 2 t/a greater than the N+P starter treatments for conventional and strip tillage (Treatments 9 and 10). Though not statistically significant, the positive results of the P-only starter could indicate that N was not limiting early in the growing season, possibly due to slow growth early in the season due to above-average rainfall, or that the small amount of N available in the N+P starter material was of little value for crop growth and development. These results should be reassessed in years with more favorable growth conditions.

Conclusions

This data supports our previous conclusions that strip tillage can result in lower yields and sugar quality under unusually wet field conditions. Under extreme soil moisture and disease conditions, strip tillage resulted in a 39% yield reduction relative to conventional tillage (comparing full N rates). The high level of variability and poor field conditions is illustrated by the fact that strip tillage treatments with 20%, 30%, and 40% N rate reductions all produced higher root yields than the full N rate strip tillage treatment. This data is valuable as part of a larger body of data investigating N use and strip tillage under a range of field conditions, but additional research should be conducted in order to provide accurate recommendations for N application rates with strip tillage and other N banding systems. It is difficult to assess, based on this data, whether reducing the N rate is advisable with strip tillage under normal growing conditions.

Acknowledgement

Funding for this project was provided by the Sugarbeet Research and Education Board of Minnesota and North Dakota. Authors greatly acknowledge the support of American Crystal Sugar Quality Tare Lab, East Grand Forks, MN and NDSU Soil Testing Lab.

Table 1. Nitrogen rate and placement effects on strip-tilled and conventionally-tilled sugarbeet yields during 2011 growing season. Least significant difference (LSD) values provided for P<0.05; n.s. signifies no significant differences. Different capital letters indicate significant difference at 95% significance level.

	Treatment	Roots yield (Tons/a)	Gross Sucrose (%)	Slm%	Net Sucrose (%)	RSA (lb/ac)	RST (lb/ton)	Tare%	Gross Ton ($/ton)	Gross Acre ($/acre)
1	CheckST	12.7	14.97^{AB}	1.17^{C}	13.80^{AB}	3475^{BCD}	276^{AB}	1.63^{B}	46.38^{AB}	579^{BCD}
2	NbroadFull	21.8^{A}	15.13^{A}	1.28^{BC}	13.86^{A}	6069^{A}	277^{A}	1.87^{B}	46.72^{A}	1028^{A}
3	NBroad20%less	18.0^{ABCD}	14.97^{AB}	1.34^{BC}	13.63^{AB}	4917^{ABC}	273^{AB}	1.40^{B}	45.34^{AB}	818^{ABC}
4	NSTFull	13.2^{CD}	14.73^{AB}	1.42^{B}	13.31^{ABC}	3498^{BCD}	266^{ABC}	1.43^{B}	43.44^{ABC}	569^{BCD}
5	NST20%less	16.1^{ABCD}	15.13^{A}	1.23^{BC}	13.91^{A}	4515^{ABCD}	278^{A}	1.13^{B}	47.02^{A}	768^{ABCD}
6	NST30%less	17.4^{ABCD}	15.00^{AB}	1.29^{BC}	13.71^{AB}	4766^{ABCD}	274^{AB}	1.70^{B}	45.82^{AB}	797^{ABCD}
7	NST40%less	15.6^{ABCD}	14.47^{ABCD}	1.26^{BC}	13.21^{ABC}	4137^{ABCD}	264^{ABC}	1.53^{B}	42.82^{ABC}	672^{ABCD}
8	Ponlystarter	19.4^{ABC}	14.67^{ABC}	1.25^{BC}	13.42^{ABC}	5238^{ABC}	268^{ABC}	1.70^{B}	44.08^{ABC}	866^{ABC}
9	N+PStarterBroad	17.7^{ABCD}	14.87^{AB}	1.25^{BC}	13.62^{AB}	4797^{ABCD}	272^{AB}	1.17^{B}	45.30^{AB}	795^{ABCD}
10	N+PStarterST	17.2^{ABCD}	14.83^{AB}	1.32^{BC}	13.51^{AB}	4666^{ABCD}	270^{AB}	2.17^{AB}	44.64^{AB}	774^{ABCD}
11	FullFallN+2×2	20.5^{AB}	14.77^{AB}	1.30^{BC}	13.47^{AB}	5538^{AB}	269^{AB}	1.03^{B}	44.38^{AB}	916^{AB}
12	20%lessN+2×2	15.3^{ABCD}	15.23^{A}	1.22^{BC}	14.01^{A}	4316^{ABCD}	280^{A}	1.30^{B}	47.66^{A}	737^{ABCD}
13	NSTFullLate	11.6^{D}	12.93^{D}	1.70^{A}	11.23^{D}	2777^{D}	225^{D}	3.50^{A}	30.98^{D}	409^{D}
14	NST60%late	14.4^{BCD}	12.97^{CD}	1.41^{B}	11.55^{CD}	3461^{BCD}	231^{CD}	2.13^{AB}	32.90^{CD}	515^{CD}
15	NST80%late	13.7^{CD}	13.33^{CD}	1.40^{BC}	11.94^{BCD}	3374^{CD}	239^{BCD}	1.63^{B}	35.20^{BCD}	514^{CD}
	LSD (P<0.05)	6.62	1.72	0.24	1.91	2084	38.3	1.44	11.48	395

*%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