PHOSPHORUS FERTILITY IN STRIP TILLAGE

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Introduction

This study examines the possibility of reducing phosphorus (P) application rates in strip tillage. We examined the effect of 20%, 30%, 40%, and 50% P application reductions on low P testing soils compared to full rate applications with strip tillage. We included similar P rate treatments with broadcast application in conventional tillage for comparison.

Phosphorus (P) fertilizer prices have shown tremendous volatility during the past several years and prices remain unpredictable for future years. In the soil, P is readily “fixed” into unavailable forms in some soils of the Red River Valley of ND and MN and Southern MN (most notably high pH and calcareous soils); under such soil conditions, accurate P application rate and placement becomes critical. Banding P fertilizer near or in the crop row can increase P availability for plants under the soil conditions described. Strip tillage allows banding of P fertilizer in the crop row at the same time that strips are placed. By improving the efficiency of P uptake into sugarbeet tissues, it may be possible to reduce the application rate that is recommended for conventional broadcast fertilization application. **This study investigated 1) banding P fertilizer with strip tillage equipment to increase plant availability of P relative to conventional broadcast application, and 2) the potential reduction of P fertilizer application rates (without sacrificing beet root yield and quality) if it is determined that P uptake efficiency increases with strip tillage.** Results that indicate that P fertilizer application rates can be reduced in strip tillage systems would represent cost savings to farmers currently strip tilling and may influence other farmers to consider strip tillage for their farming operations.

A study conducted in 1996 in Waseca, MN on corn determined that under very low soil test P conditions, banding P fertilizer at half the recommended broadcast rate was not sufficient to optimize corn grain yield relative to conventional tillage with full rate broadcast application (Randall et al., 2001). For this reason, we select rates of P reduction between
20% and 50% to examine the full range and allow us to more exactly identify the effect of P rate reduction.

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 an east/west row orientation in September 8, 2010. Soil samples taken in September 2010 indicated that there was 60 lb N acre^{-1} (to a depth of 4 ft.) and 8 ppm P (Olsen extraction). On October 17th 2010, we applied 70 lb. N acre^{-1} as urea and 55 lb. P_2O_5 as triple super phosphate or some fraction thereof, as described in Table 2. Starter fertilizer was not applied to any treatments. In strip tillage treatments, N fertilizer was applied with the strip tiller using urea and triple super phosphate at the same time strips were made. 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 before planting. Nine treatments comprised this experiment are as follows:
Treatments - (ST = Strip Till; CT = Conventional chisel plow tillage)

1. no P added check
2. recommended P rate fall broadcast
3. recommended P rate fall banded w/ ST
4. 20% less than recommended fall broadcast
5. 20% less than recommended fall banded w/ ST
6. 30% less than recommended fall broadcast
7. 30% less than recommended fall banded w/ ST
8. 40% less than recommended fall banded w/ ST
9. 50% less than recommended fall banded w/ ST

Individual treatment plots measured 11 feet wide and 30 feet long. Sugarbeet variety Crystal 658RR was planted in a smooth, moist, firm, seedbed on May 12, 2011 with a John Deere MaxEmerge 2 planter. Sugarbeet was placed 1.25 inches deep with a 5-inch in row spacing was used. 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 leafspot 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

Average root yields ranged from 11.1 t/a for the Strip Tillage Full P Rate (Treatment 3) to 17.0 t/a for the Conventional Tillage Full Broadcast P Rate (Treatment 2, Table 1). Although Treatment 2 produced the greatest root yields, the poor growing conditions in 2011 resulted in low yields, poor quality and great variability within treatments and, consequently, no statistically significant differences among treatments for root yield. In general, all treatments performed poorly and the high disease pressure and excessive soil moisture conditions (3.14, 5.17 and 5.91 inches of rainfall in May, June and July, respectively in 2011 at the study location) were clearly the limiting factors for root growth, not tillage or fertility. Still, strip tillage was clearly less favorable for sugarbeet root yield than conventional tillage. Strip tilled systems maintain higher levels of crop residue than conventional tillage, a benefit during dry years and an advantage for improving many soil quality parameters but detrimental for crop production during excessively wet growing seasons like 2011.

The Conventional Tillage Full Broadcast P Rate (Treatment 2) provided the highest root yield, lowest sugar loss to molasses (Slm%) and highest net sucrose, resulting in the highest recoverable sugar per acre (RSA) and per ton (RST), as well as the greatest revenue per acre (Gross Acre) and per ton (Gross Ton) (Table 1). Based on these results, it is obvious that conventional tillage with the full phosphorus recommended rate applied as a broadcast application provided the best results of the treatments tested in this study. As expected, the lowest N rate (50%lessStripped, Treatment 9) provided the lowest sugar content, RST, Gross Ton, and Gross Acre. Unexpectedly, the Strip Tillage Full P Rate provided lower root yield than any of the reduced P rate treatments, probably reflecting the extremely poor growing conditions and high variability in plant stand and root quality.

Conclusions

In contrast with the 2010 results, this study does not demonstrate that strip tillage provided a more effective means of delivering P fertilizer to sugarbeet in low-P soils. These results were strongly influenced by the poor growth environment of the 2011 year, which was characterized as excessively wet and favorable for extremely high Aphanomyces and Rhizoctonia root rot infection. More data should be collected under more normal growing conditions in order to make safe and accurate recommendations regarding P fertilizer application rates with strip tillage systems.

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Table 1. Phosphorus 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.

Trmt	Roots yield (Tons/a)	Gross Sucrose (%)	*Slm%	Net Sucrose (%)	RSA (lb/ac)	RST (lb/ton)	Tare%	Gross Ton ($/ton)	Gross Acre ($/acre)
CheckNoP	11.20	13.63	1.55	12.1	2820	242	1.88 ABC	36.05	437.20
Pbroadcast	17.00	14.50	1.36	13.2	4602	263	1.70 ABC	42.45	761.68
Pstriptilled	11.10	13.23	1.53	11.7	2764	234	1.95 AB	33.74	425.84
20%lessStripped	14.70	13.75	1.51	12.2	3845	245	1.13 BC	37.01	616.66
20%lessbroadcast	13.30	12.88	1.56	11.3	3385	226	0.95 C	31.50	532.48
30%lessStripped	15.70	13.65	1.44	12.2	4113	244	2.00 AB	36.87	660.23
40%lessBroadcast	14.40	13.48	1.55	11.9	3837	238	1.63 ABC	35.12	625.28
40%lessStripped	11.90	13.45	1.54	11.9	3047	238	2.20 A	35.06	481.41
50%lessStripped	11.60	12.60	1.55	11.0	2777	221	1.00 C	29.87	409.17
LSD (P<0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.93	n.s.	n.s.

*%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