EFFECT OF TILLAGE ON NITROGEN AVAILABILITY TO SUGAR BEETS

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INTRODUCTION

With the introduction of Roundup Ready® sugar beets in 2008, sugar beet growers in Idaho became interested in utilizing strip-tillage to potentially increase economic returns. The advantages associated with strip tillage over conventional tillage in sugar beet production are reduced soil compaction, soil erosion, weed pressure, and labor costs, while increasing total yields, sugar content, soil carbon concentrations, and overall soil quality. Growers are concerned that changing tillage practices will alter nitrogen mineralization dynamics in the soil. Sugar beets have very specific nitrogen needs, producing low yields if the overall available nitrogen is too low, and producing low sugar yields if the nitrate concentrations are too high late in the season. Tillage practices have the potential to impact residue decomposition. Conventional moldboard plowing increases the constant exposure of the residue to air, moisture, soil, and soil microbes, which could hasten the conversion of organic carbon to carbon dioxide. In strip tillage, crop residue is left on soil surface, decreasing the contact between soil and the residue, and therefore reducing decomposition rates compared to conventional tillage methods. Decomposition rates directly affect carbon and nitrogen ratios, which can affect nitrogen mineralization rates. Understanding the effect that tillage operations have on N mineralization will allow growers to develop efficient nutrient management plans specific to tillage operations.

The goal of this project is to determine the effect of tillage method and nitrogen rate on nitrogen available to sugar beets planted after a cereal crop.

MATERIALS AND METHODS

This study was performed in collaboration with a field study conducted by David Tarkalson and David Bjorneberg at the USDA-ARS station in Kimberly, Idaho. The experimental design of the field study consisted of three tillage methods (moldboard plow, chisel plow, and strip tillage), two tillage timings (fall and spring), four fertilizer N rates plus a control, and three replications. Fifteen soil samples from each plot were extracted from a depth of 12 inches one week after the only application of nitrogen fertilizer (urea) and composited. Soils from each plot were incubated at temperatures adjusted weekly to match the most recent four-year average temperature at an 8 inch soil depth for the ARS station in Kimberly. Samples were analyzed every three weeks for nitrate and ammonium concentrations to estimate nitrogen mineralization and immobilization in the soil. Soils were also analyzed for total carbon and nitrogen content through combustion. Plant available nitrogen in the soil was estimated by summing nitrate and ammonium concentrations.

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RESULTS AND DISCUSSION

Plant available nitrogen in the soil was estimated by summing nitrate and ammonium concentrations at the conclusion of the growing season in each of the soil bags (Table 1). Spring moldboard plowing immobilized a significant proportion of added fertilizer N at all N rates. Fall moldboard plowing significantly increased plant available nitrogen concentrations in comparison to spring mold plowing at the 0, 50, and 100 lb N/acre application rates. Tillage timing (fall vs. spring) had no significant effect on plant available N accumulation over a growing season for strip-till and chisel plowed soils, although there was a trend toward less available N at the 50 and 100 lb N/acre rate.

Table 1. Plant available nitrogen accumulated in a Portneuf silt loam after 5 months of incubation at temperatures adjusted weekly to reflect soil temperatures over a growing season in Kimberly, Idaho.

Tillage	Bedding	UAN application rate (lbs N/acre)				
		0	50	100	150	200
		----------lbs plant available N/acre----------				
Strip tillage	Fall	81.8 *ab*	124.4 *ab*	154.8 *ab*	161.2	171.2
	Spring	89.2 *ab*	94.0 *ab*	121.6 *abc*	186.4	200.0
Chisel Plow	Fall	71.8 *bc*	112.0 *ab*	162.8 *a*	146.4	159.2
	Spring	62.6 *c*	92.0 *b*	126.8 *abc*	148.4	172.0
Moldboard Plow	Fall	89.6 *a*	152.8 *a*	154.8 *ab*	186.4	234.8
	Spring	70.0 *bc*	83.6 *b*	88.0 *c*	119.2	112.8
P>0.05/LSD		*14.1*	*60.4*	*48.8*	*NS*	*NS*

Tillage timing also has a greater effect on soil carbon content than tillage, with a trend toward greater carbon content for spring than fall tilled soils (Figure 1). Fall moldboard plow treatment had significantly less carbon content than all of the spring tillage treatments, an apparent result of residue decomposition over the winter. It is likely that the lower carbon content in the fall moldboard plow treatment in comparison to the spring moldboard plow treatment allowed for increased nitrogen mineralization of the organic N from the residue and from soil organic matter.

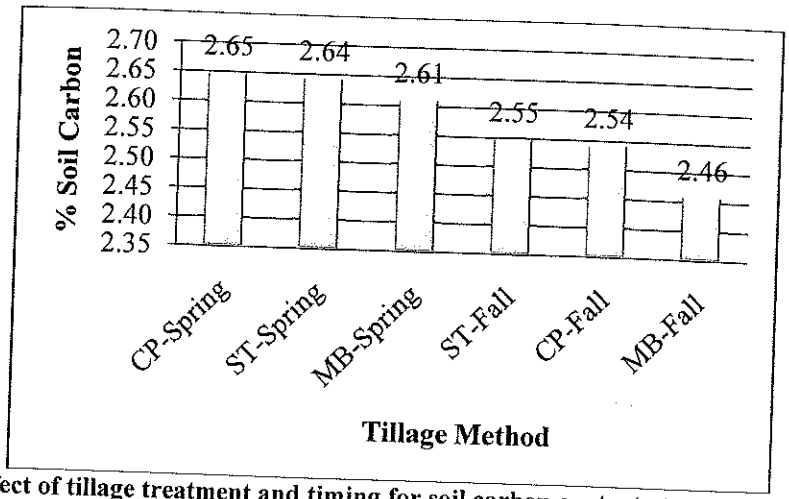

Figure 1. Effect of tillage treatment and timing for soil carbon content at a one-foot depth for a Portneuf silt loam at planting. CP = Chisel plow, ST = Strip-till, MB = Moldboard plow.

To evaluate the effect of fertilizer application on N release over time, control values for plant available N were subtracted from the total plant available N concentration for each N rate. This relationship is illustrated below for the 150 lb N/acre rate (Figure 3). The majority of N was released from fertilizer N one month after fertilizer application for all tillage methods and timings. There appears to be little evidence that fertilizer N is contributing to N mineralization spikes later in the season.

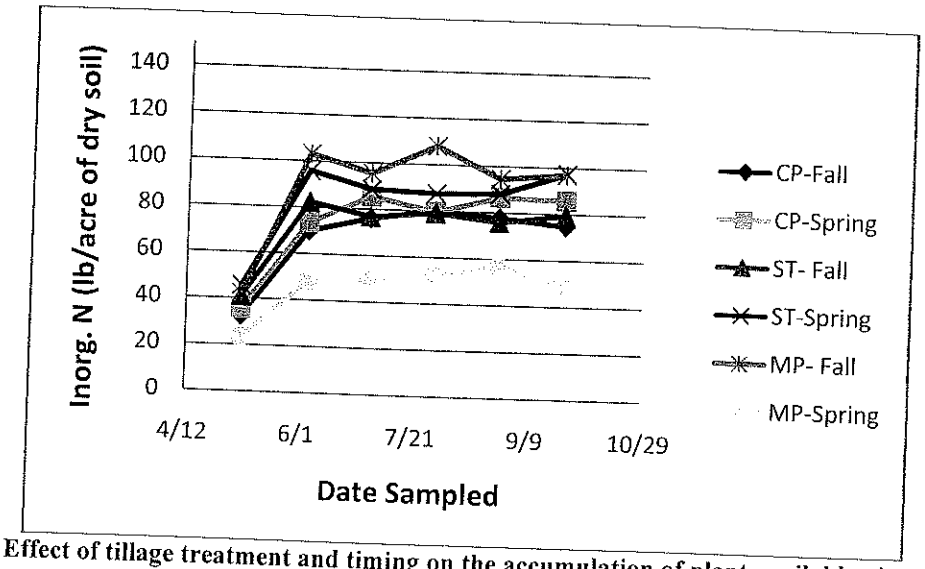

Figure 2. Effect of tillage treatment and timing on the accumulation of plant available nitrogen at the 150 lb N/acre application rate on a Portneuf silt loam, with control concentrations of plant available N subtracted. CP = Chisel plow, ST = Strip-till, MB = Moldboard plow.

The release of N for tillage treatments not receiving N fertilizer applications (controls) was relatively linear for all treatments from May to September, with the greatest amount of N released in August (Figure 3). Sugar content decreases and impurities increase in sugar beets when plant available nitrogen concentrations in the soil increase after early July in Southern Idaho. The continual release of N in July and August from soil organic

matter is a challenge to sugar beet growers, as soil organic matter content can only be adjusted slightly in most soils.

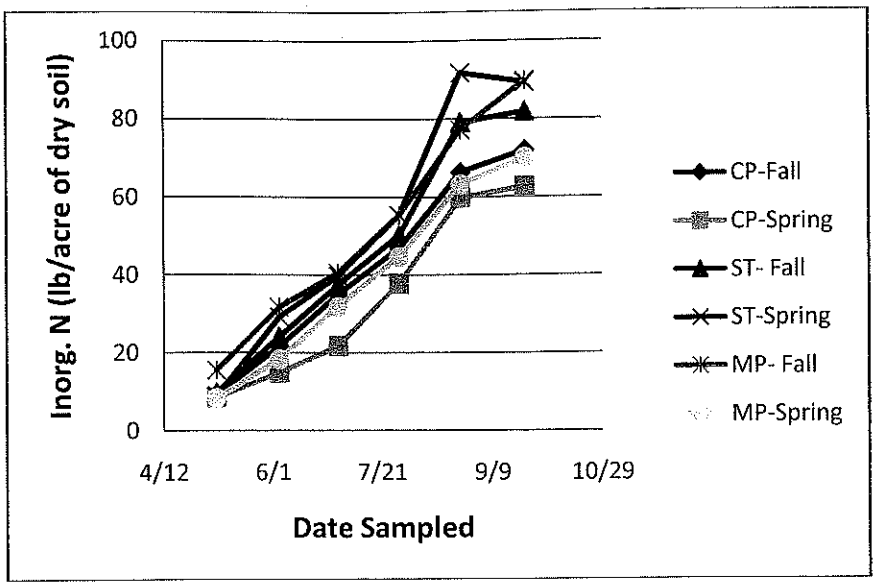

Figure 3. Effect of tillage treatment and timing on the accumulation of plant available nitrogen without the addition of nitrogen fertilizer. CP = Chisel plow, ST = Strip-till, MB = Moldboard plow.

CONCLUSION

In the first year of research, we found that spring moldboard plowing immobilized a significant proportion of fertilizer N over a growing season, which could severely lower yields and nitrogen use efficiency potential. Adversely, moldboard plowing in the fall significantly increased plant available N concentrations over spring plowing. Tillage timing (fall vs. spring) had no significant effect on plant available N accumulation over a growing season for strip-till and chisel plowed soils, indicating that growers working with these tillage practices may not have to account for tillage timing when estimating N availability. Carbon content appeared to have the greatest effect on N availability, with a trend toward greater carbon content with spring tillage treatments compared to fall tillage treatments.