EFFECT OF ROW ORIENTATION AND TILLAGE ON SUGARBEET YIELD AND QUALITY

I. AGRONOMIC ANALYSIS

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Introduction/Objectives

A primary concern among growers considering strip tillage is that cool and wet early season conditions may delay crop planting and slow seed germination and seedling emergence in high residue conditions, such as in strip tillage. In sugarbeet production, the effect of planting delays and/or poor early season physiological growth could reduce plant stand and diminish root tonnage or sugar concentration. Preliminary data from a strip tillage study conducted in 2007, suggested that row orientation (north-south vs. east-west orientations) can influence soil temperatures of strips near the seeding depth prior to planting. Most growers in the Red River Valley of ND and MN orient crop rows in a north-south direction. Some growers report that they have reduced wind damage as a result of the north-south row orientation. The row orientation effect on soil temperature was an unexpected discovery of the 2007 study, resulting from preliminary soil temperature and moisture measurements taken at the two study locations. At the Prosper location, strips were oriented north-south and at the Moorhead location, strips were oriented in the east-west direction. The unexpected results from the 2007 research indicated that in the east-west oriented field, soil temperatures were essentially the same for strip till and conventionally tilled treatments. In the north-south oriented location, however, soil temperatures were 5-8 degrees warmer in strip tilled plots relative to conventionally tilled plots. However, the results were confounded by the different soil types and field conditions potentially influencing soil temperature and moisture in the 2007 study.

To make confident assertions regarding the effect of row orientation, a study comparing row orientations was conducted at the Prosper Research Station in 2008. To allow comparison of early season soil temperature and moisture between strip tillage and conventionally tilled fields, a chisel plowed treatment with rows oriented in north-south and east-west directions was also included. According to anecdotal wisdom, it was expected that soil temperatures in strip tilled plots would be cooler than in conventionally tilled plots regardless of row orientation.

In order to better understand the effect of row orientation on factors such as moisture evaporation and early season soil temperatures, a research study was designed to examine soil temperature and moisture characteristics using high performance dual probe sensors made in the NDSU Soil Science Department according to the engineering design of the research scientists who pioneered the dual probe sensor technology. The field design of the study implemented two row orientations, north-south vs. east-west, in a strip tillage system and a conventional treatment of fall chisel plow and spring light cultivation. Strip tillage was tested with two strip tillage machines, which differed slightly in designs and modifications (denoted as strip tiller 1 and strip tiller 2). The major distinctions between the two machines were depth of tillage, shape of the tillage points on shanks, birm height produced by bedding disks, design and setting of residue cleaners, between-unit clearance affecting residue height, and form of N fertilization. Strip tiller 1 was set to till about 1 inch deeper than Strip tiller 2. Strip tiller 1 created a birm that was slightly higher than strip tiller 2. The residue cleaners on strip tiller 1 did not clear the row as cleanly as strip tiller 2, leaving more residue in the strip. Strip tiller 1 did not have as much clearance above residue as strip tiller 2, leaving inter-row residue more pressed down, whereas strip tiller 2 left residue standing upright. Strip Tiller 1 was capable of applying dry fertilizer and Strip Tiller 2 was capable of applying liquid fertilizer.

The objectives of this project were to determine if row orientation is related to soil warming and moisture content in early season fields under strip tillage and conventional tillage and to determine if observed early season differences affect final yield and quality in sugarbeet production.

This report focuses on the agronomic factors of sugarbeet growth and vigor throughout the season and harvested root yield and sugar quality.

Materials and Methods

The study was designed to compare two row orientation treatments (north-south versus east-west) and to compare between two strip tillage machines and a conventionally tilled check. Tillage treatments were denoted as 1) Strip Tiller 1, 2) Strip Tiller 2, and 3) Conventional Tillage.

The experiment was established in wheat residue chopped to about 7 inches high on a Beardon Perella silt loam (coarse-silty, frigid Aeric Calciaquoll) at a research site near Prosper, ND. Tillage treatments were established in late October 2007. Strips were applied in a single pass into wheat residue with each of the strip till machines. Conventional tillage was conducted by chisel plowing two times in the fall and cultivating lightly with a harrow in the spring. Soil nitrogen levels were adjusted to 130 lb N/a to a depth of 4 feet in the spring. Fertilizer was applied in the fall, applying 110 lb of N to all treatments. Nitrogen was applied as urea in the conventionally tilled treatments by surface broadcasting fertilizer and incorporating it. Nitrogen was applied as urea pellets with Strip Tiller 1 and as UAN with Strip Tiller 2. Soil test results indicated that P and K fertilization was not required.

The trial was planted into a smooth, moist, firm seedbed on May 6th, 2008. The experimental design selected was a randomized complete split plot with 4 replications. Individual treatment plots measured 11 feet wide and 30 feet long and contained 6 rows per plot with a spacing of 22-inches between row centers. Non-Roundup Ready Rhizomania-resistant variety, Beta 1305R, regular pellet was planted at 4 mph with a John Deere MaxEmerge II planter. Sugarbeet was placed 1.25 inches deep, and was planted to stand at a 5-inch in-row seed spacing. Counter insecticide was surface band-applied at 10.9 lbs/A at planting and incorporated with a drag chain. Four post emergence micro-rate herbicides, one cultivation in the conventional tillage treatments and hand labor was used as needed for weed control. Three fungicide applications, Eminent, Supertin/Topsin and Headline were applied for Cercospora leaf spot control.

The middle two rows were harvested for root yield determination and sugar quality evaluation on September 29, 2008. Yield determinations were made and quality analysis performed at the American Crystal Sugar Quality Lab, East Grand Forks, MN.

Results and Discussion

In 2008, this study was conducted at the Prosper research station. According to data from the NDAWN weather station installed on site, this location received 19.5 inches of rain from June through September. That precipitation value is 70% greater than the 5-year average for the same period (11.5 inches). This 4 month rainfall accumulation is within the range of the *yearly* precipitation value in an average year (often quoted as 18-22 inches for the Red River Valley region). Additionally, the site for this particular study was, unfortunately, located at a low end of the research station in an area that accumulates runoff water from other areas. Consequently, the study remained inundated with water much of the 2008 season. Concerns that saturated soil conditions may have adversely affected representative treatment plots prompted us to analyze all data for statistical outliers. No outliers were detected, however, so data reported is the complete data set[1].

The effects of row orientation and tillage on sugarbeet yield and quality parameters can be seen in Table 1. Root yields varied among treatments from 22.0 ton/a to 26.3 ton/a. There was no difference in root yield between chisel plowed and Strip Till 1 treatments. However, the root yields for Strip Till 2 were lower than for both chisel plow and Strip Till 1. It is possible that different N sources (urea versus UAN) resulted in more N lost as a result of high rainfall and consequent leaching and denitrification in the treatments fertilized with the Strip Till 2 strip tiller. If this is the case, then yield differences in this treatment were the result of fertilizer differences rather than differences in seed bed quality, water-holding capacity, or other physical factors directly related to the design of the strip till machines. Soil samples were taken on August 19th, after visual observations suggested that plants in Strip Till 2 treatment plots were N deficient. No differences in soil test N levels between tillage treatments were determined. It

[1] With the exception of one sample which was lost.

is still plausible, however, that soil N was lost through plant uptake in some plots or treatments and lost through denitrification in other plots or treatments. Differences in soil moisture, including standing water in some areas, was observed in this study, especially after intense rainfall events. These large wet areas remained for as long as a week in some cases, and was sufficient to create anaerobic conditions, which may have caused denitrification as well as sugarbeet stunting and death.

Row orientation did not significantly affect root yield when compared within any single tillage treatment. North-South oriented rows yielded non-significantly greater root yields in the chisel plowed and Strip Till 1 treatments. Sugar loss to molasses was significantly greater in the east-west oriented Strip Till 1 treatment. It is unclear why two of the four replicates for this treatment were so high (1.337 and 1.300); the third value was 1.124 and the fourth value was not available because the sample was lost. In general, greater impurities were extracted from the Strip Till 1 treatments, both north-south and east-west orientations. The reasons for this are unclear, as no field observations were made that would explain the greater impurities in these treatments. The results of net sugar followed gross sugar values and were not consistent among treatments. The final beet stand counts were also inconsistent and did not differ for row orientation within any single tillage treatment. Final stand values were non-significantly higher for chisel plowed compared to strip tilled treatments. When averaged over row orientation, the chisel plowed treatment averaged 152 plants/100 feet, Strip Till 1 averaged 140 plants/100 feet, and Strip Till 2 averaged 139 plants/100 feet. This can be contrasted with early establishment and stand counts in the spring. It is interesting to note that weather, and specifically soil moisture, played a strongly significant role in seedling emergence and establishment in the spring. Early in the spring, when the soil seedbed was dry, there was a clear germination advantage in strip tilled treatments, even though there was less soil moisture in the strip tilled seedbed. After June 3rd, however, when it began to rain and even created saturated conditions, the germination advantage reversed to favor the chisel plowed treatment, probably due to lower moisture content in the surface soil where seeds were planted. This advantage was still visible at the end of the season, even though it was not statistically significant. Gross revenue per ton (GRT) did not differ by row orientation within any tillage treatment. However, if row orientation values are combined within tillage treatment, there was a significant difference ($p = 0.0489$) between strip till machines. Strip Till 2 had a GRT (averaged over row orientation values) of $36.14/ton and Strip Till 2 had an average GRT of $33.33/ton. However, this small advantage washes out when the greater tonnage from Strip Till 2 is accounted for in the gross revenue per acre (GRA) calculation. In general GRA is greatest in north-south oriented rows. The low GRA value observed for Strip Till 1 East-West treatment ($714/a) is the result of low net sugar values, which resulted from the unexplained high loss to molasses value. The highest GRA was provided by the Strip Till 1 North-South treatment and is the result of the relatively high root yield (26.2 ton/a) and the high net sugar content (14.8%).

The agronomic data presented here does not provide evidence to strongly support or reject strip tillage as an alternative to conventional full-width sugarbeet tillage systems especially under excessively wet soil conditions. It should be remembered, however, that 2008 was an unusually wet year and strip tillage may have performed as well or better than conventional tillage under less extreme conditions. Additionally, in years when soil moisture is lacking, it seems likely based on this data that strip-tillage will out-perform conventional tillage.

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Table 1. Sugarbeet yields from 3 Tillage Treatments and 2 Row Orientations. 2008 Growing Season.

Tillage Treatment	**Row Orientation**	**Root Yield (Tons/a)**	**Gross Sugar (%)**	**%SLM (%)**	**Net Sugar (%)**	**RSA* (lb/a)**	**RST** (lb/ton)**	**Stand (Beets/100ft)**	**GRT† ($/Ton)**	**GRA‡ ($/a)**
CHISEL PLOW	N/S	26.3	15.6	1.0651	14.5	7665	291	142	33.9	895
CHISEL PLOW	E/W	24.8	15.9	1.0297	14.9	7375	298	161	35.6	881
STRIP TILL 1	N/S	26.2	15.9	1.0802	14.8	7767	296	134	35.2	924
STRIP TILL 1	E/W	23.1	15.2	1.2537	13.9	6439	279	145	31.0	714
STRIP TILL 2	N/S	22.0	16.1	0.9806	15.1	6652	302	148	36.7	810
STRIP TILL 2	E/W	22.5	15.9	0.9927	14.9	6692	297	130	35.5	800
LSD		3.67	0.4	.09649	0.40	1136	8	19.4	1.99	145

* Recoverable Sugar per Acre
** Recoverable Sugar per Ton
† Gross Return per Ton
‡ Gross Return per Acre