EFFECT OF CROP SEQUENCE FOR SUGARBEET PRODUCTION: FINAL REPORT

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Introduction

Corn and soybean acreage has increased in ND and MN during the past ten years. Some economists predict a dramatic growth of corn production with the onset of the ethanol industry in the Midwestern United States. In 2007, corn acreage increased by 47% from 2006. The increase in corn acreage contributed to a reduction in soybean acres in 2008. Fluctuating commodity prices and volatile oil and fertilizer prices make it difficult to predict the number of acres of corn and soybean that will be planted in coming years. Considering these factors and the introduction of improved short day corn varieties, it seems likely that sugarbeet growers will begin incorporating corn into their cropping rotation with increasing regularity. In recent years, sugarbeet growers increasingly report planting sugarbeet after soybean or corn. Growers have reported poor stands and lower yield for sugarbeet planted after corn. Other growers and researchers have reported differences in fertility, weed management, and net sugar measurements for sugarbeet following soybean. Farmers and researchers have expressed interest in the effect of crop sequence on sugarbeet crop yield and quality.

One concern involving crop sequence is the level of residual N remaining after the preceding crop and how it may affect the current year's beet sugar production. Disease issues and pesticide carry-over, weed management, crop-related phytotoxicity (allelopathic interactions), and water and nutrient use are all factors that should be considered when making cropping rotation decisions.

This is the first study (to the best of our knowledge) that examines crop sequence effect in the same field location throughout the full rotation. It is currently unknown how management of crops like soybean and corn, which have not traditionally preceded sugarbeet in a rotation (at least in the Red River Valley), may affect growth, sugar level, disease concerns, and/or weed management needs for sugarbeet. **The objective of this study is to evaluate the effect of corn, soybean, and wheat as preceding crops on yield and sugar quality in a sugarbeet cropping system.**

Materials and Methods

This study was established in spring 2006 at the Prosper research station to examine the rotation sequence effect of corn, soybean, and wheat on sugarbeet yield and quality. The previous year, 2005, the study area had been used for wheat production. Corn and soybean are crops that have not traditionally preceded sugarbeet in the Red River Valley. Wheat is a treatment included as a standard of comparison since it has been more commonly used as a crop preceding sugarbeet in this area.

The study is designed as a completely randomized block experiment and replicated four times. The experiment consists of six combinations of the four crops:
1) Corn/Soybean/Sugarbeet
2) Soybean/Corn/Sugarbeet
3) Wheat/Corn/Sugarbeet
4) Wheat/Soybean/Sugarbeet
5) Corn/Wheat/Sugarbeet
6) Soybean/Wheat/Sugarbeet

Treatment plots are separated by an eleven foot buffer to minimize risk of drift damage from neighboring treatments. Plots are 30 feet long and six rows wide and all crops are seeded using a 22-inch row spacing. Weed control, disease management, and other cultural needs are assessed individually for each crop and managed according to NDSU Extension guidelines. Soil samples were taken in fall and the study was fertilized each fall or spring by hand-broadcasting and incorporating urea pellets based on NDSU Extension fertility recommendations for each crop. No nitrogen credit was given for soybean or sugarbeet residues. Soil sample results indicated that no phosphorus or potassium fertilizers were needed. Periodic vigor and stand ratings are made throughout the season to evaluate potential allelopathic, weed, disease, or chemical effects resulting from management of previous crop.

In 2006, the study was initially established by planting each of the four replications to a single crop (sugarbeet, soybean, corn, or wheat). Each sequential year, additional crops were introduced and randomly placed in the replications to allow for determination of the effect of the preceding crop and also allow for each crop to be planted in each of the four growing seasons. In 2009, the study was planted on May 21st and 22nd, with Roundup Ready sugarbeet variety Hilleshog 4012RR, soybean variety 07008RR from Petersen Seed (165,000 seeds/a), corn variety Pioneer stacked (39D85-NM08 at 33,500 seeds/a), and wheat variety Alsen (80 lbs/a). Sugarbeet was planted at three-inch row spacing and later hand thinned to 5.5 inch. Wheat, soybean, corn, and sugarbeet were harvested on August 26th, September 25th, October 27th, and September 27th, 2009 respectively.

Results and Discussion

Review of previous years' results: In 2007, sugarbeet tonnage was lower for beet following wheat. This may have been due to greater weed pressure in a corner of the field where these plots were located. As a result of lower tonnage following wheat, recoverable sugar per acre was greater for beet following corn or beans than for beet following wheat. Data analysis revealed that the following sugarbeet parameters did not change as a result of the preceding crop in this study: beets per 100 ft of row, net sugar, recoverable sugar per ton, gross profit per ton, and gross profit per acre. Sugarbeet after corn resulted in the highest (although non-significant) sugarbeet yield and recoverable sugar per acre.

In 2008, sugarbeet yielded non-statistically greater root yield when grown after wheat than any other crop. However, the difference in root yield between wheat, soybean, and corn was fairly small, about 2 tons/a, and did not indicate that soybean or corn resulted in lower sugarbeet root yield. The most notable treatment effect in 2008, although not statistically significant, was a sharp increase in sugar loss to molasses (slm) when sugarbeet was grown after soybean. Sugar loss to molasses was about 25% greater following soybean than following either wheat or corn. The reason this is not a significant difference is related to the low replication of this treatment. Greater loss to molasses following soybean production is most likely the result of nitrogen being released from soybean residues late in the growing season, creating an excess of N which is converted into protein and results in the sugarbeet root allocating resources to the production of protein rather than sugar. Perhaps if an N credit had been allocated to the sugarbeet fertilization rate following soybean treatment, then less slm would have occurred.

Results of all years' data combined: Six crop sequence combinations conducted over two full three-year rotations (2006-2007-2008 and 2007-2008-2009) can be analyzed from this study. Table 1 displays the average sugarbeet yield and sugar quality measurements at the completion of the two full rotations for all crop combinations ending in sugarbeet. Large growing season differences between years resulted in high variability between years and replications. The high seasonal variability coupled with subtle treatment effects resulted in no measureable differences for any sugarbeet yield or quality parameter as a result of the full three-year rotation. Essentially, this means that there was no three-year rotation sequence that consistently proved superior to any other sequence. Unfortunately, and despite thinning efforts every spring, sugarbeet stand at harvest did vary significantly between treatments in one instance (Corn-Soybean-Sugar and Wheat-Corn-Sugar). The differences in stand were accounted for in the statistical analysis by including stand count as a covariate with the treatment effect. Based on our observations, it is most likely that final plant stand differences are the result of inconsistent thinning, weed pressure, and disease rather than a direct result of the preceding crop's residue or allelopathic interactions. Sugarbeet seedling emergence was good in all years and for all treatments and seemed most directly related to moisture and seedbed preparation conditions. Stand counts taken each year indicated that there were no significant differences in seedling emergence due to previous crop interactions.

We narrowed our analysis to examine just the effect of the preceding crop (soybean, corn, and wheat) on sugarbeet yield and sugar quality (Table 2). With this analysis, the variability of final plant stand is reduced over treatments and becomes non-significant. However, we maintained the value BEETS/100' as a covariable in the statistical analysis to account for differences in treatment effects that resulted from plant stand. When data from three growing seasons is combined, differences in root yield as a result of preceding crop were minor and statistically non-significant; yield values differed by less than one ton per acre as a result of preceding crop. None of the sugar-related parameters (gross sugar, sugar loss to molasses, or net sugar) were significantly different as a result of preceding crop. The sugar-related parameters were very similar regardless of the preceding crop. Since yield and sugar parameters were not affected by preceding crop, it is not surprising that recoverable sugar per acre or per ton were likewise unaffected by preceding crop. The highest yielding RSA resulted from soybean as a preceding crop and the lowest resulted from corn as a preceding crop; wheat was intermediate. The difference between the highest and lowest values was 271 lb sugar per acre, about 3% difference.

Overall, this data indicates that over a full three-year crop rotation, the sequence of crops will have relatively little effect on the yield and sugar quality of the sugarbeet crop. In individual years, differences in sugarbeet yield and sugar quality may be observed as a result of the preceding crop. An example of this might occur when moisture is limiting in spring following sugarbeet planting. Under such conditions, a sugarbeet crop planted following wheat would be expected to display better germination and emergence than one following a later harvested crop like corn or soybean because the wheat field would collect moisture following the wheat harvest which would provide greater moisture the following spring to sugarbeet seedlings. In the absence of specific production-related problems, such as moisture limitation, weed control, and nitrogen mineralization, we conclude that there is no measurable advantage to any of the crop sequences tested in this study.

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Table 1. Yield and quality data for three sugarbeet rotations following the full rotation (ending in sugarbeet); values are averages of two years (2008 and 2009). LSD values indicate least significant difference for P<0.1. If LSD is recorded as *NS*, then no treatment differences were significant.

ROTATION	*YIELD*	*SUGAR*	*SLM*	*NET SUGAR*	*RSA*	*RST*	*BEETS/100'*
C-SOY-SUG	33.3	15.08	1.2779	13.80	9110	275.75	232
SOY-C-SUG	29.9	15.48	1.1715	14.30	8658	286.05	209
W-C-SUG	30.0	14.22	1.3784	12.85	7694	256.66	182
W-SOY-SUG	29.8	15.27	1.2544	14.05	8358	280.31	203
C-W-SUG	31.6	15.18	1.1783	14.00	8854	280.11	207
SOY-W-SUG	32.5	15.16	1.2470	13.90	9084	278.38	200
LSD (P<0.10)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**50**

Table 2. Effect of preceding crop on sugarbeet yield and quality parameters; BEETS/100 is included as a covariate; values are means of 3 years. Yield (ton/a); Net sugar (% sucrose); RSA = Recoverable Sugar per Acre (lb/a); RST = Recoverable Sugar per Ton (lb/ton); Beet/100' = # beets per 100 feet of row. LSD values indicate least significant difference for P<0.1. If LSD is recorded as *NS*, then no treatment differences were significant.

PRECEDING CROP	*YIELD*	*SUGAR*	*SLM*	*NET SUGAR*	*RSA*	*RST*	BEETS/100'
Beet after Soy	31.8	15.60	1.2333	14.37	9096	287.30	203
Beet After Corn	31.1	15.36	1.2533	14.11	8825	282.13	191
Beet After Wheat	31.4	15.63	1.2238	14.41	9054	288.12	190
LSD (P<0.10)	**NS**	**NS**	**NS**	**NS**	**N/A**	**NS**	**NS**