CROP SEQUENCE EFFECT IN SUGARBEET, SOYBEAN, CORN, AND WHEAT ROTATIONS

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Introduction

Based on information from the American Crystal Sugar database of sugarbeet cropping systems averaged over years 2003-2007, wheat preceded sugarbeet in the crop rotation on 1.75 million acres and barley was the preceding crop for 96,000 acres. Of all the preceding crops represented in the database, wheat and barley accounted for 83% of the total acreage. The only crop that rivals these two as a preceding crop for sugarbeet is beans, which is planted on 131,000 acres. However, further examination of American Crystal Sugar's database of crop acreages reveals that soybean acreage has seen a marked increase among sugarbeet growers since 2003. In 2003, soybean acreage was slightly less than 6,000 acres (as the previous crop to sugarbeet) among American Crystal Sugar's sugarbeet growers. By 2006, that value increased 2.6 times to 15,400 acres and from 2006 to 2007 it more than doubled again to 33,300 acres. A dramatic increase in corn acreage in 2008 contributed to a reduction in soybean acres to 20,400 acres that year. 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 2009. Corn prices will affect the acreages of other crops including soybean and wheat in the Northern Great Plains. 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. Each year greater numbers of sugarbeet growers report planting sugarbeet after soybean or corn. Growers have reported poor stands and lower yield for sugarbeet planted after corn.

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. A frequently overlooked consideration for cropping sequence decisions is the role of beneficial soil organisms. Sugarbeet is one of only a few crops that do not host beneficial fungi called arbuscular mycorrhizae. The fungi assist many crops, including corn, soybean, and (to a lesser extent) wheat with nitrogen, phosphorus and water uptake. Crops following sugarbeet are more likely to suffer from nutrient deficiencies or be less resistant to drought stress as a result of lower colonization of beneficial mycorrhizal fungi in soils. Corn is a crop that is considered highly dependent upon mycorrhizal fungi, and therefore may suffer as a result of reduced fungal colonization in fields following sugarbeet production. Although we are not aware of studies specifically documenting reduction of arbuscular mycorrhizal fungi (AM fungi) in sugarbeet systems, studies have documented that soybean plants planted after Brassica crops, which also do not host AM fungi, display a lower rate of AM fungal associations within the root of the soybean (Hill, 2006).

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 and soybean 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 sequence combinations of the four crops:
1) wheat/corn/soybean/sugarbeet
2) wheat/corn/sugarbeet/soybean
3) wheat/soybean/corn/sugarbeet
4) wheat/soybean/sugarbeet/corn
5) wheat/sugarbeet/soybean/corn
6) wheat/sugarbeet/corn/soybean

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 with 22 inches between row centers. 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 2007 and crops were fertilized in fall 2007 by hand-broadcasting and incorporating urea pellets based on NDSU Extension fertility recommendations. 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 were 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 so that each of the four replications was individually planted to one of the four crops. Each sequential year, additional crops are 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. The study was planted on May 6th, 2008, with non-Roundup Ready sugarbeet variety Crystal R434, soybean variety 07008RR from Petersen Seed (165,000 seeds/a), corn variety Pioneer stacked (39D85-NM08, 32,000 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. Based on the high stand counts taken at harvest, it appears that sugarbeets should have been thinned more carefully. Wheat, soybean, corn, and sugarbeet were harvested on August 13th, September 28th, October 22nd, and September 29th, respectively.

Results and Discussion

In 2008, each of the four crops in the rotation (sugarbeet, soybeans, corn, wheat) was planted into land that had been previously planted to each of the other three crops in 2007. For example, there were three sugarbeet treatments in 2008: sugarbeet planted where soybean was grown in 2007; sugarbeet planted where corn was grown in 2007; and sugarbeet planted where wheat was grown in 2007. We describe this more efficiently by referring to the preceding crop, which was the crop planted in 2007. Each of the 12 crop/previous crop combinations was replicated two times in 2008. Average crop yields are presented in Table 1.

The concern that soybean and corn may perform poorly following sugarbeet due to reduced mycorrhizal colonies in the soil following sugarbeet was not confirmed by the data. Soybean yielded statistically the same following sugarbeet as following corn and both of these previous crops produced statistically greater yields than soybean following wheat. Similarly, corn following sugarbeet produced yields that were statistically the same as soybean and wheat following corn. Corn grown after sugarbeet even produced a non-significantly greater yield than any other treatment. We suggest that the narrow carbon to nitrogen ratio of sugarbeet tops may have made a readily-available nitrogen source for the corn plant at a critical time, perhaps between tasseling and grain fill, where other residues did not decompose to release as much N for corn uptake at that time. Mycorrhizae provide a more noticeable and quantifiable advantage to crop plants under conditions of nutrient or drought stress, so it may be unreasonable to expect to see an effect from reduced mycorrhizal colonization of soybean or corn following sugarbeet in a year when rainfall was adequate and soil nutrient status was sufficient, as in 2008.

It is interesting to note that both soybean and corn produced lowest yields in the treatments with wheat as a preceding crop. Observation of these plots in mid-June indicated that there were more grass weeds in plots where wheat was planted in 2007. We propose that grass seeds dispersed in fall 2007 found a good environment in the recently harvested wheat plots and the spring tillage and cultivation activities of 2008 provided access to soil and moisture, creating a grass control problem in 2008 in those plots where wheat was grown in 2007. Another possible explanation for the relatively poorer growth observed in corn and soybean crops planted where wheat was grown in 2007 is that the soil contained more moisture in those plots and may have created conditions where roots were

waterlogged and nitrogen was denitrified. Moisture measurements were not taken in these treatments, but it is generally accepted that short-season crops, like wheat, allow more soil water to accumulate for the following year than when longer-season crops, like corn, soybeans, or sugarbeet, are grown. The excessive amount of precipitation received in 2008 may have created anaerobic conditions for a period of days in these treatments and if the 2007 wheat plots already had a soil moisture surplus, the water-logged conditions in those plots would be expected to occur sooner and perhaps last longer than in plots planted to some other crop in 2007.

In contrast to corn and soybean, sugarbeet actually produced non-statistically greater root yield following wheat than after any other crop. Since wheat is still, by far, the most common crop preceding sugarbeet in the Red River Valley, these results were encouraging and indicate that wheat is a good preceding crop for sugarbeet production. 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. Table 2 gives more detailed information about sugarbeet sugar production as a result of preceding crops. The most notable treatment effect, although not statistically significant, was a sharp increase in sugar loss to molasses (slm) when sugarbeet was planted 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. Further studies might be considered to investigate whether N credits to soybean would affect recoverable sugar content of sugarbeets. In conclusion, it does not appear that corn or soybean as preceding crops have negative effects on sugarbeet root yield; however, data do suggest that planting sugarbeet in fields where soybean was planted the previous season may result in increased impurities and reduced recoverable sugar.

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References

Hill, Julie. 2006. Inhibition of Vesicular-Arbuscular Mycorrhizae on Soybean Roots following Brassica Cover Crop. J. of Nat. Resour. Life Sci. Educ. 35: 158-160.

Table 1. Yields of crops following other crops in rotation sequence. Because there were significant differences among yield values for all crops, LSD values were determined by individually analyzing each crop, treating the preceding crop as the treatment effect.
LSD values indicate least significant difference for P<0.1. If LSD is recorded as *NS*, then no treatment differences were significant.

Crop	Preceding Crop	Average Yield
Soybean	Beet	47.4 bu/a
Soybean	Corn	51.6 bu/a
Soybean	Wheat	34.6 bu/a
LSD		**11.4**
Corn	Beet	208 bu/a
Corn	Soybean	195 bu/a
Corn	Wheat	169 bu/a
LSD		**NS**
Wheat	Beet	66.0 bu/a
Wheat	Soybean	82.1bu/a
Wheat	Corn	36.0 bu/a
LSD		**37.9**
Beet	Corn	31.30 ton/a
Beet	Wheat	33.45 ton/a
Beet	Soybean	33.25 ton/a
LSD		**NS**

Table 2. Sugarbeet sugar and quality parameters. Values are means averaged across reps. 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; Gross Ton = Gross profit ($/Ton beet); Gross Acre = Gross Profit ($/acre).
LSD values indicate least significant difference for P<0.1. If LSD is recorded as *NS*, then no treatment differences were significant.

Treatment	Gross Sugar	slm	Net Sugar	Beet/100'	RSA	RST	Gross Ton	Gross Acre
Beet after Corn	15.76	1.2049	14.55	237	9165	291	37.40	1183.26
Beet After Wheat	15.60	1.1953	14.40	256	9640	288	36.68	1227.57
Beet After Soy	14.05	1.5074	12.54	244	8328	251	27.46	909.75
LSD	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**