SOIL MANAGEMENT FOR SUGARBEET PRODUCTION

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INTRODUCTION

Wind/water erosion are responsible for significant soil loss in the Red River Valley of North Dakota and Minnesota. Intensive tillage operations in the fall and spring accelerate the soil erosion processes particularly during early spring (prior to stand establishment) and after harvest. Fields with crops having minimum residue cover like sugarbeet, soybean, after harvest are particularly prone to erosion. During 2021 growing season, on-farm field experiments were conducted to determine the influence of three promising soil conservation practices, (i) stale seedbed, (ii) fall-seeded cover crop (interaction with nitrogen fertilizer application time), and (iii) interseeded cover crop on sugarbeet yield and quality parameters.

Stale seedbeds receive primary tillage in the fall but sugarbeet are planted in the spring without any additional tillage. Spring tillage operation may cause significant loss of soil moisture and stand emergence can be adversely affected due to the dry spell after planting. Moreover, hard rains after a spring tillage can create significant crusting on the soil surface for clay, clay loam and silt loam soils. Eliminating tillage operations will also save money on fuel and machinery. The objective of this study was to investigate the effect of eliminating spring tillage in sugarbeet production system.

Cover crops have potential to improve soil health and nutrient use efficiency through reducing erosion and nutrient losses. Moreover, legumes as cover crops can add atmospheric N_2 through symbiotic fixation. Fall seeded cover crops are most common, planted in fall and terminated following year before planting. Another option is to interseed cover crops in sugarbeets at mid- or late-growing season, in between the application of herbicide (glyphosate) and canopy closure. Selection of cover crop species and planting time are critical to optimize the benefits from cover crops. In the Red River Valley of ND and MN, some growers apply fertilizer-N in fall, but this may lead to significant loss of N through leaching during snowmelt in early spring. Cover crops can protect fertilizer N by reducing leaching loss. Interaction between fertilizer N application time (fall vs. spring) and cover crop species may improve the sugarbeet N use efficiency. Three trials, (i) stale seedbed, (ii) fall-seeded cover crops and N management, and (iii) interseeding cover crops, were conducted to achieve the goal of soil conservation under sugar beet production system, during 2021 growing season.

METHODS

Trials were conducted at Ada, MN (47.3198, -96.3856). Initial soil properties are presented in Table 1. Soils are very deep, formed in silty glacial lacustrine sediments and delta sediments on glacial lake plains (Coarse-silty, mixed, superactive, frigid Aeric Calciaquolls). Previous crop was spring wheat. Each plot measured 11 feet wide and 30 feet long, and 22 inches row spacing (six rows). Initial soil sample was collected on Sept. 1, 2020 and recommended N, P, and K were applied in the form of urea, MAP and MOP, respectively. During 2021 growing season, early spring was extremely dry and stand establishment was poor (Fig.1). A glyphosate tolerant cultivar was planted at 63,000 plants per acre at 4.5 inches spacing using John Deere planter for all three trials on April 29. Three applications of glyphosate were applied for weed control and recommended fungicides were applied to control Cercospora leafspot. The two-middle rows of the 6-row were harvested on September 29, 2021. Plots were mechanically defoliated, and a scale mounted harvester was used to dig and weigh the sugar beetroots from the center two rows of each plot. A sub-sample of 15-20 sugar beetroots were analyzed to determine sucrose concentration and recoverable sucrose at American Crystal Sugar Quality Tare Lab, East Grand Forks, MN.

Table 1. Initial soil properties of experimental site located at Ada, MN

Depth	Organic matter%	Soil pH	CEC meq/kg	EC dS/m	Nitrogen (lb/ac)	Olsen-Phosphorus (ppm)	Potassium (ppm)	Sulfur (lb/ac)	Fertilizer N (lb/ac)	P_2O_5 (lb/ac)	K_2O (lb/ac)
0-6”	2.1	8.4	25.2	0.15	6.4	6	50	32	120	55	90
6-24”		8.5		0.13	3.5			78			

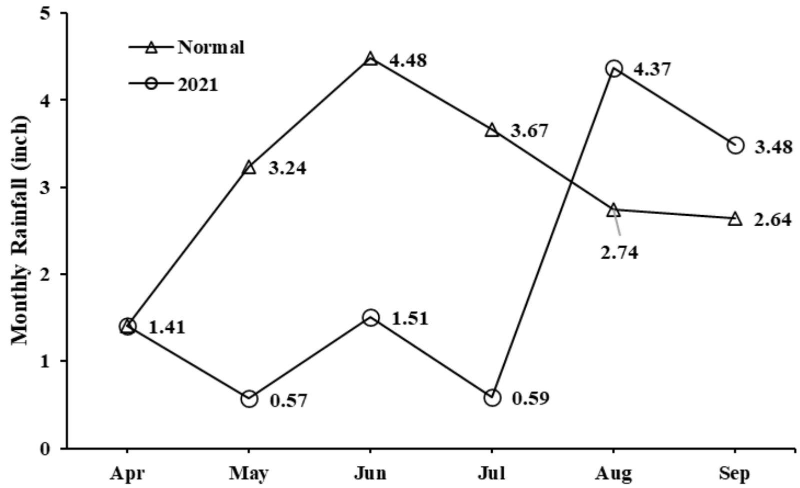

Figure. 1. Monthly rainfall distribution during growing season in comparison to normal (Source: NDAWN)

For the stale seedbed trial, three treatments were (i) conventional (fall and spring tillage), (ii) trash wheels in the down position at planter (Stale- TW down), and (iii) trash wheels in up position at planter (Stale- TW up), laid out in strip with four replicates. The stale seedbed treatments were planted directly into last year's fall tillage (2020). The field had been tilled only once last fall. Typically, when planting into stale seedbed, the field would have been worked once in the fall soon after combining the wheat, and then fertilized and tilled again in mid- to late-October in preparation for planting directly into the seedbed in the spring. Recommended fertilizers were applied on the soil surface prior to planting. Seedbed was uneven at planting because of only being worked once last fall. Also, there was a large amount of wheat straw residue on the soil surface, and conditions at planting were extremely dry leading to poor or uneven germination across the plots. Conventional treatment was fertilized and incorporated into the soil with a field cultivator prior to planting. Therefore, perhaps there was less loss of fertilizer on the conventional treatments than the stale seedbed treatments. Because we tilled the conventional treatments, we may have dried out the soil losing moisture and affecting the germination. Weather conditions at planting of the stale seedbed was hot, dry, and windy.

For the fall seeded cover crop trial, three cover crop treatments, (i) control (no cover crop), (ii) winter wheat, and (iii) cereal rye, and three fertilizer-nitrogen (N) application time treatments, (i) 100% of recommended N in fall, (ii) 100% of recommended N in spring, and (iii) 50% of recommended N in fall and rest 50% in spring before planting, were laid out in factorial randomized block design with four replicates. On Sept. 4, cover crop seeds, cereal rye (ND Dylan) and winter wheat (Jerry) at the rate of 40 lb/ac, were broadcasted; and on the same day, fall fertilizer N treatments were also broadcasted. In spring, cover crop biomass production was determined by clipping biomass within 2 ft by 2 ft quadrat per plot on April 22 and glyphosate was applied to terminate cover crops. Cover crop biomass was dried at 130°F and weighed. Dried biomass was ground using a Wiley mill and analyzed for total N. Cover crop tissue samples were digested with H_2SO_4-salicylic acid and N was analyzed using Kjeldahl distillation method. Biomass N uptake was determined by multiplying biomass with tissue N concentration. For all plots, soil samples within 0-6" depth were collected in fall (Oct 13, 2020), spring (Apr. 21, 2021) and at harvest (Sep. 9, 2021) to determine inorganic N availability.

For cover crop interseeding trial, recommended fertilizers were broadcasted and incorporated, and sugar beet was planted like other trials. On June 22nd, cover crops were interseeded only for middle two rows used for harvesting. Cereal rye (ND Dylan), winter wheat (Jerry) and pea (Austrian)were planted at the rate of 20 lb/ac, brown mustard (Kodiak) and brown flax (CDC Neela, Meridian Seeds) were planted at 10 lb/ac and winter camelina (Joelle) was planted at 6 lb/ac. Cover crop seeds were seeded using a V-shaped hoe with two blades 6-inch apart to make a parallel furrow to simulate planting with a commercial interseeder. The furrows were half-inch deep and centered in each of sugarbeet rows. Cover crop seeds were distributed evenly into the furrows by hand; furrows were then covered with soil. Due to dry condition, cover crop growth was sporadic and not enough for biomass determination.

Sugarbeet root yield and quality parameters, and soil N availability were analyzed using the general linear model (GLM) of the Statistical Analysis System 9.4 (SAS Inc., Cary, NC). Probabilities equal to or less than 0.05 were considered significant for main and interaction effects. The least significant differences (LSD) test was used to separate difference between treatment means if analysis of variance indicated the presence of such differences.

RESULTS AND DISCUSSION

Experiment l. Effect of different stale seedbed preparation on sugar beet production

Eliminating spring tillage had no negative effect on stand germination, yield, and quality parameters (Table 2). Stand count at harvest data showed variations across replicates for all three treatments. Conventional tillage practice had the highest root yield, but stale seedbed with trash-wheel up had the highest sugar and lowest sugar loss to molasses.

Table 2. Influence of stale seedbed preparation on stand count (per 100 ft) at harvest, root yield and quality parameters at Ada, MN during 2021 growing season. *Values in bracket indicate standard deviation

Treatments	Stand count	Yield (ton/ac)	Sugar%	SLM%
Conventional	148(16)	31.2(3.9*)	17.1(0.6)	1.26(0.2)
Stale-TW down	154(15)	29.4(4.8)	16.9(0.8)	1.26(0.1)
Stale-TW up	149(20)	29.8 (4.4)	17.2(0.7)	1.18(0.2)
P<0.05	NS	NS	NS	NS

SLM: Sugar loss to molasses

Experiment 2. Effect fall-seeded cover crops and fertilizer nitrogen (N) application time on sugar beet production

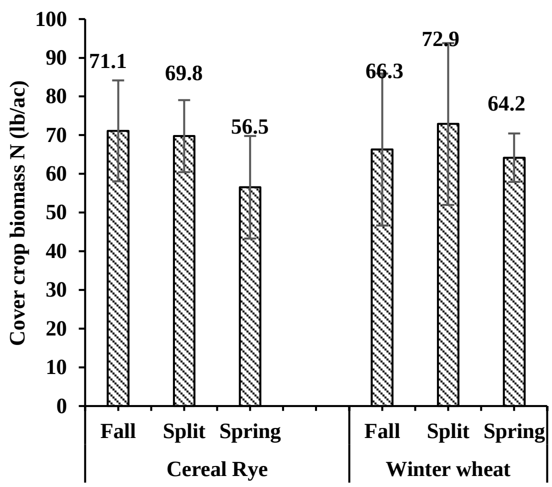

Figure 2. Cover crop biomass nitrogen (lb N/ac) in response to cover crop species and fertilizer nitrogen application timing. Means were not significant at 95% level.

Table 3. Effect of two fall-seeded cover crops (CC) and fertilizer-nitrogen application time (Time) on sugarbeet yield (tons/ac) and quality parameters at Ada, MN during 2021 growing season.

Factors	Root yield (ton ac^{-1})	Sugar (%)	SLM (%)
CC			
Control	23.6	13.4	1.53^{A}
Cereal Rye	20.9	14.3	1.39^{B}
Winter wheat	25.9	13.9	1.49^{AB}
Time			
Fall	23.8	14.0	1.42^{B}
Spring	21.9	13.4	1.55^{A}
Split	24.7	14.3	1.44^{B}
Coeff. Var.	20.9	6.97	8.62
CC	0.05	0.07	0.04
Time	0.39	0.11	0.02
CC×Time	0.85	0.41	0.45

SLM: Sugar loss to molasses

Selection of cereal rye and winter wheat and fertilizer N application time had no effect (*P*<0.05) on the N removal in cover crop biomass (Fig. 2). However, for both cover crops, lower biomass N for spring applied fertilizer treatment compared with fall and split application indicated that a portion of fertilizer-N applied in fall was taken up by cover crop biomass. The reduction in biomass N removal was higher for rye than wheat (although differences were not significant).

Influence of cover crop and fertilizer-N application time interactions on sugarbeet root yield, sugar concentration and sugar loss to molasses percent (SLM) was presented in Table 3. Cover crop and fertilizer N timing did not affect root yield and sugar concentration. Cover crop selection and fertilizer N timing both had significant effect on SLM percent. Control (without cover crop) had the highest impurities or SLM and significantly higher than plots under cereal rye, but similar to winter wheat. These results suggest that cereal rye has potential to reduce SLM concentration by removing the excess soil N available during root development. Cereal rye removed more soil N than winter wheat.

Table 4. Effect of Fall seeded cover crops (CC) and nitrogen application time (Time) on soil nitrate (ppm) availability within 0-6" soil depth during Fall 20 (Oct. 13, 2020), Spring 21 (Apr.21, 2021) and Fall 21 (Sep. 9, 2021)

Factors	Fall 20	Spring 21	Fall 21
CC	Inorganic N (ppm)		
Control	19.7	27.8^{A}	5.33
Cereal Rye	23.2	3.08^{C}	5.46
Winter wheat	21.7	13.6^{B}	4.75
Time			
Fall	39.0^{A}	24.2^{A}	5.17
Spring	6.54^{B}	6.58^{C}	5.58
Split	19.0^{B}	13.7^{B}	4.79
Coeff. Var.	78.7	41.1	39.2
CC	0.88	<0.01	0.66
Time	0.01	<0.01	0.64
CC×Time	0.78	0.01	0.53

Cover crop had significant effect on soil inorganic N concentration only in spring 2021, before planting sugarbeet. Control soils had the highest soil available N than both cover crop treatments. Winter wheat had higher soil available N than cereal rye. Fertilizer N application timing had significant effect on surface soil inorganic N concentration in fall of 2020 and spring 2021. At both sampling time, fall N application had the highest soil available N, followed by split N application treatment; the lowest soil available N was observed under spring N application. From September 2 (fertilizer N applied) to October 13 (soil sampled for inorganic N) of 2020, fall application of fertilizer-N increased inorganic N concentration because mineralization does not cease until soil temperature drop below 50˚F. Cover crop and fertilizer N application timing did not influence the residual soil N sampled after harvest during fall of 2021.
Cover crop particularly cereal rye has potential to reduce the loss of fall applied N. Cereal rye also can improve sugar recovery by removing the excess N availability without a significant (P<0.05) effect on root yield and sugar concentration. Spring applied N can increase the SLM% particularly when sugar beet plant growth suffers due to the hot and dry condition.

Experiment 3. Effect of cover crop interseeding on sugarbeet production

Table 5. Effect of cover crop interseeding on sugarbeet yield and quality and soil available nitrogen within 0-6" depth at harvest

Cover crop species	Root yield (tons/ac)	Sugar%	SLM%	Soil NO_3 (ppm)
No cover crop	20.9(3.9)	13.9(0.4)	1.42(0.1)	5.00(1.2)
Camelina	19.8(2.6)	13.4(0.4)	1.61(0.2)	4.75(0.9)
Mustard	22.5(7.8)	14.0(1.3)	1.58(0.1)	5.50(2.7)
Cereal rye	20.5(6.2)	13.5(1.3)	1.52(0.2)	3.50(0.6)
Winter wheat	21.3(3.8)	13.1(0.8)	1.47(0.2)	4.50(0.7)
Flax	25.9(5.5)	13.8(1.8)	1.56(0.2)	4.13(0.8)
Pea	23.3(6.9)	14.4(1.6)	1.41(0.3)	6.38(1.4)
P<0.05	NS	NS	NS	NS

SLM: Sugar loss to molasses; *values in bracket indicate standard deviation of mean

Cover crops were interseeded following a rain but germination was extremely poor due to dry spell and high air temperature near 90˚F. Cover crop biomass was not sampled. Cover crop interseeding had no significant effect on root yield, sugar, and SLM concentrations, and residual surface soil inorganic N concentrations. Cover crop interseeding is not an option for years having low rainfall and warm summer months.

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