

## Nitrogen Needs of Sugarbeet Produced with Reduced-Tillage Systems

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### ABSTRACT

Recent studies have shown that sugarbeet (*Beta vulgaris* L.) can be produced with reduced-tillage systems; however, the effects that reduced-tillage systems may have on N requirements of sugarbeet have not been studied. Therefore, field studies were conducted on a furrow-irrigated silty clay loam soil (Typic Argiboroll) to determine N requirements for optimum sucrose production by sugarbeet grown with reduced-tillage systems. Tillage treatments were conventional tillage (CT), strip tillage (ST), and no-tillage (NT). Four N rates of 0, 56, 112, and 168 kg/ha in 1980 and 1981, and 0, 84, 140, and 196 kg/ha in 1982 were imposed on each of the tillage treatments in a split-plot design. Fertilizer N was applied prior to establishment of tillage treatments in the fall prior to spring sugarbeet planting. Sucrose yields were ST > NT = CT. Application of N significantly increased root yield as well as gross and recoverable sucrose yields, but reduced sucrose content of the sugarbeet root and clear juice purity of all tillage treatments similarly. Except for clear juice purity, tillage × N interactions were not significant when averaged over 3 yr. Therefore, N recommendations formerly developed for yield and quality relationships for sugarbeet produced with conventional tillage can be used to make N recommendations for sugarbeet produced with reduced-tillage systems.

SOIL EROSION caused by winter and spring winds in the Rocky Mountains and other sugarbeet growing areas is a major problem for producers. Soil crusting can also be a problem on heavy textured soils, resulting in reduced emergence and unsatisfactory stands of sugarbeet seedlings. Use of reduced-tillage systems for sugarbeet production that maintain previous crop residues on the soil surface will reduce the severity of these problems (2,4,6,9). Recent changes in the federal farm program to reduce soil erosion on cropland have enhanced the need to produce sugarbeet with reduced-tillage systems to comply with the rules of the program.

Recent studies have shown that sugarbeet yield and quality can be maintained at levels comparable to conventional tillage systems when reduced-tillage practices are used to produce sugarbeet (1,3,4,6,8). However, published information on the effects that reduced-tillage systems may have on the N needs of sugarbeet is lacking. The objective of this phase of the study was to determine the effects of seedbed tillage system on N requirements of sugarbeet for optimum yield and quality.

### MATERIALS AND METHODS

The study was conducted at Sidney, MT, on a Savage silty clay loam soil (fine, montmorillonitic Typic Argiboroll) from 1980 through 1982. Seedbed tillage methods were: (i) con-

ventional till (CT), where all small-grain crop residues were incorporated into the surface 15 cm of soil with a rototiller; (ii) strip tillage (ST), where all small-grain crop residues in 18-cm-wide strips, located 61 cm apart (56 cm in 1980), were incorporated into the surface 7 to 10 cm of soil with a modified rototiller; and (iii) no-tillage (NT), where sugarbeet was planted directly into standing 15- to 20-cm-tall small-grain stubble. Oat (*Avena sativa* L.) stubble was used in 1980 and 1982, and spring wheat (*Triticum aestivum* L.) stubble in 1981. Loose straw was baled and removed from the plot area before establishment of treatments. Soil samples were collected from the 0- to 120-cm soil profile at several locations throughout the plot area prior to establishment of N treatments, and analyzed for soil organic matter content and NO<sub>3</sub>-N (Table 1).

A randomized block, split-plot design with tillage treatments as main plots and N fertilizer rates as subplots, with six replications, was used each year. Nitrogen fertilizer (ammonium nitrate) rates (N1, N2, N3, and N4, respectively) were 0, 56, 112, and 168 kg N/ha in 1980 and 1981, and 0, 84, 140, and 196 kg N/ha in 1982. The N3 fertilizer rate was estimated to be the N rate needed for optimum sucrose production under conventional tillage, taking into account residual soil NO<sub>3</sub>-N (0 to 120-cm depth), soil organic matter content, and an estimated total N need of about 235 kg N/ha required for optimum sucrose production with conventional tillage. Only the N fertilization phase of the project will be discussed in detail, because the effects of tillage treatment on sugarbeet yield and quality have been presented previously (6). All differences discussed are significant at the 95% confidence level unless otherwise noted.

The N treatments were applied and tillage treatments established in the fall prior to spring planting of the sugarbeet. Nitrogen was broadcast applied as dry granules. All N applied to the CT treatments was incorporated, while only the N in the 18-cm-wide strips of the ST treatments was incorporated by tillage. There was no incorporation of N in the NT plots. The sugarbeet was planted to stand with a modified conventional sugarbeet planter on 9 Apr. 1980, 12 May 1981, and 3 May 1982. Harvest dates were 23 Sept. 1980 and 1981, and 14 Oct. 1982. Two sugarbeet rows, each 9 m long, were harvested from each of the six-row by 9-m plots. Row spacings were 56 cm in 1980 and 61 cm in 1981 and 1982. The sugarbeet was washed before yield, sucrose concentration, and quality were determined on the harvested sample. Sucrose concentration was determined by polarimetry, and recoverable sucrose was estimated by using an impurity index value to calculate extractable sucrose concentration, as reported previously (5,7). The sugarbeet was furrow irrigated two to three times each growing season as needed with approximately 70 mm of water per irrigation.

Table 1. Average soil organic matter (O.M.) in the 0- to 15-cm soil depth, and average available N level (residual soil NO<sub>3</sub>-N plus fertilizer N) for each N treatment each crop year.

Crop year	Soil O.M. g/kg	Nitrogen level			
		N1†	N2	N3	N4
		soil NO <sub>3</sub> -N plus fertilizer N, kg N/ha			
1980	26	33	89	145	201
1981	40	41	97	153	209
1982	24	18	102	158	214
Average	33	31	96	152	208

† N1 = residual NO<sub>3</sub>-N in the 0- to 120-cm soil depth with no N fertilizer added (0 N rate).

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Table 2. Root yield, sucrose content, gross sucrose yield, clear juice purity, and recoverable sucrose yield for each tillage × N treatment from 1980 to 1982.

N level	1980				1981				1982			
	NT	ST	CT	Avg.	NT	ST	CT	Avg.	NT	ST	CT	Avg.
Root yield, Mg/ha												
N1	41.2	44.6	40.9	42.2	45.8	46.9	46.4	46.4	47.7	49.7	45.2	47.6
N2	44.6	53.2	47.8	48.6	48.7	51.4	49.3	49.8	57.1	54.2	55.9	55.8
N3	46.7	55.7	48.8	50.4	50.3	52.5	52.7	51.8	60.0	62.0	60.2	61.4
N4	49.9	58.0	49.7	52.5	51.9	53.8	53.9	53.2	64.3	64.8	61.4	63.5
Avg.	45.6	52.9	46.8	48.4	49.2	51.2	50.6	50.3	57.8	57.7	55.7	57.0
LSD (0.05)												
Tillage					NS				NS			
N rate					1.3				2.5			
Tillage × N	NS				NS				NS			
Sucrose content, kg/Mg†												
N1	168	171	169	170	175	174	173	174	182	184	182	183
N2	167	168	163	166	171	169	169	170	183	184	184	184
N3	159	167	158	161	166	165	164	165	178	180	181	180
N4	158	160	149	156	163	159	155	159	174	178	177	177
Avg.	163	166	160	163	169	167	165	167	179	182	181	181
LSD (0.05)												
Tillage	NS				2				NS			
N rate	3				1				2			
Tillage × N	NS				NS				NS			
Gross sucrose yield, Mg/ha												
N1	6.9	7.6	6.9	7.2	8.0	8.2	8.0	8.1	8.7	9.1	8.2	8.7
N2	7.4	9.0	7.8	8.1	8.3	8.7	8.3	8.5	10.5	10.0	10.3	10.2
N3	7.5	9.3	7.8	8.2	8.3	8.6	8.6	8.5	11.1	11.1	10.9	11.0
N4	7.9	9.3	7.5	8.2	8.5	8.5	8.4	8.5	11.2	11.5	10.9	11.2
Avg.	7.4	8.8	7.5	7.9	8.3	8.5	8.4	8.4	10.4	10.5	10.1	10.3
LSD (0.05)												
Tillage	0.7				NS				NS			
N rate	0.5				0.2				0.4			
Tillage × N	NS				NS				NS			
Clear juice purity, %												
N1	95.1	95.4	95.0	95.2	95.2	95.0	95.0	95.0	95.6	95.6	95.4	95.5
N2	94.6	94.9	94.3	94.6	94.7	94.6	94.6	94.6	95.4	95.5	95.4	95.4
N3	94.1	94.3	93.4	93.9	94.3	94.2	94.0	94.2	94.7	95.0	94.6	94.7
N4	93.3	93.5	92.9	93.2	93.7	93.3	93.1	93.4	94.3	94.5	94.3	94.3
Avg.	94.3	94.5	93.9	94.2	94.5	94.3	94.2	94.3	95.0	95.1	94.9	95.0
LSD (0.05)												
Tillage	NS				NS				NS			
N rate	0.2				0.1				0.2			
Tillage × N	NS				0.3				NS			
Recoverable sucrose yield, Mg/ha												
N1	6.2	6.9	6.2	6.4	7.2	7.3	7.2	7.2	7.9	8.3	7.4	7.9
N2	6.6	8.0	6.9	7.2	7.4	7.7	7.4	7.5	9.4	9.1	9.3	9.3
N3	6.6	8.2	6.7	7.2	7.4	7.6	7.6	7.5	9.8	10.0	9.7	9.8
N4	6.8	8.0	6.4	7.1	7.4	7.4	7.2	7.3	9.9	10.2	9.6	9.9
Avg.	6.5	7.8	6.5	6.9	7.3	7.5	7.4	7.4	9.3	9.4	9.0	9.2
LSD (0.05)												
Tillage	0.6				NS				NS			
N rate	0.4				0.2				0.4			
Tillage × N	NS				NS				NS			

† Sucrose content (fresh weight basis), kg/Mg = percent sucrose × 10.

Herbicide (ethofumesate, 2-ethoxy-2,3-dihydro-3,3-dimethyl-5-benzofuran-5-yl methanesulphonate) and one cultivation with a conventional knife and shovel beet-cultivator were used to control weeds prior to ditching for furrow irrigation. Fonofos (O-ethyl-S-phenylethylphosphonodithioate) was applied for insect control at planting.

## RESULTS AND DISCUSSION

The effects of tillage treatment on sugarbeet yield and quality are reported in Table 2, but have been discussed in detail by Halvorson and Hartman (6). In

summary, when averaged over 3 yr, ST treatments had significantly higher root, gross sucrose, and recoverable sucrose yields than CT and NT treatments. Tillage treatment had no significant effect on sugarbeet quality (sucrose content and clear juice purity) when averaged over 3 yr.

Application of N fertilizer significantly increased sugarbeet root yield similarly in each of the tillage treatments each year of the study (Table 2). The tillage × N interactions were not significant. When averaged over 3 yr, root yields increased curvilinearly as the level of soil N plus fertilizer N increased, with all til-

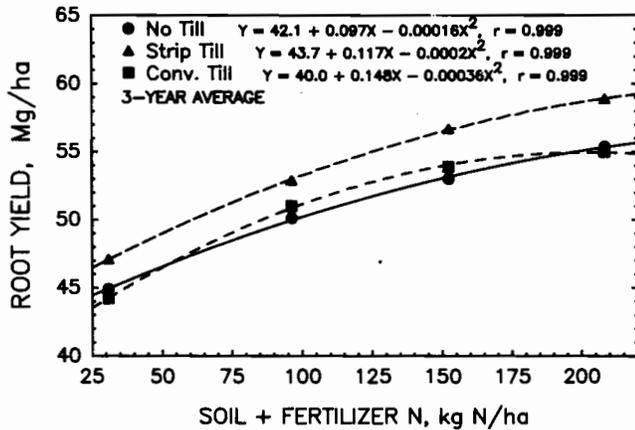


Fig. 1. Average sugarbeet root yields for each tillage treatment as a function of soil  $\text{NO}_3\text{-N}$  (0- to 120-cm depth) plus fertilizer N applied.

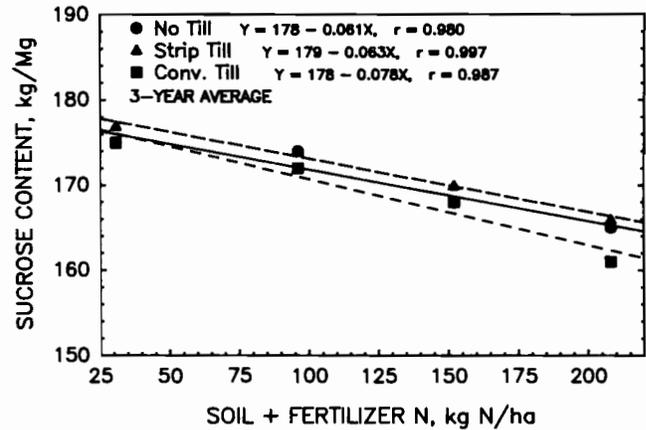


Fig. 2. Average sucrose content of sugarbeet roots for each tillage treatment as a function of soil  $\text{NO}_3\text{-N}$  (0- to 120-cm depth) plus fertilizer N applied.

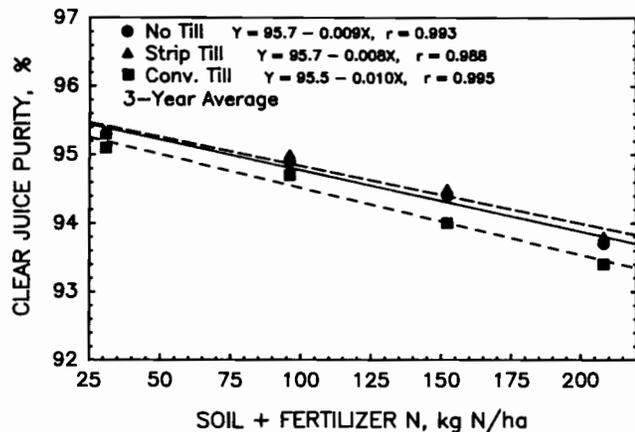


Fig. 3. Average clear juice purity percentage of sugarbeet root extracts for each tillage treatment as a function of soil  $\text{NO}_3\text{-N}$  (0- to 120-cm depth) plus fertilizer N applied.

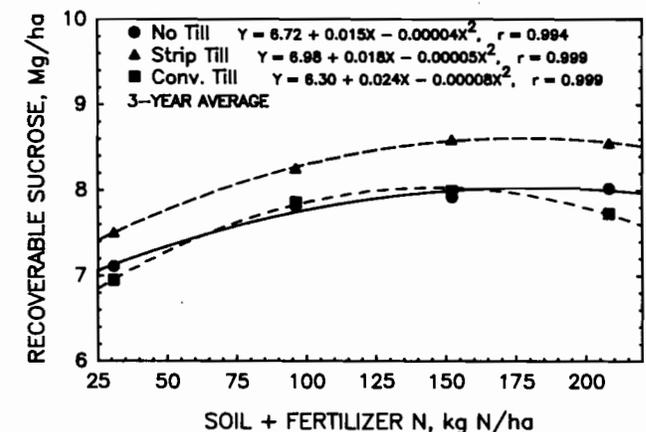


Fig. 4. Average recoverable sucrose yields for each tillage treatment as a function of soil  $\text{NO}_3\text{-N}$  (0- to 120-cm depth) plus fertilizer N applied.

lage treatments responding similarly to N (Fig. 1). The tillage  $\times$  N interaction was not significant.

Sucrose content of the sugarbeet roots was decreased significantly as the level of available N increased for each of the tillage treatments each year of the study (Table 2). The tillage  $\times$  N interaction was not significant in any of the years. When averaged over the 3 yr of the study, a significant linear decline in sucrose content was observed (Fig. 2), with the tillage  $\times$  N interaction being nonsignificant.

Gross sucrose yield was increased significantly by N application for each of the tillage treatments (Table 2). Gross sucrose yield was optimum at the N3 level of available N with the CT treatment, as was expected. The tillage  $\times$  N interaction was not significant in any of the years.

Sugarbeet quality, as indicated by clear juice purity, declined as the rate of available N increased for each of the tillage treatments (Table 2). A significant tillage  $\times$  N interaction occurred in 1981, when the clear juice purity of the CT treatment declined more rapidly at the N3 and N4 levels than did that of the other two tillage treatments. This interaction was significant when the data were averaged over the 3-yr period for the same reason (Fig. 3). When averaged over 3 yr,

clear juice purity declined linearly with increasing levels of available N for each of the tillage treatments.

Recoverable sucrose yields were significantly increased by N application for each of the tillage treatments (Table 2). When averaged over 3 yr, a curvilinear increase in recoverable sucrose yield was observed for each of the tillage treatments (Fig. 4). Recoverable sucrose yields were near optimum at the N3 level (152 kg N/ha of soil N + fertilizer N).

Except for clear juice purity in 1981 and when averaged over 3 yr, the tillage  $\times$  N interactions were not significant for any yield and quality factors measured. This indicates that the reduced seedbed-tillage treatments generally did not alter the N requirements of sugarbeet when compared to the CT system.

## CONCLUSIONS

The N fertilization versus sugarbeet yield and quality relationships established previously for CT systems will apply to reduced seedbed-tillage systems employed in sugarbeet production. Thus, N management practices will not need to be changed for reduced-tillage systems. Results of this study indicate that sugarbeet yield and quality can be maintained or improved with reduced-tillage systems.

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