Reduced Seedbed Tillage Effects on Irrigated Sugarbeet Yield and Quality[1]

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ABSTRACT

Field studies were conducted from 1979 through 1982 on a furrow irrigated silty clay loam soil (Typic Argiboroll) to determine if sugarbeet (*Beta vulgaris* L.) sucrose production levels could be maintained with reduced seedbed tillage. Tillage treatments were: a) conventional tillage (CT)—complete fall incorporation of surface residues; b) strip tillage (ST)—fall incorporation of surface residues in 18-cm wide bands located 56 or 61 cm apart; and c) no-tillage (NT)—no incorporation of surface residues. Herbicides were fall applied for weed control. Sugarbeets were seeded 10 or 15 cm apart to eliminate need for thinning. Sugarbeet stands before cultivation averaged 3.7 sugarbeets/meter of row over the 4-year period. Tillage treatment had no significant effect on spring soil temperatures and on sugarbeet stand, root yield, sucrose content, gross sucrose yield, and recoverable sucrose yield when averaged over the 4-year period. Sugarbeet quality, in terms of clear juice purity, tended to be better in the reduced tillage treatments than in the CT treatment. This difference in clear juice purity probably resulted from the higher levels of spring soil NO_3-N found under CT than under reduced tillage plots. The results indicate that sucrose production under reduced seedbed tillage conditions can be maintained at levels comparable with conventional seedbed tillage conditions. Potential advantages of reduced seedbed tillage for sugarbeets are wind erosion control, reduced soil crusting problems, better soil water conditions in the seedbed for germination, reduced energy requirements, and reduced production costs.

Additional index words: **No-tillage, Strip tillage, Band tillage, Conventional tillage, *Beta vulgaris* L., Sucrose, Root yield, Clear juice purity.**

WIND erosion is a major problem in sugarbeet (*Beta vulgaris* L.) growing areas of the Great Plains region. Generally, all surface residues are incorporated during normal fall seedbed plowing operations, leaving the soil unprotected from wind during winter and early spring months. In addition, fall mulching and leveling operations generally break large clods left by plowing, leaving the soil surface in a smooth and easily erodible condition.

Crop residue, left on the soil surface, will reduce soil erosion and seedling damage caused by wind (4, 6, 10). Small grain cover crops have been used in sugarbeet fields to reduce wind damage to soil and sugarbeet seedlings. The cover crops have been effective in reducing wind damage, but excessive cover crop residue and phytotoxicity have resulted in reduced yields (2, 4).

Strip tillage (ST) has been used in the spring under center pivot irrigation systems in Colorado to prepare seedbeds for sugarbeets in corn (*Zea mays* L.) stubble (6). Sugarbeet yield and quality under reduced seedbed tillage were generally equal to or better than under conventional tillage (CT). A similar trend in sugarbeet yield and quality has been reported for reduced tillage treatments in the Red River Valley area of North Dakota and Minnesota (1, 5, 9, 11). Preliminary work by Halvorson and Hartman (Research Report 123, January 1978, and Research Report 142, January 1979, Montana Agricultural Exp. Stn., Montana State Univ., Bozeman) indicated that sucrose yield of sugarbeets seeded under no-tillage (NT) conditions in standing grain stubble was 103% of the yield under CT conditions in 1977 and 1978. These data indicate potential for employing reduced seedbed tillage techniques for furrow-irrigated sugarbeets in the Great Plains. Reduced tillage systems, in addition to reducing wind damage, should reduce energy and labor requirements for sugarbeet production, thereby reducing production costs.

By using standing grain stubble rather than planted cover crops to reduce wind velocities at the soil surface, trap snow over winter, and protect young sugarbeet seedlings in the spring, the problems of phytotoxicities and excess residues from planted cover crops might be avoided. Reduced tillage systems may also reduce soil crusting problems on fine-textured soils and provide better seedbed moisture conditions. The objective of this study was to determine the effects of reduced seedbed tillage on sugarbeet yield and quality.

MATERIALS AND METHODS

The study was conducted at Sidney, Mont., on Savage silty clay loam soil (fine, montmorillonitic Typic Argiboroll) from 1979 through 1982. Three seedbed preparation methods were studied: a) conventional tillage—where all grain crop residues were incorporated in the surface 15 cm of soil with a rototiller; b) strip tillage—where all grain crop residues in 18-cm wide strips, located 56 cm apart (61 cm in 1982), were incorporated in the surface 7 to 10 cm of soil with a modified rototiller; and c) no-tillage—sugarbeets were planted directly into standing 15- to 20-cm tall erect grain stubble. Spring wheat stubble was used in 1979 and 1981 and oats stubble in 1980 and 1982. After cereal grain harvest, excess loose straw was baled and removed from the plot area before establishing the tillage treatments. All tillage treatments were established the fall prior to planting sugarbeets.

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. The effects of N fertilizer rates on sugarbeet yield and quality will be the subject of another paper and will not be discussed herein. Data presented in this manuscript for tillage treatments represent an average over all N treatments. All differences discussed are significant at the 95% confidence level unless otherwise noted.

The sugarbeet seeds were space planted each year to avoid hand thinning. A 15-cm seed spacing was used in 1979 and 1982 and a 10-cm spacing in 1980 and 1981. The plots were six rows wide (56- or 61-cm row spacing) by 9-m long. An IHC Model 185 unit planter[3] was used in 1979 and 1980. Each planter unit was preceded by a 46-cm diam smooth rolling coulter. A Heath air planter[3] was used in 1981 and 1982. Each planter unit was preceded by a 46-cm diam fluted coulter, followed by a small chisel point. The sugarbeets were planted on 5 May 1979, 9 Apr. 1980, 16 Apr. 1981 (killed

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[3] Trade and company names are included for the benefit of the reader and do not imply any endorsement or preferential treatment by the USDA of the product listed.

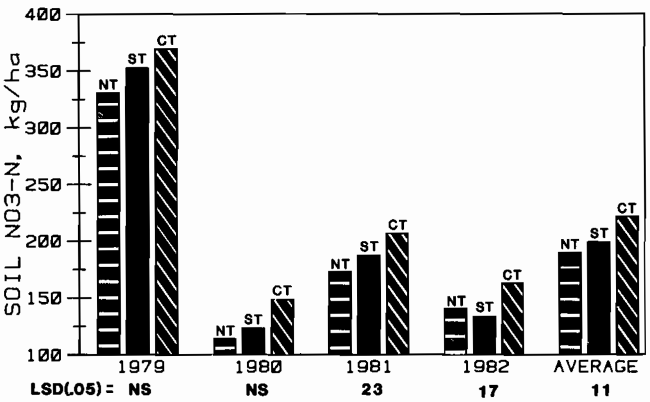

Fig. 1. Average soil NO_3-N, 0- to 120-cm soil depth, about 1 June each year for the no-tillage (NT), strip tillage (ST), and conventional tillage (CT) treatments and the 4-year average.

by frost and reseeded 12 May 1981), and 3 May 1982. Harvest dates were 25 Sept. 1979, 23 Sept. 1980 and 1981, and 14 Oct. 1982.

Two sugarbeet rows, each 9-m long, were harvested from each plot. The sugarbeets were washed before yield, sucrose content, and quality were determined on the harvested sample. Procedures used to determine sucrose content and recoverable sucrose have been reported in detail (7, 8).

Adequate moisture was present each year in the NT and ST plots to achieve satisfactory germination, but not in the CT plots in 1979 and 1980. All tillage plots were sprinkler irrigated after planting with about 2.5 cm of water to avoid a water variable in 1979 and 1980. A satisfactory stand of sugarbeets was established with the original planting without need for irrigation in 1981. Frost on 8 May killed the sugarbeets in all plots. The sugarbeets, reseeded on 12 May 1981, were sprinkler irrigated to achieve germination. Sufficient soil moisture was present for germination in all plots in 1982. Two to three furrow irrigations, approximately 7 cm water per irrigation, were applied during the growing season as needed.

Complete chemical weed control was attempted in 1979, while in 1980, 1981, and 1982, one cultivation with a conventional knife and shovel beet cultivator was used to control weeds prior to ditching for furrow irrigation. Herbicide, ethofumesate (Nortron)[4], was applied broadcast to each tillage treatment each fall prior to planting sugarbeets. Granular Nortron was used in 1979 and flowable in 1980, 1981, and 1982 at a rate of 3.9 kg/ha of a.i. Weeds that escaped the herbicide and cultivation were removed by hand during the growing season each year, except 1979. Weeds were a problem only in the NT and ST plots in 1979. Few weeds were present in the CT plots in 1979. Glyphosate[4] was applied three times in 1979 to the weeds exposed above the sugarbeet canopy using a rope-wick applicator. The weeds were killed by the glyphosate, but apparently damage to the sugarbeets also occurred. Many sugarbeet roots from the NT and ST plots were rotted off at harvest. This was probably glyphosate damage (3).

Sugarbeet stand counts were taken once in May or June (4 to 5 weeks after emergence) and at harvest each year. Eighteen meters of row from each treatment were counted. Flea beetles (*Phyllotreta pusilla*) destroyed some of the beet stand in 1980.

Soil temperatures at the 7-cm soil depth were measured with a dial thermometer in a sugarbeet row at about 1000 h on a weekly basis during April, May, and June in 1979 and 1980.

[4] This article reports the results of research only. Mention of a pesticide does not constitute a recommendation for use by the USDA, nor does it imply registration under FIFRA as amended.

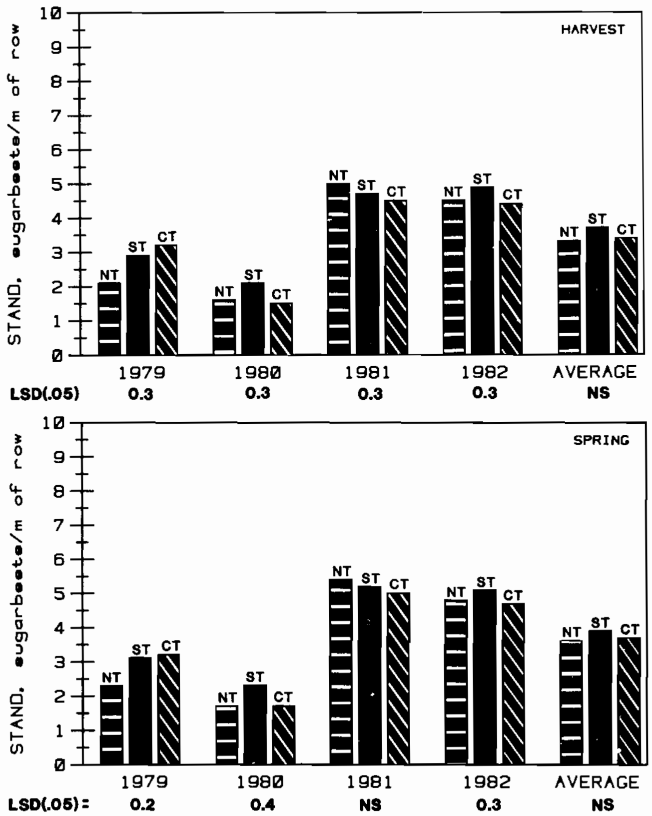

Fig. 2. Sugarbeet stand in early June prior to cultivation and at harvest for the no-tillage (NT), strip tillage (ST), and conventional tillage (CT) treatments for each year and the 4-year average.

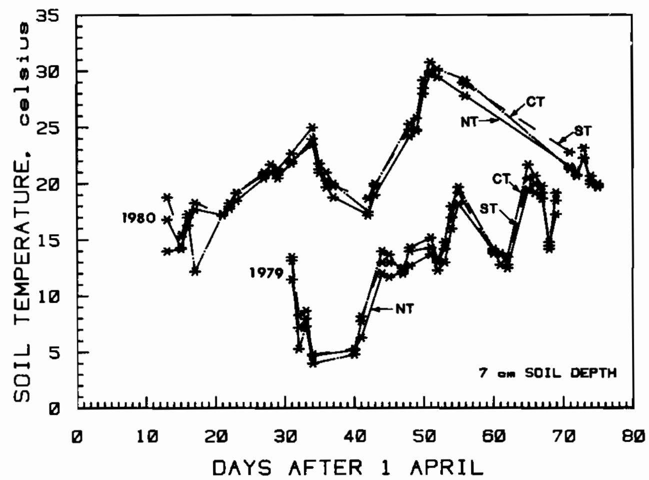

Fig. 3. Spring soil temperature at 7-cm soil depth in 1979 and 1980 for the no-tillage (NT), strip tillage (ST), and conventional tillage (CT) treatments.

Soil samples were collected from each tillage by N subplot to a depth of 120 cm about 1 June each year. The soils were analyzed for NO_3-N content using a water extract and a Cd reduction autoanalyzer procedure. Data presented for tillage treatments represent an average over all N treatments.

RESULTS AND DISCUSSION

Early June NO_3-N in the 0- to 120-cm soil profile is shown in Fig. 1. General trends were for soil NO_3-N to be higher under CT plots than under ST and NT plots with significant differences in 1981 and 1982. The

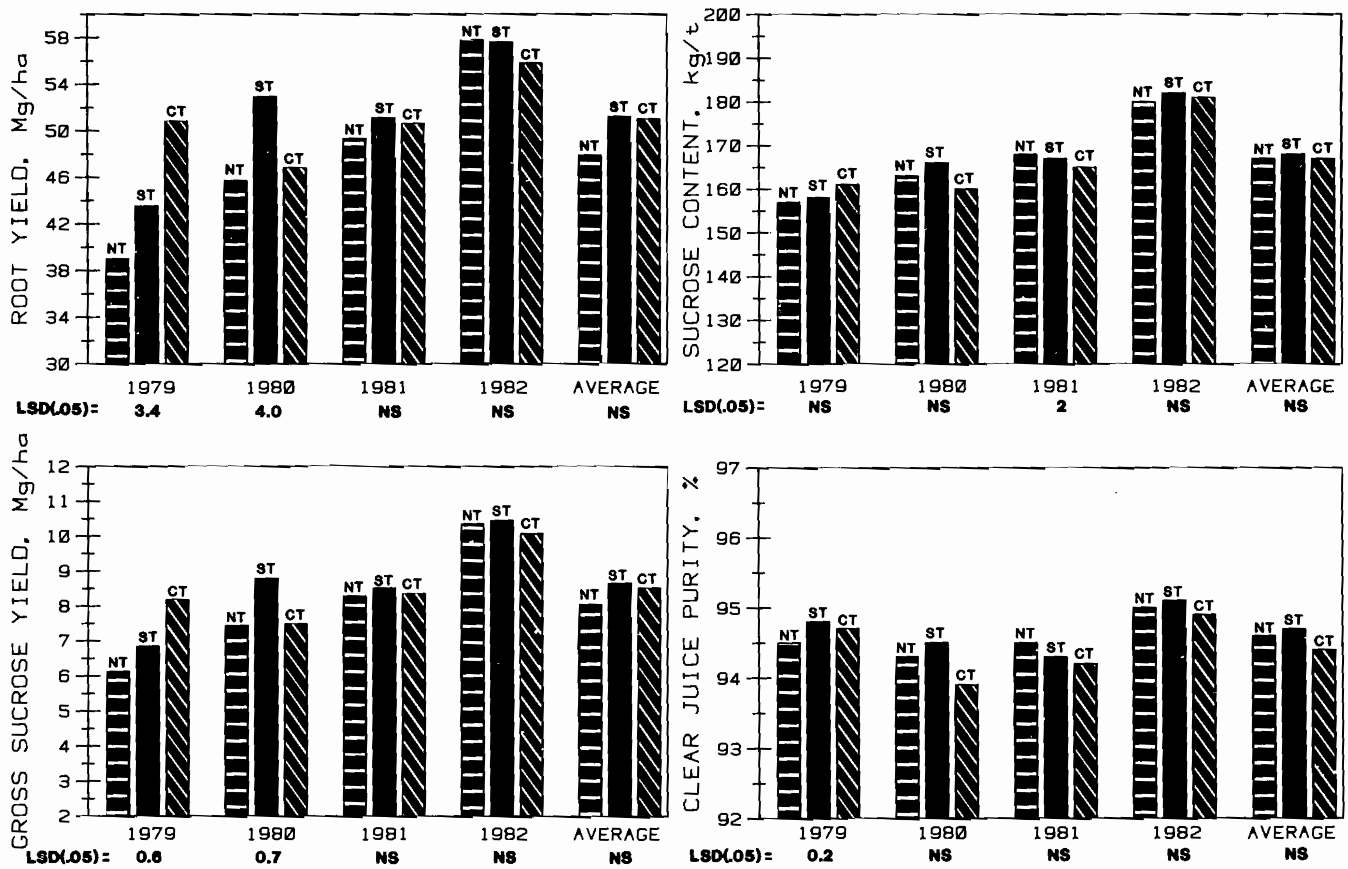

Fig. 4. Sugarbeet root yield, sucrose content, clear juice purity, and gross sucrose yield for the no-tillage (NT), strip tillage (ST), and conventional tillage (CT) treatments each year and the 4-year average.

4-year average soil profile NO_3-N was significantly higher for the CT treatment than for the ST and NT treatments. Differences in soil NO_3-N could have resulted from more N loss through volatilization of the reduced tillage plots because of less soil incorporation of the surface-applied ammonium nitrate. Possibly a greater quantity of N was mineralized in the CT plots, where all surface residues were incorporated, than in the reduced tillage plots.

The effects of tillage treatment on sugarbeet stands varied each spring (Fig. 2). Tillage treatment had little effect on soil temperature at the 7-cm soil depth (Fig. 3). Therefore, stand differences in early spring were probably not a result of soil temperature differences. When averaged over the 4-year period, tillage treatment had no significant effect on sugarbeet stand because of the yearly differences. The effect of changing planters is also evident in Fig. 2; note the lower sugarbeet stands for 1979 and 1980 than for 1981 and 1982. In the authors' opinion, a stand of about 4.4 sugarbeets/meter of row would be desirable for best sugar yields. Sugarbeet stands at harvest were significantly affected each year by tillage treatment (Fig. 2). However, due to the inconsistency between years, tillage treatment had no significant effect on sugarbeet stands at harvest when averaged over the 4-year period.

Average root yields for each tillage treatment are shown in Fig. 4. In 1979, the CT treatment had a significantly greater root yield than either the ST or NT treatments. Because the CT plots were cultivated in the spring before planting, they were relatively free of weeds, whereas the ST and NT plots were infested with kochia (*Kochia scoparia*). Kochia competition and glyphosate damage (3) resulted in reduced root yields in the ST and NT plots when compared to the CT plots.

The ST treatment had a significantly higher root yield than the CT or NT treatments (Fig. 4) in 1980. The lower root yields of CT and NT treatments were the result of poor sugarbeet stands. The poor sugarbeet stand in the CT treatment was primarily the result of dry soil at planting and severe soil crusting following sprinkler irrigation. Soil water in the 0- to 15-cm depth was 2.0 cm less in the CT plots than in the NT and ST plots on 7 Apr. 1980. Poor stands in the NT treatment resulted from damage to emerging sugarbeet seedlings caused by flea beetles. Visual inspection indicated flea beetle damage was more severe in the NT plots than the ST plots. Flea beetles did not affect the CT plots because, due to dry soil conditions, no sugarbeets had emerged at the time of flea beetle infestation.

Tillage treatment had no significant effect on root yield in 1981 and 1982. Averaged over the 4-year period, root yield was not significantly affected by tillage treatment (Fig. 4).

Tillage treatment had no significant effect on sugarbeet sucrose content, except for 1981 (Fig. 4). Beets from the NT treatment had a higher sucrose content than beets from the CT treatment in 1981. Averaged over the 4-year period, there were no significant dif-

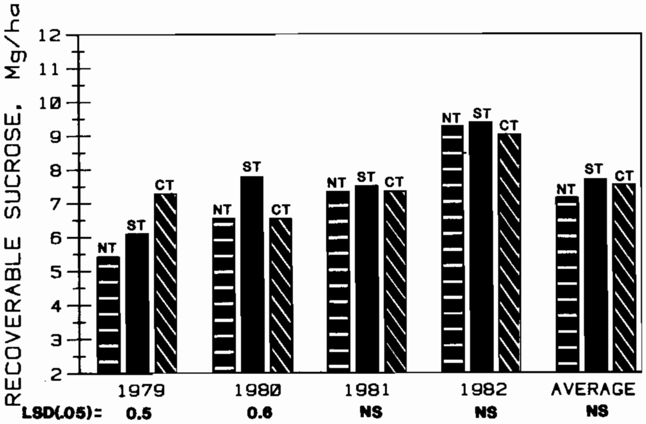

Fig. 5. Recoverable sucrose yield for the no-tillage (NT), strip tillage (ST), and conventional tillage (CT) treatments each year and the 4-year average.

ferences among tillage treatments in sugarbeet sucrose content.

Tillage treatment significantly affected gross sugar yields in 1979 and 1980, but not in 1981 or 1982 (Fig. 4). The differences observed in gross sucrose production in 1979 and 1980 reflect differences in root yield since tillage treatment had no significant effect on sucrose content. Averaged over the 4-year period, tillage treatment had no significant effect on gross sucrose production.

Clear juice purity of the sugarbeets was not significantly affected by tillage treatment, except in 1979 (Fig. 4). Sugarbeets from the ST treatment had a significantly higher clear juice purity than those from the NT treatment in 1979. The general trend was for sugarbeets of the CT treatment to have a lower clear juice purity than sugarbeets from the ST and NT treatments. When averaged over the 4-year period, this difference was significant at the 90% confidence level. The lower clear juice purity of the beets of the CT versus those of the ST or NT treatments reflects the higher level of available soil NO_3-N (Fig. 1) for the CT plots vs ST or NT plots.

Significant differences in recoverable sucrose yield between tillage treatments were found in 1979 and 1980, but not in 1981 or 1982 (Fig. 5). The differences in recoverable sucrose yield observed between tillage treatments in 1979 resulted from weed competition and herbicide damage as explained previously for root yield. The ST treatment had a significantly higher root yield than the other two tillage treatments and consequently, a greater recoverable sucrose yield in 1980. When averaged over the 4-year period, there were no significant differences in recoverable sucrose yield caused by tillage treatment.

SUMMARY AND CONCLUSIONS

Sugarbeets can be grown successfully under ST or NT seedbed conditions. When averaged over a 4-year period, no significant differences in sugarbeet stand, root yield, sucrose content, gross sucrose, and recoverable sucrose yields were observed due to seedbed preparation method—CT, ST, or NT.

Sugarbeet quality, in terms of clear juice purity, tended to be higher under NT and ST than under CT seedbed preparation methods. We can conclude from this phase of the study that sucrose production under reduced seedbed tillage conditions can be maintained at levels comparable with conventional seedbed tillage conditions. The real significance of this study lies in the demonstration of equal or better yields with dramatic changes in management system.

Some of the advantages observed for the reduced tillage systems, compared to the conventional seedbed tillage system, were: 1) reduced spring soil erosion and damage to sugarbeet seedlings caused by wind; 2) less soil crusting problems; and 3) sufficient seedbed soil moisture in the reduced tillage plots to facilitate germination in contrast to 5- to 10-cm of dry surface soil in the CT plots, requiring irrigation in 1979, 1980, and 1981. No particular problems with straw residue were encountered during cultivation, ditching for furrow irrigation, or irrigation. Except for 1979 (no cultivation used), the few weeds present were not associated with a particular tillage treatment. Good planting equipment was needed to facilitate obtaining a satisfactory sugarbeet stand.

REFERENCES

1. Deibert, E.J., J.F. Giles, J. Enz, and D. Lizotte. 1982. Reduced tillage sugarbeet production. *In* 1981 Sugarbeet Research and Extension Reports. North Dakota State Univ. and Univ. of Minnesota. 12:123–127.
2. Elliot, L.F., D.E. Miller, and A.W. Richards. 1979. Phytotoxicity of incorporated cover crops to sugarbeet seedlings. Plant Dis. Rep. 63:882–886.
3. Evans, R.R. 1983. Weed competition in sugarbeets (*Beta vulgaris*). Ph.D. Thesis, Dep. of Agronomy, North Dakota State University. 93 p.
4. Fornstrom, K.J., and R.D. Boehnke. 1976. A growing mulch tillage system to reduce wind erosion losses of sugar beets. J. Am. Soc. Sugar Beet Tech. 19:65–73.
5. Giles, J.F., E.J. Deibert, L. Smith, J.B. Fitts, and J. Enz. 1982. Sugarbeet production with reduced primary tillage. *In* 1981 Sugarbeet Research and Extension Reports. North Dakota State Univ. and Univ. of Minnesota. 12:116–122.
6. Glenn, D.M., and A.D. Dotzenko. 1978. Minimum vs. conventional tillage in commercial sugarbeet production. Agron. J. 70:341–344.
7. Halvorson, A.D., and G.P. Hartman. 1980. Response of several sugarbeet cultivars to N fertilization: Yield and crown tissue production. Agron. J. 72:665–669.
8. ———, ———, D.F. Cole, V.A. Haby, and D.E. Baldridge. 1978. Effect of N fertilization on sugarbeet crown tissue production and processing quality. Agron. J. 70:876–880.
9. Miller, S.D., and A.G. Dexter. 1982. No-till crop production in the Red River Valley. N. D. Farm Res. 40:3–5.
10. Simmons, S.R., and A.D. Dotzenko. 1975. Evaluation of conservation tillage effectiveness on sugarbeet fields in northeastern Colorado. J. Am. Soc. Sugar Beet Tech. 18:307–311.
11. Sojka, R.E., E.J. Deibert, F.B. Arnold, and J. Enz. 1980. Sugarbeet production under reduced tillage—Prospects and problems. N. D. Farm Res. 38:14–18.