# Efficient Deep Tillage for Sugarbeets on Pullman Clay Loam*

S. R. Winter

Received for Publication December 10, 1982

## INTRODUCTION

Sugarbeets in the Texas Panhandle are grown largely on soils with a naturally occurring, very dense, clay B22t horizon at about a 20- to 50-cm depth. The clay loam surface horizon is low in organic matter and subject to severe compaction. Tillage to a 30- or 40-cm depth in these soils has been shown to increase sugar yield by increasing water infiltration, improving aeration, and reducing bulk density and *Rhizoctonia* root rot (2). In Ohio, sugarbeets were very sensitive to poor aeration associated with non-capillary pore space below 8% (1).

Commonly practiced sub-soiling, followed by disking and leveling, is very energy intensive and inefficient because operations after sub-soiling strongly recompact the soil. A new tillage tool, the hipper-ripper, seems to have several advantages. With this implement, deep tillage is limited to the center of the bed where the sugarbeet taproot will penetrate. Since all subsequent traffic is limited to the water furrows between beds, recompaction of the sub-soiled zone is not a problem. This research was undertaken to test the hypothesis that the hipper-ripper would reduce fuel requirement for tillage while producing acceptable sugarbeet yield.

## MATERIALS AND METHODS

Four tillage treatments were compared in 1980 and 1981 at Bushland, Texas on Pullman clay loam (fine, mixed,

---

*Contribution from the Texas Agricultural Experiment Station, Texas A&M University, as Technical Article NO.18071 in cooperation with USDA. The author is Associate Professor, Texas Agricultural Experiment Station, Texas A&M University System, 6500 Amarillo Blvd. West, Amarillo, TX 79106.

thermic Torrertic Paleustolls) which has about equal parts sand, silt, and clay, 1.5% organic matter, and pH 6.5 to 7.0 in the upper 20 cm. The 20- to 50-cm depth B22t horizon has 44% clay and is very dense and slowly permeable. Tillage treatments were a check, hipper-ripper, sub-soiler, and hipper-ripper plus sub-soiler. Operations used on all tillage treatments prior to planting were listing to form beds on 76-cm row spacing, preplant irrigating (10 cm), and cultivating. Sub-soiling was done just prior to listing, while the hipper-ripper was used just after listing. The hipper-ripper had a sub-soiling shank operating 35 cm deep in the center of the bed and lister shovels behind to reshape the bed. The sub-soiler had shanks 50 cm apart that penetrated to a 35-cm depth on the second of two passes.

In 1980, tillage treatments were on main plots in a split-split plot design with two water levels and four cultivars as sub and sub-sub plot treatments, respectively. Water levels were 20 and 48 cm of seasonal irrigation. Cultivars were Mono-Hy D2, Mono-Hy TX1, Mono-Hy TX5, and HH32. Since there were no interactions in 1980, the experiment was simplified in 1981 by testing only the tillage variable. Mono-Hy D2 cultivar was planted on all plots and irrigated with 30 cm during the growing season which, along with 50 cm rainfall, was adequate for high yield.

The previous crop in both years was winter wheat. After wheat harvest in late June, wheat stubble was incorporated with a disk. The level-bordered plots were then leveled with a float which resulted in moderate to severe compaction of the surface soil. After leveling, weeds and volunteer wheat were controlled with sweeps operating 7 to 10 cm deep until the previously described tillage treatments were imposed.

Fuel requirement for sub-soiler and hipper-ripper operations was estimated in 1981 using a John Deere 4040 diesel tractor. Tillage operations were timed and fuel consumption per hour was estimated from Nebraska tractor

Table 1. Sugarbeet production, water intake time, diesel fuel use, and soil penetration resistance with four tillage treatments on Pullman clay loam at Bushland, Texas.

| Tillage Treatment | Root Yield | | | Sucrose | | | Water intake | Diesel fuel | Penetration resistance |
|---|---|---|---|---|---|---|---|---|---|
| | 1980 | 1981 | Mean | 1980 | 1981 | Mean | | | |
| | metric tons/ha | | | % | | | hours | liter/ha | kg |
| Check | 24.6c | 95.4a | 60.0b | 15.68a | 14.98a | 15.33a | 72.0a | 0.0d | 11.0a |
| Hipper-ripper | 35.6a | 97.9a | 66.8a | 15.48a | 15.20a | 15.34a | 16.6b | 18.7c | 8.1b |
| Sub-soil | 33.2b | 101.0a | 67.2a | 15.62a | 14.82a | 15.22a | 14.5b | 44.9b | 6.4c |
| Sub-soil+ hipper-ripper | 34.5ab | 102.4a | 68.5a | 15.05b | 15.12a | 15.09a | 8.3c | 63.6a | 6.2c |

test 1267.

A cone penetrometer (tip 1.0-cm diameter and 2.5-cm long) was used to measure the force required for soil penetration to a depth of 30 cm. The soil was moist on August 8, 1980 and March 25, 1981, but relatively dry on June 9, 1981, when penetration force was measured.

Sugarbeets were planted in late March and harvested in early November with a modified commercial harvester. Holly Sugar Corporation performed analysis for sucrose. All data were subjected to analysis of variance and Duncan's multiple range test.

The time required for 10 cm of irrigation water to infiltrate was recorded on March 10, 1980. This irrigation was applied after the tillage treatments were imposed but before planting sugarbeets.

## RESULTS AND DISCUSSION

All deep tillage treatments increased root yield compared to the check in 1980, but not in 1981 (Table 1). The first study year was characterized by excessive heat and severe drought; however, irrigation level did not

Table 2. Summary of analysis of variance for sugarbeet tillage study in 1980 and 1981 at Bushland, Texas.

| Source | df | SS | F-value | P>F |
|---|---|---|---|---|
| | | Root yield-1980 | | |
| Tillage | 3 | 468.6 | 61.2 | 0.001 |
| Tillage x irrigation | 3 | 11.9 | 1.6 | 0.205 |
| Tillage x variety | 9 | 45.0 | 2.0 | 0.054 |
| Tillage x irrigation x variety | 9 | 37.5 | 1.6 | 0.118 |
| | | Sucrose %-1980 | | |
| Tillage | 3 | 7.72 | 6.82 | 0.001 |
| Tillage x irrigation | 3 | 0.13 | 0.12 | 0.946 |
| Tillage x ivariety | 9 | 4.77 | 1.40 | 0.200 |
| Tillage x irrigation x variety | 9 | 2.34 | 0.69 | 0.717 |
| | | Root yield-1981 | | |
| Tillage | 3 | 23.9 | 1.89 | 0.202 |
| | | Sucrose %-1981 | | |
| Tillage | 3 | 0.34 | 0.96 | 0.453 |

affect the response to tillage (Table 2). Nineteen eighty one was a very good year as evidenced by yields of 100 metric tons/ha. Tillage had no effect on sucrose percent, except the sub-soiler plus hipper-ripper treatment reduced sucrose percent, for no apparent reason, in 1980 (Table 1). Since yield with hipper-ripper was as good as sub-soiler or sub-soiler plus hipper-ripper with considerably less fuel use (Table 1), it would have to be considered the most efficient tillage.

There was no interactions of irrigation or cultivar with tillage in 1980 (Table 2). Therefore, only mean tillage effects averaged over all irrigation and cultivar variables are presented in Table 1.

Water infiltration time was inversely proportional to intensity of tillage, i.e. to fuel use for tillage in 1980 (Table 1). The 72-hour infiltration time for the check treatment is excessive for a preplant application of 10 cm. Normal infiltration time would be 24 hours or less.

Treatments that were sub-soiled required less force for soil penetration than the hipper-ripper, which, in turn, was less than the check (Table 1). A mean value is given in Table 1 because penetration resistance was very nearly a linear function of depth in all cases. This indicates that there was no distinct hard pan in the upper 30 cm of any treatment. Rather, there was a general difference in compaction in this zone.

## SUMMARY

All of the deep tillage treatments significantly increased sucrose yield in 1980, but not in 1981. There were no interactions of irrigation amount or cultivar with tillage in 1980, a drought year. Water infiltration time and force required for soil penetration were inversely proportional to intensity of tillage, i.e. to fuel use for tillage. The hipper-ripper treatment was the most efficient tested. Sucrose yield with this tillage was equal to the more intensive tillage treatments with considerably less fuel use.

## LITERATURE CITED

(1) Baver, L. D. and R. B. Farnsworth. 1940. Soil structure effects on the growth of sugarbeets. Soil Sci. Soc. Am. Proc. 5:45-48.

(2) Mathers, A. C., G. C. Wilson, A. D. Schneider, and Paul Scott. 1971. Sugarbeet response to deep tillage, nitrogen, and phosphorus on Pullman clay loam. Agron. J. 63:474-477.