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Tillage Effect on Yield, Quality, Management and Cost of Sugarbeet



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Abstract

The purpose or this research was to compare sugarbeet tillage methods in terms of yield, internal quality, operational parameters and cost and determine the most suitable methods in sugarbeet cultivation. The methods that were examined in this research were traditional soil tillage methods and five different methods that were considered to be feasible in Turkey. The methods were evaluated in terms of (1) sugarbeet yield and internal quality that include beet yield, sugar content, refined sugar content, refined sugar yield; (2) operational parameters that include fuel consumption, machinery time and labour requirements; and (3) effective area capacity and costs that include gross income, net income and total cost. In conclusion it was determined the best results were in S2 tilled by mouldboard plough and cultivator and S3 tilled by chisel between the soil tillage methods.

Introduction

Soil structure is one of the important factors that effect beet yield and quality, along with plant protection and pest control, seed structures and climate. For this reason, cultivation, which is the first step, has a special importance as with the other root crops. Seedbed preparation is the first step in obtaining high yield and quality. Incorrect preparation will cause negative results in next stage. Preparing the soil for sugarbeets often starts in the autumn of the preceding year. Most beet crops follow a straw crop. Shallow cultivation with disc-harrow can incorporate straw and stubble into the soil. This encourages germination of weeds including weed beet. After disc harrow preparation, ploughing is still the most popular primary cultivation. The soil must be moist enough to break-up as the furrow slice is inverted and no wetter. The furrow slices should be level, with tidy ends at the headlands. Freedom from holes and hollows is the key to a good sugarbeet seedbed (Jaggard, 1995).

The second step is being done in Turkey some time after the first ploughing (25-30 days according to climate) to maintain the effect of the plough. The field is also being left till to spring and cultivated by combi-crumler and then drilled by mechanical precision drilling

Table 1 Tillage methods carried out in this research

Treatment	Autumn application	Spring application
S1	Disc-harrow[1] + two times mouldboard plough[2]	Combi-crumbler[3] + drilling
S2	Disc-harrow + mouldboard plough + cultivator	Combi-crumbler + drilling
S3	Disc-harrow + Chisel	Combi-crumbler + drilling
S4	-	Inter row hoeing machine + drilling
S5	-	Rototiller
S6	-	Direct drilling

[1]X type with 24 discs, [2]Reversible with two semi digger body, [3]8 curved tines and 32 chisel tooth tines + 2 crumbling roller with large diameter + 2 crumbling roller with small diameter

machine. A maximum of 30 % crop residue on the surface is accepted in conventional tillage. For that reason, creating a defenceless surface against the water and wind erosion is unavoidable. Another disadvantage of conventional tillage is the moisture loss.

Conservation tillage is successfully applied in sugarbeet cultivation. Rydberg (1991) obtained 47.6 t/ha beet yield from the conventional tillage and 95-97 t/ha from direct drilling. Wing (1996) obtained 78.8 t/ha beet yield and 18.47 % sugar content from the direct drilling and 78.6 t/ha and 18.17 % sugar content from the conventional tillage respectively. Becker (1997) expressed that there wasn't any statistically difference between direct drilling and conventional tillage methods.

In this study the objective was to determine the effects of six different sugarbeet cultivation methods on yield, internal quality, operational characteristics and cost.

Material and Methods

Field experiments were conducted in Turkish Sugar Factories Corporation, Ilgin Experimental Station, which is near Konya in Turkey in 1999, 2000 and 2001. Ilgin has territorial climate. The soil contained 2.02 % sand/kg, 32.16 % silt/kg, 65.82 % clay/kg and has a specific gravity of 2.57 Mg/m^3.

The field experimental layout was randomised block with four replicates. Each plot was of 10 m length and 6.75 m width. Tillage methods carried out in this study are shown in **Table 1**. Fifteen rows (45 cm row distance and 8 cm seed distance in a row) were drilled at the beginning and 7 rows in the middle of the plots were harvested for yield estimation at the harvest time. Genetically monogerm sugarbeet varieties produced by KWS were drilled in this study. Average thousand seed mass of this seed is 11.5 g and the power of germination is 90 %.

Massey Ferguson (MF) 275 tractor (55 kW) was used in this study. The same mechanical precision drilling machine was used for all treatments in this research. Working width was 2250 mm, row distance 450 mm, working speed 4-5 km per hour and point of seed falling height 80 mm. A narrow cultivator share was adapted in front of each unit for drilling directly into stubble. Thus, the seed drill was prevented from being clogged with stubble and other residue and the seeds were placed at an exact depth in the furrow.

Beet, samples which were taken from the harvested plots, were analysed in the experimental laboratory in the Sugar Institute and sugar content and quality values were determined. Refined sugar content (RSC) and refined sugar yield (RSY) were calculated as follows (Reinefeld et al., 1974; Akoglu, 1978):

$RSC = SC - [0.343 \cdot (Na + K) + 0.094 \cdot \alpha - N + 0.29)]$

$RSY = RY \cdot RSC,$

where RSC is refined sugar content (%), SC is sugar content (%), Na is sodium content (meq Na/100 g), K is potassium content (meq K/100 g), α - N is harmful nitrogen content (meq N/100 g), S is dry matter (%), RSY is refined sugar yield (t/ha) and RY is root yield (t/ha).

Effective area capacity was calculated as follows:

$B = 0.1 \cdot b \cdot v \cdot k,$

Where B is effective area capacity of implements or machine (ha/h), b is working width (m), v is working speed (km/h), k is time coefficient.

In this research, the working speed of the tractor was determined by using chronometer with 10^{-1} second indicator. Fuel consumption was measured with scaled plastic cylinder mounted above the tank lid and expressed as litre per hour and litre per hectare by means of measured fuel consumption and working speed data.

$FC = 3.6 \cdot MFQ / t$

$FC2 = FC \cdot TR,$

Table 2 Sugarbeet yield (t/ha)

Treatments	Year			
	1999	2000	2001*	1999-2001*
S1	75.1	71.2	64.9 a	70.4 a
S2	75.8	72.4	64.3 ab	70.8 a
S3	72.2	71.2	61.4 ab	68.3 ab
S4	70.7	67.1	59.0 ab	65.6 b
S5	73.5	70.3	58.9 ab	67.6 ab
S6	71.3	70.5	55.0 b	65.6 b

* $P < 0.01$

Table 3 Sugar content, refined sugar content and refined sugar yield determined in each year

Treat.	Sugar content, %				Refined sugar content, %				Refined sugar yield, t/ha			
	1999	2000*	2001	1999-01	1999	2000*	2001	1999-01	1999	2000	2001	1999-01
S1	16.54	19.35b	18.41	18.10	13.36	17.22bc	15.48	15.35	10.00	12.3	10.00	10.8
S2	16.36	19.33b	18.73	18.14	13.27	16.92c	15.75	15.31	10.10	12.3	10.10	10.8
S3	16.51	20.14a	18.83	18.49	13.52	18.10ab	15.74	15.79	9.76	12.9	9.66	10.8
S4	16.18	20.35a	19.20	18.58	13.17	18.39a	16.09	15.88	9.34	12.3	9.46	10.4
S5	16.28	19.95ab	19.40	18.54	13.32	17.96ab	16.35	15.88	9.81	12.6	9.61	10.7
S6	16.82	20.21a	19.36	18.80	14.00	18.22ab	16.22	16.15	9.98	12.8	8.90	10.6

* $P < 0.01$

Where FC is fuel consumption per hour (l/h), FC2 is fuel consumption per area (l/ha), MFQ is measured fuel quantity (ml), t is time passing through the plot (s) and TR is time requirement per ha (h/ha).

Labour consumption was determined in order to calculate labour cost. Labour consumption consisted of working time of tractor operator and the other needed workers during the operation. The labour cost was calculated using daily fee (7.5 hour) of labourer working for Turkish Sugar Factories (22.73 $ for 2000 and 24.38 $ for 2001).

Machinery cost including fuel cost, labour cost, machinery hiring fee, herbicide cost and total cost and net income was determined. Labour and total machinery cost were calculated as follows:

$LC = Lc \cdot LCPH$

$TMC = MHF \cdot TR$,

Where LC is labour cost ($/ha), Lc is labour consumption (h/ha), LCPH is labour cost per hour ($/h), TMC is total machinery cost ($/ha) and MHF is machinery hiring fee ($/h).

Total cost and net income were calculated as follows:

$TC = FC2 + LC + TMC$

$NI = GI - TC$,

Where TC is total cost ($/ha), NI is net income ($/ha) and GI gross income ($/ha).

Results were evaluated according to F-test, variance analysis and Duncan methods. Also double and cumulative variance analysis were applied.

Results and Discussions

Sugarbeet Yield

Sugarbeet yield which was obtained in 1999, 2000 and 2001 and three years combined Duncan test results are given in **Table 2**. The highest yield was obtained in S2 with 75.8 t/ha, 72.4 t/ha, 70.8 t/ha in 1999, 2000 and three years combined results, respectively and in S1 with 64.9 t/ha in 2001. The lowest yield was determined in S4 with 70.7 t/ha, 67.1 t/ha in 1999 and 2000 respectively and in S6 with 55.0 t/ha, 65.6 t/ha in 2001 and three years combined results respectively.

There was no significant difference between the methods in 1999 and 2000 as shown in **Table 2**. However the difference between the methods was significant in 2001 and three years combined results ($p < 0.01$).

Sugarbeet Internal Quality

Sugar content, refined sugar content and refined sugar yield results are given in **Table 3**.

The highest sugar content was obtained in S6 with 16.82 % in 1999, 20.35 % in S4 in 2000, 19.40 % in S5 in 2001 and 18.80 % in S6 in three years combined results. The lowest sugar content was determined in S4 with 16.18 % in 1999, 19.33 % in S2 in 2000, 18.41 % in S1 in 2001 and 18.10 % in S1 in three years combined results, respectively.

The difference between the methods was significant in 2000 ($p < 0.01$), however the difference between the methods was not significant in the other years and combined results. The highest refined sugar content was obtained in S6 with 14.00 % in 1999, 18.39 % in S4 in 2000, 16.35 % in S5 in 2001 and 16.15 % in S6 in three years combined results. The lowest sugar content was determined in S4 with 13.17 % in S4 in 1999, 16.92 % in S2 in 2000, 15.48 % in S1 in 2001 and 15.31 % in S2 three years combined results, respectively. The difference between the methods was significant in 2000 ($p < 0.01$), however the difference between the methods was

Table 4 Some measured parameters in each year

Year	Treatments	Fuel consumption		Labor consumption, h/ha
		l/h	l/ha	
2000	S1	31.04	51.50	7.80
	S2	29.08	55.80	8.60
	S3	23.16	30.10	5.00
	S4	18.93	18.10	2.50
	S5	24.33	34.20	4.60
	S6	10.53	7.70	1.30
2001	S1	31.43	40.10	6.10
	S2	30.43	44.70	6.90
	S3	26.21	31.10	4.30
	S4	20.16	19.60	2.50
	S5	25.81	24.80	4.30
	S6	11.23	8.00	1.20

Table 5 Cost, Gross margin and net income of the methods for 2000-01, $/ha

Treat.	Fuel cost		Labour cost		Machine cost		Total cost		Gross margin		Net income	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
S1	60.20	38.00	37.80	31.20	63.40	37.60	161.40	106.80	3,750	2,192	3,589	2,085
S2	38.80	26.30	25.80	22.40	38.20	23.30	102.80	72.00	3,810	2,208	3,707	2,136
S3	20.90	18.30	19.00	14.40	35.00	18.10	74.90	50.80	3,904	2,119	3,829	2,068
S4	12.60	11.50	7.80	8.20	14.60	11.40	80.10	76.20	3,715	2,078	3,635	2,002
S5	23.90	19.90	14.10	14.10	23.60	17.30	106.70	96.40	3,815	2,096	3,708	2,000
S6	5.40	4.70	4.10	4.00	7.90	5.90	62.50	59.70	3,876	1,952	3,814	1,892

not significant in the other years and combined results.

The highest refined sugar yield was obtained in S2 with 10.1 t/ha in 1999, 12.9 t/ha in S3 in 2000, 10.1 t/ha in S2 in 2001 and 10.8 t/ha in S1, S2 and S3 in three years combined results. The lowest sugar content was determined in S4 with 9.34 t/ha in 1999, 12.3 t/ha in S1 and S2 in 2000, 8.90 t/ha in S6 in 2001 and 10.4 t/ha in S1 in three years combined results, respectively. The difference between the methods was not significant in terms of refined sugar yield in each year.

Operational Parameters

Some measured parameters are given in **Table 4**. The lowest fuel consumption was measured in S6 with 7.7 and 8.0 l/ha in 2000 and 2001 respectively. The highest fuel consumption was measured in S2 in each year.

Cost Analysis

The calculated cost data for 2000 and 2001 are given in **Table 5**. The highest total cost was observed in S1 in each year. The lowest total cost was observed in S6 in 2000 and in S3 in 2001 respectively.

The highest net return was obtained in S3 with 3,829 $/ha in 2000, S2 with 2,136 $/ha in 2001 and S3 with 2,949 $/ha in two years combined results (**Table 5**). The lowest net return was obtained in S1 with 3,589 $/ha in 2000, S6 with 1,892 $/ha in 2001 and S4 with 2,819 $/ha in two years combined results.

Conclusions

The results of this study were summarised as follows:

1. The highest sugarbeet yield according to three years combined results was obtained in S2 with 70.8 t/ha. The yield was 70.4 in S1 and 68.3 in S3. The lowest yield was determined in S6 with 65.6 t/ha. The highest refined sugar yield and the lowest refined sugar content were also measured and calculated in S1 and S2. S6 gave the highest sugar content and refined sugar content. On the other hand, the lowest refined sugar yield was observed in S4 and S6.
2. The highest values in terms of operational parameters such as machinery time requirements, fuel and labour consumption were obtained in S1 and S2 and the lowest were S6.
3. When the methods were compared in terms of cost, S1 was determined to have the highest cost according to two years average results. The lowest cost was obtained in S6 and S3. Because the highest net income was determined in S3, chiselling may be a good alternative to the mouldboard plough. The close values were obtained between S2 and S3 in terms of net income. The lowest net income was determined in S4 and it was observed that the S6 had the lowest gross margin. In addition S6 gave better results than S1 in terms of net income.

In conclusion, S2 and S3 are regarded as the most suitable tillage methods in Middle Anatolia conditions in Turkey. In addition it was determined that S6 is successfully applicable in sugarbeet cultivation in the same area.

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