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Sunflower Yields and Energy Consumption as Affected by Tillage Systems

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Abstract: Effects of tillage systems on sunflower yield have been studied. Tillage systems were investigated as follows: conventional tillage system such as mouldboard plough and disc harrow and conservational tillage such as chisel with disc harrow and rotary tiller. Penetration resistance, bulk density, sunflower yield and energy requirement of tillage systems were measured. Soil bulk density and penetration resistance were affected significantly by the tillage systems. Soil bulk density and penetration resistance mean values in conventional tillage system were lower than the other systems. Sunflower yield and energy consumption were found lower in conservational tillage system than that of the conventional system.

Key words: Conventional and conservational tillage systems, sunflower yield, soil penetration

INTRODUCTION

Sunflower growth area has been extended in recent years in Turkey and approximately 800 000 tons of sunflower were produced on 470 000 ha area in 2003[1]. One of the problems of sunflower mechanization is tillage treatment. Besides that straw on the field area burned after first crop wheat harvest in order to make tillage easier for sunflower. Commonly sunflower is grown in a wheat-sunflower rotation. Different tillage systems are usually used to prevent of soil and water and to reduce energy consumption. A conservational tillage system has found application in areas of sunflower growth where conventional system has resulted in increasing the energy consumption.

Sunflower yield were affected by tillage systems, plant rotation, N fertilization and soil compaction. Tillage systems affected significantly the temperature, volume and moisture content of the soil and also yield of sunflower. The yield increased with an increasing tillage operation[2]. Tillage systems affected the growth of sunflower in a wheat sunflower rotation. Sunflower plants showed better early growth with higher N concentration in traditional tillage than in conventional tillage[3]. Sunflower cultivars of early and medium maturity were also affected by tillage systems (Conventional-till, CT; Minimum-till, MT; No-till, NT) and by N fertilization (34, 67 and 101 kg N ha^{-1}) within a dryland spring wheat-winter wheat-sunflower rotation. Sunflower seed yields were found greater in MT (1550 kg ha^{-1}) while 1460 kg ha^{-1} in NT and 1450 kg ha^{-1} in CT[4]. Soil compaction caused by wheel traffic affected the sunflower yield. wheel traffic applied rows and entire area after sunflower planting caused a decrease in yield by negatively affecting vegetative growth of plant[5]. No tillage (NT) and conventional-tillage (CT) systems and soil residual N affected the sunflower grain yield in semiarid climates. Tillage treatments and nitrogen-fertilizer rates (0, 50, 100 and 150 kg N ha^{-1}) were applied. Tillage system failed to exert a significant influence on any of the indexes studied except grain N content, which was found higher under CT than under NT[6].

This research was undertaken to determine the effects of tillage methods on soil properties related to the yield of sunflower crop and energy consumption.

MATERIALS AND METHODS

The trial was conducted in research field of Gaziosmanpasa University Research and Application Farm. After growing season of sugarbeet, sunflower was planted on 8 May 2001 and harvested on 20 September 2001. The experimental area comprised of two adjacent sites used for sugarbeet and sunflower rotation for several years. The experiment was conducted on clay textured soil and planned as Randomized Block Design in three repetitions.

In this research, for the tillage, conventional and conservational tillage treatments were applied in the following forms;

MD : Mouldboard plough and disc harrow
CD : Chisel and disc harrow
R : Rotary tiller

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Plots were 8 m wide and 28 m long. Tillage systems were applied to the plots randomly. The soils in the plots had the same texture initially. Sunflower variety Guardian 1 was planted in rows spaced 19 cm apart at the rate of 75187 seeds ha^{-1}. Standard tractor and the pneumatic precision planter weights were 2.91 and 0.64 Mg, respectively. The planter with vacuum pressure, holed disk and 4 rows was used in the experiment. Planting depth was set to 0.8 m and working speed was 5 km h^{-1}. Some characteristics of the tractor, tillage equipment and planter used in the experiment are given in Table 1 and 2.

Soil bulk density and penetration resistance were determined before and after tillage and after planting operation. Six samplings were taken for soil bulk density and penetration resistance per plot for tillage systems. Soil bulk density was determined by cylinder method[7]. Bulk density and gravimetric water content were taken from 0-15 and 15-30 cm soil depth as duplicate undisturbed samples in 100 cm^3 cylinders, after drying for 24 h at 105°C in the oven. These cylinders were approximately 10 cm in length. Soil penetration resistance was measured with a hand-pushing penetrometer having maximum measurement range 5000 kPa and 80 cm depth. The standard set of cone penetrometer has a cone with 30° tip angle, a standard cone base area (1 cm^2) and shaft diameter (8 mm). Soil penetrometer measurements were made by pushing vertically the penetrometer to the soil at an approximated speed of 2 cm s^{-1}[8].

Fertilizing and crop protection were uniform for the whole experimental field. Moisture contents by dry weight of different treatment locations were significantly different from one another. Bulk density and penetration resistance are usually used as the most important parameters of the soil physical status.

The energy consumption of the tillage systems was estimated by using the formulas:

$$Et = Em + Efu + Eh \quad (1)$$

Where, Et is total energy for tillage systems (MJ ha^{-1}); Em is energy of machine, (MJ ha^{-1}); Efu is energy of fuel for machine (MJ ha^{-1}) and Eh is energy of human (MJ ha^{-1}).

The mature sunflower crop was harvested and threshed by hand and crop yield was determined. Sunflower yield were estimated by harvesting in all eight rows in each plot. Wet weighting sunflower yields were obtained for each plot. To evaluate the datas, analysis of variance and LSD for mean comparisons were conducted[9]. Results from the experiment were analyzed as a Randomized Complete Block Design with split plot.

Table 1: Characteristics of the tractor used in the experiment

Power (kW)	56
Maximum motor rotation (min^{-1})	2. 16 x 10^3
Weight without operator (mg)	2. 91
Front axe weight (mg)	1. 21
Rear axe weight (mg)	1. 70
Distance between front and rear axes (m)	2. 30
Characteristics of front wheel	7. 50 - 16 (6 ply)
Characteristics of rear wheel	18. 40 - 15 / 30 (6 ply)

RESULTS AND DISCUSSION

Soil moisture content: Before tillage, the highest soil moisture content mean values were changed from 13.9 to 14.7% in MD tillage system and the lowest soil moisture content mean values were changed from 9.7 to 12.6% in R tillage system, respectively at the 0-15 and 15-30 cm soil depths.

After tillage, the highest soil moisture content mean values were measured in MD tillage system from 8.3 and 10.6% and the lowest soil moisture content mean values were measured in R tillage system by 7.4 and 9.1%, respectively at the 0-15 and 15-30 cm soil depths.

The tillage system and tillage statements affected the soil moisture content. The soil moisture content values were decreased by tillage statement (Table 3). Soil moisture content mean values in R tillage system were lower than the other tillage systems at the 0-15 and 15-30 cm soil depths.

Tillage decreased the moisture content by 40.3 and 27.9% in MD and 24 and 28% in R, at the at the 0-15 and 15-30 cm soil depths, respectively.

Similar results were also reported by Ulger *et al.*[2] that the moisture content was affected by tillage methods on sunflower. They found that the difference between tillage systems was significant.

Soil bulk density and penetration resistance: Before tillage, the highest soil bulk density mean values were changed from 1.3 to 1.4 g cm^{-3} in MD tillage system and the lowest soil bulk density mean values were changed from 1.2 to 1.3 g cm^{-3} in R tillage system, respectively at the 0-15 and 15-30 cm soil depths. After tillage, the highest soil bulk density mean values were changed from 1.0 to 1.2 g cm^{-3} in MD tillage system and the lowest soil bulk density mean values were changed from 1.1 to 1.2 g cm^{-3} in R tillage system, respectively at the 0-15 and 15-30 cm soil depths.

Before tillage, the highest soil penetration resistance mean values were changed from 2.5 to 4.2 MPa in R tillage system and the lowest soil penetration resistance mean values were changed from 2 to 3.6 MPa in MD tillage system, respectively at the 0-15 and 15-30 cm soil depths. After tillage, the highest soil penetration resistance mean

Table 2: Characteristics of the tillage equipment and planter

	Mouldboard plough	Disc harrow	Rotary tiller	Chisel	Pneumatic planter
Weight (mg)	0. 29	0.30	0.80	0. 34	0. 64
Working width (mm)	900	1500	2100	2200	2800
Working depth (mm)	250	80	90	400	100
Rotor diameter (mm)	-	-	480	-	-
Roller diameter (mm)	-	-	450	-	-
Spacing on the row (mm)	-	-	-	-	28-369

Table 3: The effects of tillage statement and tillage systems on moisture content (%)

Soil depth (cm)	Tillage statement	MD	CD	R	Mean	LSD values
0-15	BT	13.9	11.3	9.70	11.79a†	1.42
	AT	8.30	8.13	7.37	8.72b	
	Mean	11.10ab‡	9.60bc	8.53c		2.00
15-30	BT	14.7	12.4	12.6	13.38a†	0.97
	AT	10.6	10.4	9.07	10.60b	
	Mean	12.67ab‡	11.42bc	10.83c		1.36

BT: Before tillage; AT: After tillage; MD: Mouldboard plough and disc harrow; CD: Chisel and disc harrow; R: Rototiller;
† : The tillage and compaction means in the same group not followed by the same letter (within same line and column) are not significantly different according to Fisher protected LSD test (P= 0.05)
‡ : The compaction means in the same group not followed by the same letter (within same line and column) are not significantly different according to Fisher protected LSD test (P= 0.01)

Table 4: The effects of tillage statement and tillage systems on soil bulk density (g cm^{-3}) and penetration resistance (MPa)

Soil properties	Soil depth (cm)	Tillage statement	MD	CD	R	Mean	LSD Values
Bulk	0-15	BT	1.29	1.21	1.17	1.24	
density		AT	1.01	1.10	1.08	1.15	
		Mean	1.15b‡	1.16b	1.13b		0.16
Bulk	15-30	BT	1.42	1.35	1.33	1.37a†	7.96
density		AT	1.20	1.16	1.16	1.26b	
		Mean	1.31ab‡	1.26b	1.25b		0.16
Penetration	0-15	BT	1.97	2.48	2.47	2.28a‡	0.34
resistance		AT	0.80	1.27	1.00	1.35b	
		Mean	1.38b‡	1.76b	1.74b		0.49
Penetration	15-30	BT	3.60	4.05	4.22	4.03a‡	
resistance		AT	1.20	1.60	1.40	2.09b	
		Mean	2.40b‡	2.83b	2.81b		0.47

BT: Before tillage; AT: After tillage; MD: Mouldboard plough and disc harrow; CD: Chisel and disc harrow; R: Rototiller
† : The tillage and compaction means in the same group not followed by the same letter (within same line and column) are not significantly different according to Fisher protected LSD test (p=0.05)
‡ : The compaction means in the same group not followed by the same letter (within same line and column) are not significantly different according to Fisher protected LSD test (p=0.01)

Table 5: Mean values of energy consumption of tillage systems (MJ ha^{-1}) and sunflower yield (Mg ha^{-1})

Tillage systems	Energy consumption (MJ ha^{-1})	Yield (Mg ha^{-1})
MD	1558.7	2.60
R	716.9	1.34
CD	958.4	1.79

values were changed from 1.0 to 1.4 MPa in R tillage system and the lowest soil penetration resistance mean values were changed from 0.8 to 1.2 MPa in MD tillage system.

The tillage system and tillage statements affected the soil bulk density and soil penetration resistance. The soil bulk density and penetration resistance values were decreased by tillage statement while the soil bulk density and penetration resistance values were increased by soil depth (Table 4). Soil bulk density and penetration resistance mean values in MD tillage system were lower than the other tillage systems at the 0-15 and 15-30 cm soil depths.

According to tillage statement, the highest and the lowest changing ratio of soil bulk density mean values were found 27.7 and 14.7% decreasing in MD tillage system and R tillage system at the 0-15 and 15-30 cm soil depths, respectively. The highest and the lowest changing ratio of soil penetration resistance mean values were found 201 and 95.3% decreasing in MD tillage system and R tillage system at the 0-15 and 15-30 cm soil depths, respectively.

These results showed that tillage system followed by tillage statement might have a significant affect soil bulk density and penetration resistance. This is similar to results obtained by Ulger *et al.*[2] who reported that the difference between tillage systems was significant. With the moulboard plough, soil bulk density and penetration resistance decreased than the rototiller and chisel plough.

Yield and energy consumption: The maximum yield value was found in MD (2.60 Mg ha^{-1}) and the lowest in CD

(1.34 Mg ha^{-1}) tillage systems (Table 5). The energy consumption mean value was found similar tendency with yield of sunflower. The highest energy consumption was found in MD (1558.7 MJ ha^{-1}) and the lowest in CD (716.9 MJ ha^{-1}) tillage systems (Table 5).

Similar results were reported by Ulger *et al.*[2] that energy consumption values were significantly different in tillage systems. The yield and energy consumption of sunflower mean values were changed from 1.66 to 2.13 Mg ha^{-1} and 860.7 to 2164.1 MJ ha^{-1}, respectively among the tillage systems.

In conclusion, tillage system was affected soil moisture content, bulk density and penetration resistance. Soil bulk density and penetration resistance mean values in conventional tillage system were lower than conservational systems. Sunflower yield was lower in chisel and disc harrow conservational tillage system than conventional systems. But energy consumption was higher in moulboard plough conventional system than conservational system.

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