EFFECTS OF DIFFERENT CONVERSATION TILLAGE SYSTEMS ON SOIL PHYSICAL PROPERTIES IN WEST MEDITERRANEAN IN TURKEY

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Abstract

The study was conducted during two summer seasons (2012 and 2013) under Mediterranean area conditions (South of Turkey) to determine the effect of four tillage system (conventional tillage (T_1) "Plough + disc harrowing + float + pneumatic seeding machine", reduced tillage I (T_2) "rotovator + float + pneumatic seeding machine", reduced tillage II (T_3) "rotary tiller combination + pneumatic seeding machine" and no tillage (T_4) "seeding by direct seeding machine") on the soil physical properties in the area. The soil of the experimental parcel was classified as silty. There was no significant different statistically among soil porosities of tillage systems in all depths at after tillage and harvesting operation. For variation though conversation tillage methods, tillage methods X measuring time, tillage methods X depth and tillage methods X measuring time X depth interactions were significant statistically for four tillage systems ($p<0.001$).

Key words: conversation tillage, maize, soil properties, penetration resistance.

INTRODUCTION

Farming systems today have more obvious and detectable social, ecological, economic, and environmental implications than ever before because of the growing concerns about agricultural sustainability and the environment (SHRESTHA AND CLEMENTS, 2003). "Agricultural sustainability implies an increasing trend in per capita productivity to meet the present needs without jeopardizing the future potential. This demands appropriate methods of land stewardship for the development of sustainable agricultural systems".

An important aspect of land stewardship is tillage that important to provide the correct conditions for crop establishment and growth, and in general, requires mechanical manipulation of the soil by equipment that either cuts, shatters, inverts or mixes the soil (CANNELL, 1985; GAJRI ET AL., 2002). Tillage is performed in order to optimize productivity by alleviating physical, chemical and biological constraints of soil (GAJRI ET AL., 2002). Current tillage systems can be divided into two broad categories; inversion tillage, known as conventional plough tillage, and non-inversion tillage, known as conservation tillage including minimal tillage and direct drilling (DAVIES AND FINNEY, 2002).

The tilth or soil condition resulting from the use of different tillage tools depends on both the type of implement used and the soil condition. At present, it is not possible to adequately predict the resulting soil conditions from a tillage practice (TAPELA AND COLVIN, 2002). Studies have shown that tillage practices alter soil physical properties (BARZEGAR ET AL., 2003), influencing the water storage and hydraulic conductivity of soil and consequently the hydrological behavior of agricultural watersheds (XU & MERMUD, 2001). Tillage treatments affect the soil physical properties, especially when a similar tillage system has been practiced for a long period (JORDHAL & KARLEN, 1993; MIELKE & WILHELM, 1998). BUSCHIAZZO ET AL. (1998) reported that tillage systems had greater influence on the soil physical properties in a humid climate and in loamy soils compared to that in an arid climate and sandy soils. Soil physical properties mediate several physical chemical, and biological processes in soil that should be kept optimal (LAL, 1991). Therefore, it is important to apply a proper tillage system that results in the soil sustaining physical properties suitable for the successful growth of agricultural crops.

Although a lot of literature on tillage is available, still the degree in which various tillage operations alter soil physical properties is poorly understood and cannot be adequately predicted (CRUSE AND LINDEN, 1980).

"The soil physical properties are important in determining plant growth and yield. It has been realized for many years that low productivity of soil may be associated with unfavorable physical conditions for growth such as infiltration rate, soil bulk density, soil mechanical resistance to penetration, and water percolation and distribution".

Soil physical properties such as dry bulk density, moisture storage capacities, porosity and resistance to penetration were commonly assessed and evaluated to detect the influence of different tillage practices on soil and crop growth and yield. Therefore, an experiment was conducted at Antalya, Turkiye to examine the prospective effects of tillage practices on physical properties of soil in the area to cultivate second crop maize (*Zea mays* L.) after tillage and harvesting operation.

MATERIALS AND METHODS

Work area and soil

This experiment was conducted at the Bati Akdeniz Agricultural Research Institute, Antalya, Turkiye, during two summer seasons (2012 and 2013). The soil in the experiment field was a clay silty with pH of 7.5 and organic matter matter content of 1.8%. The results of soil analyses are given Tab. 1. The average weather conditions during growing seasons such as annual temperatures and rainfall etc. are showed in Tab. 2.

Tab. 1. – The result of soil analyses

pH (1:2.5)	7.5
Lime (%)	19.6
EC micromhos/cm (25°C)	195
Sand (%)	21
Clay (%)	33
Silty (%)	46
Organic matter (%)	1.8
P ppm	16
K ppm	250
Ca ppm	4585
Mg ppm	409

Tab. 2. – Average climate dates of a long-term at the site of experimentation

	May	June	July	August	September	October
Temperature (°C)	20.4	25.4	28.4	28.1	24.7	19.8
The highest Temperature (°C)	25.9	31.3	34.4	34.3	31.3	26.7
The lowest Temperature (°C)	14.8	19.4	22.5	22.4	19.1	14.9
Sunshine duration (hour)	9.5	11.4	11.5	11.3	9.5	8.0
Number of rainy days	5.0	2.4	0.7	0.5	1.7	5.4
Rainfall (kg/m^2)	29.3	7.1	3.3	1.6	11.0	74.8

The experiment, which was begun in June 2012 and finished 2014 compared four tillage systems for maize (*Zea mays* L.) production following a wheat-maize rotation. Seeds of maize (Zea mays saccharata Sturt.) were used in this study. The standard cultural practices recommended by Batı Akdeniz Agricultural Research Institute; other than treatments, were followed throughout the growing seasons.

The experiment was established as a randomized block design with four replications. Plots were 5 m wide (four rows) and 25 m long with an inter row spacing of 0.7 m distance. After the field had been selected and before the application of the treatments, the land was freed from weeds and crop residues except the no-tilled plots. The experimental procedures were the same for the both seasons.

Tab. 3. – Soil tillage methods utilized in experiments

Tillage systems	Tillage operations
T_1 (conventional tillage)	plough + disc harrowing + float + pneumatic seeding machine
T_2 (reduced tillage I)	rotovator + float + pneumatic seeding machine
T_3 (reduced tillage II)	rotary tiller combination + pneumatic seeding machine
T_4 (no tillage)	Seeding by direct seeding machine

Conservation Tillage Systems

Tillage systems are shown in Tab. 3 and the specifications of the tools used in the experiment are given Tab. 4.

For the conventional tillage method, the soil was first ploughed with five bottom moldboard plough. After plowing, the field was harrowed with disc harrow and leveled with float. In the reduced tillage method I, soil was prepared for seeding with only one pass of soil tillage, float and pneumatic seeding machine. In the reduced tillage method II, soil was prepared for seeding with only one pass of soil tillage with rotary tiller combination and then pneumatic seeding machine. For the direct seeding application, seeding was made without tillage. Massey Ferguson 5400 (Engine Power 105 HP) tractor was used in the experiments.

Tab. 4. - The specifications of the tools used in experiments

Tools	Avarage speed (km h^{-1})	Working depth (mm)	Working width (mm)
Plough	5.5	300	1500
Disc harrowing	6.5	150	2200
Rotovator	6	220	2000
Rotary tiller combination	2.8	200	2500
Float	7	-	3000
Seeding machine	6.3	40-50	2800
Direct seeding machine	5.6	40-50	2800

Investigations and data collection

Soil samples were collected from the field with three replications on each plot after tillage and harvesting operation at 0–30 cm for bulk density, porosity, moisture content and penetration resistance at 0-60 cm

The determination of water content of soil (% d.b.) was carried out twice during the season. The first one was done before tillage operations and the second one was done before harvesting. Samples were transported to the laboratory and then oven dried at 105°C for 24 hours to determine dry-basis gravimetric soil water content.

Dry bulk density of the soil was determined after tillage and harvesting operations both seasons using the clod method (BLACK ET AL., 1965). Soil samples were randomly taken from each strip-plot from 0-30 cm soil depths.

Total porosity (φ) was obtained through the following equation:

$$\varphi = \left(1 - \frac{\delta b}{\delta r}\right) x100 \qquad (1)$$

Where δr was the soil particle density assumed to be 2.65 Mgm^{-3} and δb was the soil bulk density

Soil resistance to penetration was measured after tillage and harvesting operations both seasons using a manually operated cone penetrometer. Three samples were randomly taken from each strip-plot using a cone with a 2.0 cm^2 area from soil depths of 0-10, 10-20, 20-30, and 30-40, 40-50, 50-60 cm, then converted to MPa.

RESULTS AND DISCUSSION

Soil moisture

Data pertaining to soil moisture content at 0-30 cm depth before the tillage operation and after harvesting during 2012-2103 growing season the second growing period of maize are presented in the Tab. 5.

Maximum soil moisture contents were observed in soil tilled with T4 at 20-30 cm soil depths followed by that in soil tilled with T3 at 20-30 soil depths after tillage and harvesting operation, maximum soil moisture content were determined in soil tilled with T4 at 20-30 cm soil depths followed by that in soil tilled with T3 at 20-30 cm soil depths during both years. These results are in agreement with those reported by BOYDAS AND TURGUT (2007), RASHİDİ AND KESHAVARZPOUR (2008).

Soil bulk density

The results found to soil bulk density at 0-30 cm depth after the tillage and harvesting operation during 2012-2103 the second growing period of maize are shown in the Tab. 6.

Tab. 5. - Effect of Conversation Tillage Systems on Soil Moisture content (2012-2013 growing season)

		T1	T2	T3	T4	CV	LSD	Sign.
After tillage	0-10	18.42	20.36	19.35	21.26	1.622	0.011	***
	10-20	20.40	21.37	22.32	21.16			N.S
	20-30	21.90	22.01	22.24	22.40			N.S
After harvest	0-10	22.21	20.07	18.61	21.35	0.841	0.022	***
	10-20	23.01	22.93	23.41	23.90			N.S
	20-30	23.24	22.93	23.93	24.64			N.S

Tab. 6. – Effect of Conversation Tillage Systems on Soil bulk density (2012-2013 growing season)

		T1	T2	T3	T4	CV	LSD	Sign.
After tillage	0-10	1.305	1.304	1.306	1.287			N.S
	10-20	1.296	1.288	1.303	1.309	1.214	1.021	**
	20-30	1.309	1.299	1.308	1.311			N.S
After harvest	0-10	1.307	1.298	1.294	1.305			N.S
	10-20	1.295	1.308	1.300	1.305			N.S
	20-30	1.295	1.309	1.284	1.311	1.678	0.265	***

For After tillage operation, the lowest soil bulk density (1.28 $g.cm^{-3}$) was recorded in soil tilled with T2 at 10-20 cm soil depths and for after harvesting operation, the lowest soil bulk density (1.284 $g.cm^{-3}$) was recorded in soil tilled with T3 at 20-30 cm soil depths. BARZEGAR ET AL. (2003) also observed significant differences in soil bulk density among tillage practices and these results are in agreement with RASHİDİ AND KESHAVARZPOUR (2008), KARAYEL AND OZMERZİ (2003).

Soil bulk porosity

Soil porosity as a function of depth (0-30 cm) and conversation tillage systems are shown in Tab. 7, after the tillage and harvesting operation during 2012-2103 the second growing period of maize.

Tab. 7. – Effect of Conversation Tillage Systems on Soil porosity (2012-2013 growing season)

		T1	T2	T3	T4	CV	LSD	Sign.
After tillage	0-10	0.420	0.420	0.423	0.423	-	-	N.S
	10-20	0.427	0.450	0.443	0.417	-	-	N.S
	20-30	0.417	0.420	0.417	0.427	-	-	N.S
After harvest	0-10	0.433	0.430	0.430	0.431	-	-	N.S
	10-20	0.413	0.440	0.423	0.430	-	-	N.S
	20-30	0.427	0.430	0.417	0.420	-	-	N.S

The result of the soil samples analyses in terms of soil porosity after tillage operation and harvest operation are shown for four different conversation tillage system in Tab. 3. As you see, the porosity of samples at 0-30 cm soil dept was over 40% for all tillage systems. There was no significant different statistically among soil porosities of tillage systems in all depths at after tillage operation and harvesting operation. After tillage operation, the lowest soil porosity (41.7 %) was recorded in soil tilled with T1 and T3 at 20-30 cm soil depths. After harvest operation, the lowest soil porosity (41.3 %) was found in soil tilled with T1 at 10-20 cm soil depths. The similar results were determined by BARUT AND AKBOLAT (2005) and OZPİNAR AND CAY (2005).

Soil penetration resistance

The result of penetration different point in the field in terms of soil penetration resistance After tillage operation and harvesting operation are explained for different conversation tillahe system in 2012-2013 growing season in Fig. 1 ve Fig. 2.

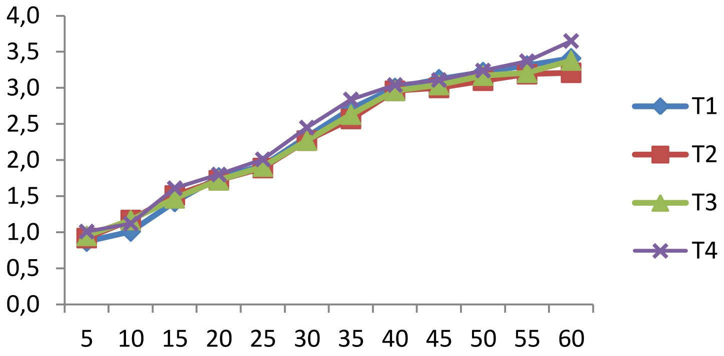

Fig. 1. – Soil penetration resistance (0-60 cm) before tillage harvesting operation

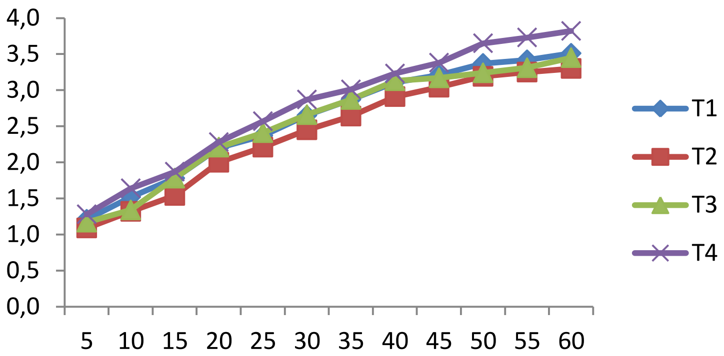

Fig. 2. – Soil penetration resistance (0-60 cm) after harvesting operation

As you see in Tab. 4, soil penetration resistance for all tillage system increase with soil depth (0-60 cm). After tillage operation, the highest soil penetration resistance (3.65 and 3.41 MPa) was recorded in soil tilled with T4 and then T1 at 0-60 cm soil depths, respectively. After harvesting operation, the highest soil penetration resistance (3.82 and 3.51 MPa) was found in soil tilled with T4 and then T1 at 0-60 cm soil depths, respectively. OSUNBİTAN ET AL. (2004) reported that soil penetration resistance for different tillage methods increased with soil dept. For variation though conversation tillage methods, tillage methods X measuring time, tillage methods X depth and tillage methods X measuring time X depth interactions were significant statistically for four tillage systems ($p<0.001$).

CONCLUSIONS

As a result of study, conversation tillage system significantly affected soil penetration resistance, dry bulk density, moisture content in all depths at after tillage and harvesting operation. There was no significant different statistically among soil porosities of tillage systems in all depths at after tillage and harvest operation. For variation though conversation tillage methods, tillage methods X measuring time, tillage methods X depth and tillage methods X measuring time X depth interactions were significant statistically for four tillage systems ($p<0.001$). The no tillage system produced the highest soil penetration resistance both after tillage and harvesting operation in 0-60 cm soil depth.

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