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Effects of Different Tillage Methods on Soil Physical Properties under Second Crop Sesame in the Harran Plain, Southeast Turkey

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Abstract: This study was addressed for determination of the best soil tillage method in sesame production. A replicated randomized complete block design with the treatments of cultivator and scrubber (T_1), rotarytiller and roller (T_2), plough, rotarytiller and roller (T_3) and rotary cultivators for row crops and scrubber (T_4) has been conducted for three years at the Sanliurfa Rural Affairs Research Institute in Turkey. In this study, four different tillage systems were compared in terms of their effects on some physical properties of soil (bulk density, penetrometer resistance and porosity), fuel consumptions, labor and time efficiency and crop yield. In the research, second crop sesame was planted as rotational crop with four different tillage applications. The purpose of this research was to determine the best tillage method to provide the most reliable environmental conditions for sesame growth. Statistical analyses were used to compare the different soil tillage methods. Statistical results indicated that all of the tillage parameters were significant. The results of this research were indicated that the T_2 tillage method had the highest bulk density results and the highest crop yield (473.84 kg ha^{-1}). On the other hand, the T_3 method had the highest porosity values. The penetrometer resistance values of soils were decreased by all tillage applications from average 3.7 to 2.0 MPa. It was suggested that T_2 (Rotarytiller and roller) method can be used in sesame farming for the proper soil physical properties and the highest crop yield.

Key words: Second crop, sesame, tillage systems, Harran Plain

INTRODUCTION

In the world and Turkey sesame production is as average of 3,257,448 Mt and 22,000 Mt, respectively (FAO, 2004). Sesame production in the Southeast Anatolian Project (GAP) region is low and sesame planted area in Sanliurfa is about 40% of total planted land in the GAP region. However, sesame production is only 21% (Anonymous, 2001).

The main goal in agricultural production is to improve the yield and quality of the harvest and to increase profits. Another way to increase profits is to reduce the use of agricultural inputs. Among the agricultural inputs, the effect of agricultural mechanization is remarkably important for increasing agricultural production. When the use of agricultural machinery is considered, the importance of the soil tillage and seed bed preparation processes cannot be ignored (Yalcin *et al*., 2002).

Annual ploughing to the same depth (normally 20-25 cm) results in plough pan on clay soils. On the other hand, the mouldboard plough embeds the residues, weeds, minerals and organic fertilizers and improves the soil's physical condition. However, a disc harrow is used as a complete replacement of the mouldboard plough in minimum tillage systems to cut and mix the soil (Silva and Soares, 2000).

Minimum tillage and no-till planting reduces the erosions, conserves the soil and reduces the fuel consumption that allows the fuel saves. But there are some problems regarding to the soil type and the location of the application of no-till planting in some plants. More researches are needed to solve the problems associated with minimum tillage and no-till planting and increase the application of these methods (Yalcin *et al*., 2005).

Some physical soil constraints on seedling emergence and the yield consist of the soil penetration resistance, bulk density and soil porosity (Letey, 1985). The bulk density is used to evaluate tillage and crop management effects on soil quality and vital information to assess seedbed properties (Logsdon and Douglas, 2004). Penetration resistance of the soil can be regarded as other factor determining the quality its structure. Soil

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porosity plays a critical role in the sustaining soil quality of agricultural soils (Kay and Vanden Bygaart, 2002).

At the completed some studies some properties with different tillage systems and sesame farming were determined. At the completed a studies on sesame in USA, it was determined which is 1-15 may of seeding time, narrow rows is check to wild herbals and which is increase of crop (Yermanos, 1960). It was stated to requesting to seeding to 400-1000 g da^{-1}, 60-70 cm of row distance and 1.5-2.5 cm of seeding depth (Anonymous, 1990). In the farm lands of South east Anatolia project (GAP), it was stated as significant a branch to second crop farming after cereal farming in region with to start of productive to irrigation farming. Barut and Akbolat (2005) evaluated the conventional and conservation tillage systems for maize. They found the yield in conventional systems. However the lowest time and fuel consumption were found 4.0 h ha^{-1} and 28.8 L ha^{-1}, respectively on conservation tillage. McGonigle *et al.* (1999) aimed to determine if similar responses occur in maize-soybean rotations, which are more typical of current farming in Ontario, Canada. Similar responses were expected because both are AM crops and the mechanism by which tillage reduces P uptake is thought to be a negative impact on the development of effective mycorrhizae. Ozpinar and Cay (2005), researched to effects of minimum and conventional tillage systems on soil properties and yield of winter wheat. They recommend rotarytiller to be adopted for economic and higher crop production. Yalcin *et al.* (2005) studied on effects of reduced tillage and planting systems on seed cotton yield and quality. They found to conclude that reduced tillage systems were more advantageous than conventional tillage systems. Shafiq *et al.* (1994) reported to soil parameters that are adversely affected bye comparison or loosening of soil particles are those that control the content and transmission of water, air, heat and nutrients. Bayer *et al.* (2002) determined to stocks and humification degree of organic matter fractions as affected by no-tillage on a subtropical soil. This study aimed to compare the long-term (9 year) effects of no-tillage (NT) and Conventional Tillage (CT) on C and N stocks in the two above mentioned organic fractions in a Brazilian Acrisol. Galvez *et al.* (2001) studied populations of spores of VAM fungi, mycorrhiza formation and nutrient utilization of maize (*Zea mays* L.) grown in moldboard plowed, chisel-disked or no-tilled soil under conventional and low-input agricultural systems. They were determined that the effect of tillage was consistent through all growth stages, with higher P use efficiencies in plants under moldboard plow and chisel-disk than under no-till and plants grown in no-tilled soils had the highest shoot P concentrations throughout the experiment.

The objective of this study was to examine the four different tillage systems in the GAP region under second crop sesame farming. The tillage systems were analyzed in terms of some physical properties of soil (Penetrometer resistance, bulk density and porosity), fuel consumption, labor requirements and crop yield.

MATERIALS AND METHODS

This research was carried out in Sanliurfa (GAP Region in Turkey) Rural Affairs Research Institute. Study area average annual rainfall, temperature and relative humidity are 364.0 mm, 17.2°C and 50%, respectively. None irrigated crops produced in the area are cereals, lentil and sesame. In irrigated areas growing crops are cotton, fruit, second crop corn, clover and vegetables.

Research was carried out as three replications to split plot trial designed of coincidence blocks and used to local sesame cultivar. Parcel areas were 40.0×11.20 m = 319.20 m^2 and planting row distance was 70 cm. For determining effect of which crop yield and plant growth of four tillage were evaluated with variance analysis test (Acikgoz *et al.*, 1993). Research field was prepared for four tillage methods. Tillage was named as "T" and following farm machineries were used.

Used tillage machineries

Method 1: Cultivator and scrubber (T_1)
Method 2: Rotarytiller and roller (T_2)
Method 3: Plough, rotarytiller and roller (T_3)
Method 4: Rotary cultivators for row crops and scrubber (T_4)

In this research, with different tillage practices and fertilizer and irrigation were applied to the plots. The MF tractor with 70 BG was used to operate the whole tillage operations. Penetrometer measurements were taken until 50 cm depth from the soil before and after tillage using a penetrologger (Eijkelkamp equipment, Giesbeck, the Netherland). Soil samples were taken from 0-10, 10-20 and 20-30 cm depths as disturbed and undisturbed before and after tillage. Soil samples were tested for bulk density using methods described by Blake and Hartge (1986), respectively. The soil porosity (n) was computed by using the following relationship (Osunbitan *et al.*, 2004).

$$n = (1-\rho_d/\rho_d);$$

Where: ρ_d is soil bulk density and ρ_d is particle density (assumed to be 2.65 g cm^{-3})

In this study, forward speed and fuel consumption were measured and from the data, slip, tillage efficiency and fuel consumptions per plot were calculated.

RESULTS

Soil bulk density: The results of the soil sample analyses in terms of bulk density for before tillage and after tillage are presented four different tillage applications in Fig. 1 and 2. Obtaining samples before tillage at 0-10, 10-20 and 20-30 cm depths for soil bulk density showed the highest values in T_2 tillage methods (cultivator and scrubber). At before tillage sampling T_1 values were found as 1.39, 1.38 and 1.53 g cm^{-3}. After tillage T_1 values were 1.37, 1.44 and 1.47, respectively for different depths. There was a clear difference among 0-10, 10-20 and 20-30 cm layers for same tillage methods. Soil bulk density was found 1.61 g cm^{-3} as the highest value for T_2 at 20-30 cm depth. Osunbitan *et al.* (2004) have reported as similar observed significantly higher bulk density under no tillage. They were stated that the bulk density increased with time after tillage for all tillage treatments as the soil gradually get compacted under the influence of rainfall and particle resettlement. Lampurlanés and Cantero-Martínez (2003) were reported that the effect of tillage on bulk density was significant in the three strips. They were found that the bulk density was greater for no-tillage system (mean of 1.34 g cm^{-3}), medium for minimum tillage methods (1.27 g cm^{-3}) and lower for subsoil tillage methods (1.22 g cm^{-3}) based on the tillage intensity. Singh and Malhi (2005), Barut and Akbolat (2005) and Ozpinar and Cay (2005) also reported the similar results for different tillage methods and different crops.

Soil porosity: The results of the soil sample analyses in terms of soil porosity before and after tillage are presented for four different tillage practices in Fig. 3 and 4. The porosity of the sample at 0-10 cm depth was over 39% for all of tillage methods. There was no significant difference among soil porosities of tillage methods in all soil depths

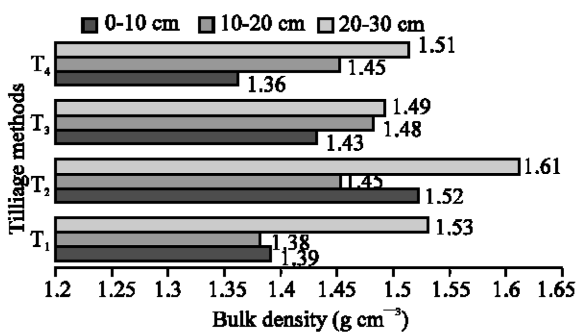

Fig. 1: Bulk density mean values of soil samples at different soil depths at the beginning of the study (before tillage applications)

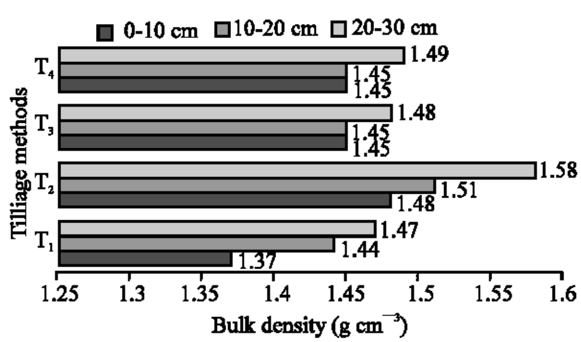

Fig. 2: Bulk density mean values of soil samples at different soil depths at the end of the study (after tillage applications)

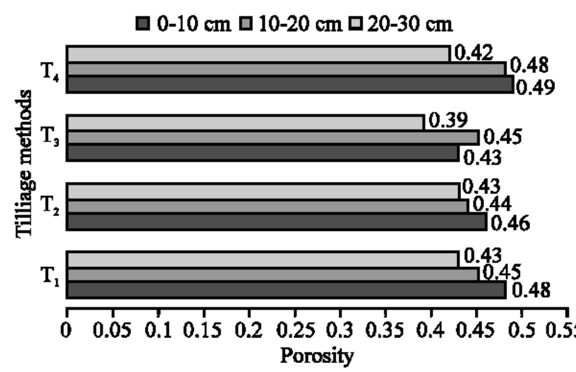

Fig. 3: Porosity mean values of soil samples at different soil depths at the beginning of the study (Before tillage applications)

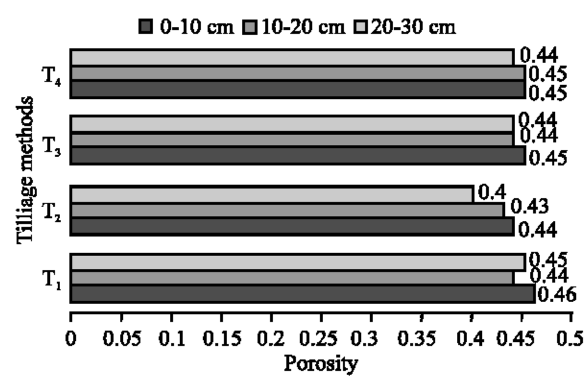

Fig. 4: Porosity mean values of soil samples at different soil depths at the end of the study (after tillage applications)

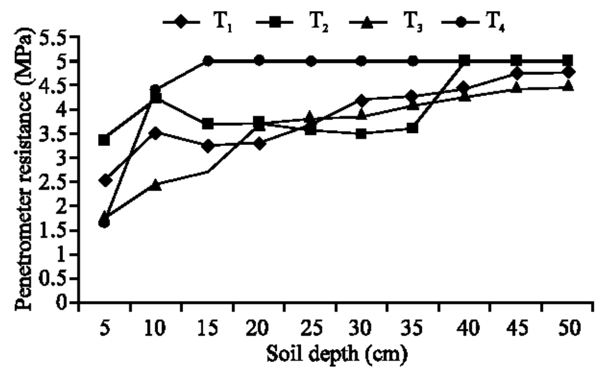

Fig. 5: Penetration resistances of study soils before tillage methods

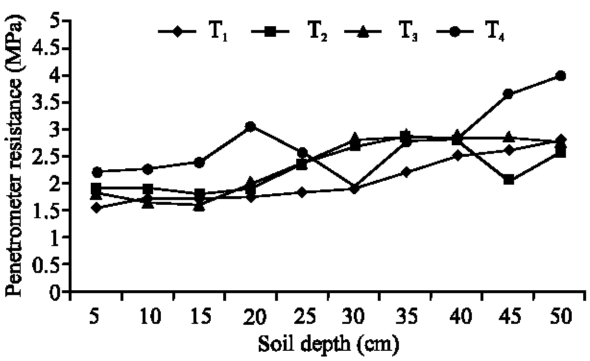

Fig. 6: Penetration resistances after tillage methods

Table 1: The fuel consumption and task time using as a function of different tillage methods

Tillage methods	Fuel consumption (L ha^{-1})	Task time using	
		Task time using for manpower (h ha^{-1})	Task time using for machine (h ha^{-1})
T_1	25.9	7.7	7.00
T_2	37.6	9.3	8.55
T_3	62.9	14.0	13.00
T_4	21.1	7.6	7.15

at before and after tillage. Before tillage, the highest porosity value was founded as 49% at T_4 method in 0-10 cm soil samples; however the lowest value was founded as 39% at T_3 methods in 20-30 cm soil samples. After tillage, the highest value was founded as 46% at T_1 methods in 0-10 cm samples, but the lowest value was founded as 40% at T_2 methods in 20-30 cm. Generally, there was no significantly difference among the four different tillage methods. Osunbitan *et al.* (2004) reported increasing porosity at the soil surface (0-5 cm) with 8-week period of the intensive soil manipulation by tillage. The similar results were reported by Singh and Malhi (2005), Barut and Akbolat (2005), Kasap and Coskun (2006) and Ozpinar and Cay (2005).

Soil penetration resistance: Soil penetration resistance as a function of depth, measurement date and tillage treatments are shown in Fig. 5 and 6. Penetration resistance for all treatments showed an increasing trend with depth. For variation though tillage systems, tillage system×soil depth interaction, tillage system×measurement date and tillage system×soil depth×measurement date interactions were very significant in the four methods ($p<0.0001$). Penetration resistances of T_1, T_2 and T_3 tillage methods before tillage in the topsoil layer (0-20 cm) were found below 3.5 MPa, but for T_4 method the value was over 4.5 MPa. At same soil depth (0-20 cm) penetration resistances after tillage were found similar results for all tillage methods. But at the 0-20 cm soil layers penetration resistances after harvesting were found over 3.50 MPa for all tillage methods. At all tillage methods the highest penetration resistance values obtained in T_4 (<4 MPa). Kasap and Coskun (2006) observed that penetrometer resistances of soil for different tillage systems increased with soil depth. Ulger *et al.* (1993) reported that the difference between tillage systems was important. They indicated that soil penetration resistance more decreased with mouldboard plough than the rototiller and chisel plough. Osunbitan *et al.* (2004) reported to the soil's penetration resistance generally increased with increasing depth for all treatments while the time after tillage operations had no significant effect on penetration resistance of the plots. They reported reduction in soil penetration resistances with the intensity of soil manipulation during tillage. Zhang *et al.* (2001) determined an important increase in the soil penetration resistance and increase in share stress with increase in bulk density and they were reported this to lower saturation of the soil with high bulk density compared with the low density soil at the same potential and this tend to increase its adhesion on the soil with lower bulk density.

The fuel consumption and task time using: The fuel consumption and task time using as a function of tillage methods are shown in Table 1. The highest fuel consumption was determined as 62.9 L ha^{-1} in T_3 method (Plough, rotarytiller and roller), whereas the lowest fuel consumption was 21.1 L ha^{-1}. The lowest task time for a manpower was found 7.6 h ha^{-1} in T_4 method (Rotary cultivators for row crops and scrubber), but the highest task time for manpower was found 14.0 h ha^{-1} in T_3 method. The task time for using machine was highest as 13.0 h ha^{-1} in T_3 method, whereas the lowest task time for using machine was found 7.0 h ha^{-1} T_1 (Cultivator and scrubber). Ulger *et al.* (1993) reported similar energy

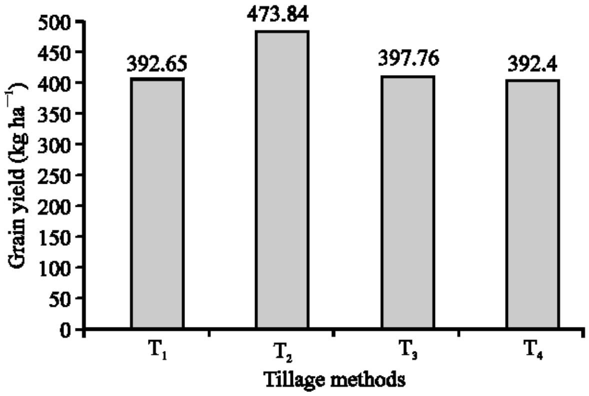

Fig. 7: Grain yield under different tillage methods for sesame (kg ha^{-1})

consumption values that were significantly affected with different tillage methods.

Crop yield: The highest yield value was of 473.84 kg ha^{-1} at T_2 (Rotarytiller and roller) as compared to other tillage systems. The lowest yield values was found 392.40 and 392.65 kg ha^{-1} in T_4 (Rotary cultivators for row crops and scrubber) and T_1 (Cultivator and scrubber), respectively. The interaction of year×tillage methods was not significant, but tillage method was found as significant ($p<0.005$) (Fig. 7).

CONCLUSIONS

Tillage system affected soil bulk density, porosity, penetrometer resistance, fuel consumption and task time using and crop yield.

Overall it can be concluded that;

- Soil bulk density and porosity were not changed significantly after tillage at all of tillage methods. However, at T_2 tillage method bulk density was the highest among the all tillage methods,
- At after tillage, penetrometer resistance was significantly reduced. Among tillage methods penetrometer resistance was found as highest at T_4 method than the other methods at all soil depths,
- The T_4 method was more advantageous than other tillage methods when fuel consumption and task time using were considered,
- The sesame grain yield with T_2 method was the highest among all other methods, but with T_1 and T_4 methods the grain yield was the least.

Finally, It was suggested that T_2 (Rotarytiller and roller) method can be used in sesame farming for the proper soil physical properties and the highest crop yield.

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