ORIGINAL PAPER

TILLAGE EFFECTS ON SUNFLOWER (HELIANTHUS ANNUUS, L.) EMERGENCE, YIELD, QUALITY, AND FUEL CONSUMPTION IN DOUBLE CROPPING SYSTEM

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ABSTRACT

The relation between crop growing and soil tillage treatment are play important role in agricultural production. Soils under conventional tillage (CT) generally have lower bulk density and associated higher total porosity within the plough layer than under no tillage (NT). No-till farming can reduce soil erosion, conserve soil moisture and minimize labor and fuel consumption. The aim of this study were to investigate the effects of conventional, reduced and no-tillage methods on soil physical properties, sunflower yield and yield components, protein and oil content and fuel consumption in Southeastern of Turkey. Six tillage methods for the second crop sunflower were tested and compared each other within after lentil harvesting at 2003 and 2004 years in a clay loam soil. According to results, the first year, the bulk density had decreased from 1.29 to 1.09 g cm^{-3}, the second year the δb had decreased from 1.41 to 1.23 g cm^{-3}. Differences between years and tillage methods in terms of yield were found significant ($p<0.05$). However, no differences were found between the NT and CT. There were also no significance differences in content of protein, oil and ash among six tillage methods. The highest fuel consumption was measured in conventional method (CT) whereas the lowest value was found in direct seeding method as 33.48 L ha^{-1} and 6.6 L ha^{-1}, respectively.

Key words: Tillage, fuel consumption, soil physical properties, sunflower, yield

INTRODUCTION

The main objective in agriculture production, so far, focused mostly on the increase of yield and production. Meanwhile, economic production and sustainable agriculture are in getting attention improvement in product quality, reduction in production inputs, conservation the natural resources, and environmental awareness gain importance [24]. Tillage practices are needed to increase agronomic stability and productivity while enhancing the environment [11].

For this reason, sustainable farming and conservation tillage are becoming increasingly attractive to because clearly reduces production cost relative to conventional tillage [6]. In conservation tillage, plants residues remain on the soil surface. They decompose slowly when they are left on the surface. Over the time, a layer of mulch will develop on the soil surface. The mulch layer not only protect the soil from erosion, but will also increase the amount of rainfall that soak into the ground, keeping the water in the soil from evaporating into the atmosphere[9].

Sustainable farming and increasing the cost of fuel in soil tillage operations force farmers to change the farming methods and forces to find alternative economic tillage treatment. Minimum tillage and direct tillage are some of methods that farmers apply recently for a long term erosion free farming at lower fuel cost. Considering the negative effect of intensive farming in the field direct seeding becomes more vital for farmers to establish the nature of the soil and the flora allowing natural plant growth with less plant protection problems [2, 27].

In order to combat soil loss and preserve soil moisture, attention has been focused on conservational tillage involving soil management practices which minimize the disruption of the soil structure [23]. Maintenance of crop residues on the soil surface is widely recognized for its positive effects on soil and water conservation. Benefits of residue cover left on soil include improved soil water storage, enhanced organic matter content of soil, nutrient recycling and protection against water and wind erosion [11,13,15]. Also, conservational tillage systems may help less use of fossil fuels and reduced labor requirement, reduce environmental problems, such as soil degradation and decline in biodiversity, related to intensive cropping [4,8,17].

Conservation tillage leaves most or part of crop residues on the soil surface, thus effecting chemical, biological, and physical properties of soil. Soil temperature, water content, bulk density, porosity penetration resistance and aggregate distribution are some of the physical properties affected by tillage systems. Changes in soil physical properties due to use of no-tillage depend on several factors including differences in soil properties, weather conditions, history of management, intensity and type of tillage [7,19]. The physical properties of the seedbed therefore have a considerable effect on seedling emergence, plant stand establishment, and subsequent plant growth and yield [20]. Considerable research has been performed on different tillage systems in agricultural production methods and tillage systems in sunflower and other crop. Osunbitan et al. (2005) examined the effects of tillage on bulk density, hydraulic conductivity and strength of a loam sand soil. They found that the bulk density and penetration resistance of surface soil decreased with increase in the intensity of soil loosening by tillage operation. Bayhan et al. (2006) studied possibilities of direct drilling and reduced tillage in second crop silage sunflower. Yalcin and Cakir (2006) observed the effect of different tillage methods on yield and wedding for second crop silage corn. The highest yield was found in two passes subsoil tillage methods as

Table 1. Means of temperature, humidity and rainfall at the site of experimentation for long years (average 62 years) and 2003-2004.

Months		January	February	March	April	May	June	July	August	September	October	November	December	Sum
Long years	T* (°C)	1.6	3.6	8.1	13.8	19.3	25.9	31.0	30.3	24.8	17.0	9.6	4.1	
	RH (%)	76.0	72.0	65.0	63.0	56.0	37.0	27.0	27.0	32.0	48.0	67.0	67.0	
	R (mm)	73.5	67.1	67.9	70.5	42.1	7.0	0.7	0.5	2.7	31.1	54.0	71.5	488.7
2003	T (°C)	4.0	2.5	6.5	13.4	20.4	26.4	31.7	31.5	25.0	19.0	9.0	4.0	
	RH (%)	78.0	76.0	64.0	66.0	45.0	25.0	14.0	15.0	21.0	40.0	68.0	76.0	
	R (mm)	68.4	151.8	80.7	80.6	5.4	26.9	0.0	0.3	0.9	33.3	62.5	87.9	600.7
2004	T (°C)	3.3	2.7	9.6	12.8	18.0	26.4	31.1	30.0	25.0	18.2	8.2	1.4	
	RH (%)	82.0	80.0	54.0	50.0	54.0	23.0	12.0	14.0	19.0	41.0	60.0	73.0	
	R (mm)	84.6	93.4	1.5	54.9	97.5	16.0	0.0	0.0	0.0	0.7	123.1	4.7	476.4

Source: Diyarbakir Meteorology Bulletin (2004).
*T: temperature (^{0}C), RH: relative humidity %, R: rainfall (mm)

72.6 Mg ha^{-1} and 61.6 Mg ha^{-1}, whereas direct seeding gave lowest yield as 64.7 Mg ha^{-1} and 37.2 Mg ha^{-1} in the first and the second year, respectively.

Fabrizzi et al. (2005) studied soil water dynamics, physical properties and sunflower and wheat responses to minimum and no-tillage systems in the southern Pampas of Argentina.

Samarajeewa et al. (2006) pointed out that conservation tillage systems could be more productive than conventional tillage (CT) systems as a result of improved soil quality and water use efficiency of plants. Lopez et al. (2003) studied the tillage treatments varies CT, RT and NT. The three treatments were compared under the traditional CF rotation and under CC with barley. De Vita et al. (2007) studied effects of NT and CT on wheat yield. They found that greater yield is obtained with NT than as with CT.

To increase production and decline production cost in soil tillage operations, reduced tillage and direct seeding system is of great importance. Appropriate tillage and sowing technique can reduce factors that impede seedling emergence reduce energy and labor cost, and control weeds. However, tillage systems are location specific; their success depends on soil, climate and local practices [20].

In recent years in Turkey, especially, introduction of agricultural irrigation in Southeastern Anatolian region has lead to a dramatic increase in irrigating farming and thus second crop farming have gained importance. Still today farmer continue to use intensive conventional tillage in this region of Turkey, result in physical degradation of soil and increased soil erosion. However, the European Community agricultural policy has strongly encouraged conservation tillage practices in order to decrease soil loss [6]. Also, there is limited information available on effect on alternative soil tillage methods in this region.

The objective of this study was to investigate effects of different tillage methods on some soil physical properties, crop seedling emergence rate, fuel consumption, and yield and yield components of second crop (sunflower) in southeastern part of Turkey. Also, the effect of tillage on protein, oil and ash content were considered to be determined. Reduced and no-tillage methods were compared with conventional tillage systems.

MATERIALS AND METHODS

Study Sites and Tillage Experiment

The field studies were conducted at the University of Dicle, Agriculture Faculty, Diyarbakir Province (latitude 37°53´N and longitude 40°16´E, 680 m above sea level), Southeastern part of Turkey, in years 2003 and 2004. The soil in the experiment field was clay loam with pH of 7.7 and organic matter content of 2 %. The average weather conditions such as annual temperatures of air and soil, relative humidity, and rainfall are summarized in Table 1.

Field plots 15 m x 5.6 m, with three replications. Sunflower seed was drilled by a pneumatic planting machine with 0.7 m spaced rows on June 23 in 2003 and June 25 in 2004. Sunflower cultivar Bora from Agro May (Turkey) was planted as second crop just after harvesting of lentil.

Table 2. Soil tillage methods are used in experiment

Conventional tillage (CT)	Plough+ disk harrow+ float + direct seeding machine
Reduced tillage (RT1)	Disc harrow+ float + direct seeding machine
Reduced tillage (RT2)	Stripe tiller by rotary+ float + direct seeding machine
Reduced tillage (RT3)	Cultivator+ float + ridge tillage + direct seeding machine
Reduced tillage (RT4)	Cultivator + float + direct seeding machine
No-till direct seeding (NT)	Direct seeding machine

Table 3. The specification of the tools used in experiment

Tool	Type	Working depth (cm)	Working width (m)	Working speed (m s^{-1})
Mouldboard plough	Four bottom	25-30	1.42	0.50
Heavy disk harrow	24 disk –tandem	15	2.5	0.45
Cultivator	11 sweeps	15	3.10	0.45
Rotary row tiller	Four row	12	2.8	0.45
Ridge tool	-	-	0.7	0.40
Float	-	-	2.9	0.60
Direct planter	Four row	4-6	2.8	0.40

Table 4. Profile soil properties before and after soil tillage treatments.

Before treatments	Depth, cm	Moisture content, %		Bulk density, g cm^{-3}		Porozite, %	
		2003	2004	2003	2004	2003	2004
	0-10	9.22	10.91	1.29	1.41	51.43	50.54
	10-20	15.06	17.82	1.21	1.37	54.22	54.72
	20-30	17.05	20.66	1.09	1.23	58.77	61.13
After treatments	**Depth, cm**	**Moisture content, %**		**Bulk density, g cm^{-3}**		**Porozity, %**	
	0-10	15.78		1.29		51.32	
	10-20	19.79		1.27		52	
CT	20-30	23.15		1.23		53.58	
	0-10	13.81		1.28		51.69	
	10-20	19.66		1.25		52.83	
RT1	20-30	21.73		1.24		53.2	
	0-10	11.08		1.31		50	
	10-20	22.74		1.27		52	
RT2	20-30	23.38		1.25		52.83	
	0-10	15.62		1.30		50.94	
	10-20	22.54		1.26		52.45	
RT3	20-30	22.4		1.20		54.72	
	0-10	12.15		1.4		47.16	
	10-20	16.44		1.27		52	
RT4	20-30	20.42		1.20		54.72	
	0-10	12.52		1.26		52.45	
	10-20	17.58		1.20		54.72	
NT	20-30	20.77		1.18		55.47	

Table 5. Fuel consumption and field efficiency about tools and machinery used in research.

Tool/machinery	Fuel consumption L ha^{-1}	Field efficiency ha h^{-1}
Mouldbord plough	13.38	0.72
Heavy disk harrow	5.7	1.76
Field cultivator	6.05	2.20
Rotary tillage	2.9	2.40
Float	2.1	2.60
Ridge tool	1.85	1.66
Direct seeding machine	6.6	1.87

Table 6. Average values of fuel consumption of tillage methods.

Tillage methods	Fuel consumption L ha^{-1}	Field efficiency ha h^{-1}
CT	33.48	0.29
RT1	14.4	0.67
RT2	11.6	1.04
RT3	16.6	0.50
RT4	14.75	0.73
NT (Direct seeding)	6.6	1.87

All operations were conducted with Ford 7740 tractor.

In the first year, dry soil was irrigated after planting and the second year before planting, the soil was irrigated. The plots were irrigated by sprinkler irrigation method. Each tillage method was applied to the same plots for 2 years to find out the effect of tillage methods on subsequent years. Six tillage methods for the second crop sunflower were tested. The tillage methods are given in Table 2. The specifications of the tools used in experiment are given in Table 3.

The CT was conducted with four–bottom mouldboard plough to 30 cm depth once followed by two operations of disc harrowing. After plowing, the field two times harrowed with

disk-harrow at 15 cm depth and leveled with float. In the no- tillage direct seeding treatment, NT, the residue is left on the soil surface until seeding. Seeding was made without tillage. RT consisted of four tillage methods (Table 2).

Soil Properties Measurement and Penetration Resistance

After lentil harvest, soil was collected from the field with three replications on each plot before tillage and after tillage at depth of 0–30 cm. Samples were transported to the laboratory and then oven dried at 105 ºC for 24 hours to determine dry-basis gravimetric soil water content. Ten measurements were made at each depth interval in each plot on the same date; hence bulk density and porosity were evaluated.

Soil bulk density (δb) was determined on an oven-dry basis by the core method. The undisturbed soil cores were taken between rows from 0-10 cm, 10-20 cm and 20-30 cm soil depth. Core samples of 100 cm^3, 5 cm diameter (three replicates) were taken from the depths of 0-10, 10-20 and 20-30 cm to find the soil water retention and total porosity [7, 13]. Total porosity (φ) was obtained through the following equation

$$\varphi to = \left(1 - \frac{\delta b}{\delta r}\right) \times 100$$

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

Penetration resistance (PR) of soil was measured at 5 cm increment from soil surface to 20 depths at pre-tillage and after tillage, using a recorder penetrografy (Eijkelkamp Equipment, Eijkelkamp Gresbeck, The Netherland). Penetrometer had a 30º cone with angle with base diameter 11.28 mm at random sites in each plot.

Crop Residue Cover

The amount and type of surface lentil residues were determined just following harvesting and after tillage treatments. Residues were randomly collected with in 0.5m x 0.5m metal frame at four locations per plot. Standing residues were collected and bagged separately from residues lying flat on the soil surface, and then the stubble, stalk and weed were taken and weighed by a electronic balance equipment [15]. The percentage of crop residues on soil surface was determined by the following equation.

$$CR = \left[\frac{(B-A)}{B}\right] \times 100$$

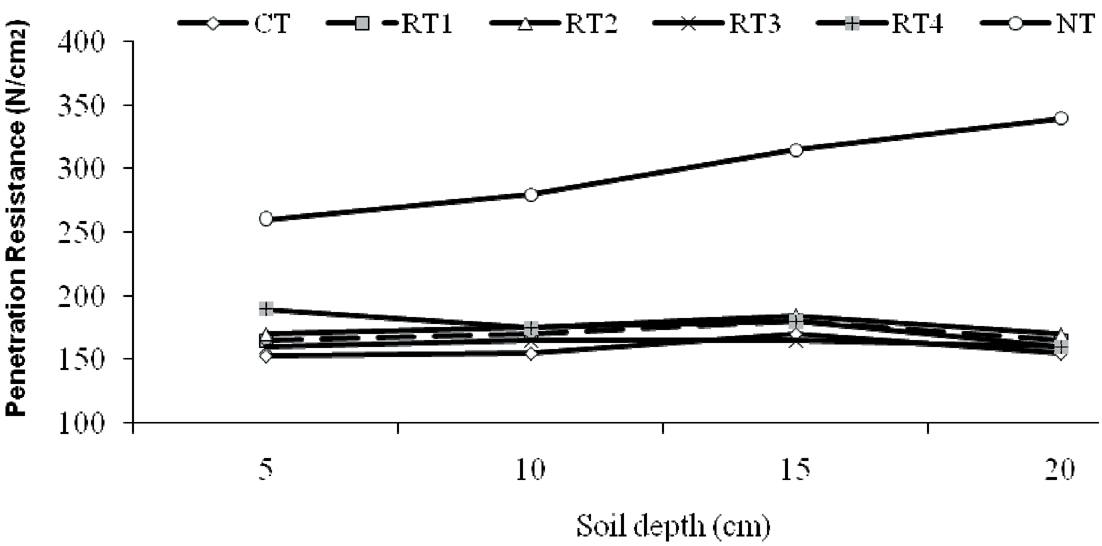

Fig.1. Penetration resistance as a function of soil depth at the after soil tillage treatment (2004-2005).

Where, CR is the burying rate of surface stubble, B is rate of surface stable before tillage, and A is rate of surface stable after tillage.

Fuel Consumption and Field Efficiency

In order to compare the tillage methods and fuel consumption were measured for each method. From the data, fuel consumptions per area and effectiveness of each method were determined [26]. For measuring the fuel consumption of the tools and machines used in the test, full tank method was used. The fuel tank of the tractor was filled full before the study and after the study; the fuel consumption was determined by measuring the amount of the fuel added to the tank. Time consumption was determined by using a stopwatch. Standard plots were used in the study (66.5 m x 105 m) for working time and fuel consumption (12).

Seedling Emergence

Seedling emergence rates were counted 3 times at 3 days in intervals during emergence the rows with 5 m length for each treatment. Plant counts were made in the marked rows after 4, 7 and 10 days from the first emergence. From these counts, percentage of emerged seedling (PE) was calculated using formula below [3].

PE=(Total emerged seeds m^{-1})/(Number of planted seeds m^{-1})x100

Crop Yield and its Component

Plant agronomic properties such as mean plant height, head diameter, stalk diameter, yield and yield components were determined by hand harvesting of (5 m x 0.7 m)3.5 m^2 area at harvesting time per each plot [5,6,23,27]. Samples were brought to the laboratory and threshed to obtain the grain.

Effect of Tillage Methods on Protein, Oil and Ash Content

Several hundred seeds were selected randomly from the threshed grain of each plot and dried in a forced-air oven at 60 ºC for 24 h. Then seed protein content was determined by means of the Kjeldahl method. The oil content of the grain from each tillage system was determined using a Soxhlet extraction method. Ash content was determined by dry-oven method [28].

Experimental Design and Statistical Analysis

The Statistical analysis system program was used to perform the analysis of variance (ANOVA) as outlined for a randomized complete block design with three replications was used for statistical analysis of data. The data were analyzed using SPSS statistical package program for analysis of variance. Means were compared by Tukey tests at $p<0.05$.

RESULTS AND DISCUSSION

Field Conditions

Before and after tillage treatments, soil moisture content, soil bulk density and porosity values are given in table 4.

The second year before tillage, soil moisture content and bulk density were higher than the first year at three depths. While depth increases the bulk density decreases. The first year, the δb had decreased from 1.29 to 1.09 g cm^{-3}, the second year the δb had decreased from 1.41 to 1.23 g cm^{-3}. The difference in these values may be due to the influence of irrigation after tillage in the second year [18]. This was probably caused by compaction due to cultivation [22]. Soil compaction increases bulk density and decreases pore volume. If bulk density becomes too high, it can limit plant row growth. For this reason, bulk density is frequently identified as indicator of soil indicator [14]. The bulk density was significantly greater before treatment than after tillage for all treatments. Results presented here are consistent with those obtained by Barzegar et al. (2003) who studied the influence of different tillage systems on bulk density. No significant differences were found between CT and the other RT and NT treatments. Similar results were also obtained by Hammad and Dawelbeit (2001) and Logsdon and Karlen (2004).

Table 4 shows the mean values of bulk density of soils at depths after the tillage treatment for the six tillage methods under consideration. The statistically difference was not found ($p>0.05$) between both years. The δb had decreased with increase depth at all methods. Also, the difference was not found between tillage methods in bulk density after soil tillage treatments. These results are in agreement to those found by Osunbitan et al. (2005). Total porosity increased with increase depth all tillage methods. However, there was no significant difference in porosity between tillage methods. But the higher value was found at under NT methods as 55.47 % at 20-30 cm depth. The changes in the total porosity are related with alterations in pore size distribution. The relation can be different depending on soil type [13]. Soil water content was significantly greater after tillage than before tillage in all treatments.

Fabrizzi et al. (2005) found greater soil bulk density under conservation tillage than conventional tillage. Among tillage treatments statistically differences were not observed. However, significant was found at depth the δb which was decreased from 1.26 to 1.18 at 10-30 cm soil depth, under NT. The values of δb were blow the range of the 1.4-1.5 Mg m^{-3} reported by Fabrizzi et al. (2005) as affecting root growth. Crop yields can be reduced by soil compaction due to increased resistance to root growth. Our results are in agreement with those found by Fabrizzi et al. (2005). However these values are not root restriction. According to Logsdon and Karlen (2004) root restriction value is 1.55 Mg m^{-3}.

Fabrizzi et al. (2005) observed changes in bulk density in tillage system could also be related to the type of machinery used for harvest and the soil compaction at harvest. Osunbitan et al. (2005) similarly observed significantly higher bulk density under no tillage cultivation when compared to conventional tillage treatment. These findings are in agreement with what was reported by Hammad and Davelbeit (2001) and Olaoye (2002).

Penetration Resistance

Soil penetration resistances at different depths are presented in Fig.1. As it can be seen from the Fig. 1, values have been found high as the soil was not tillage in the NT method for both two years. Tillage methods were a significant effect on penetration resistance. However, measuring of 2004 year has been higher compared to 2003. The soil PR generally increased with increase in

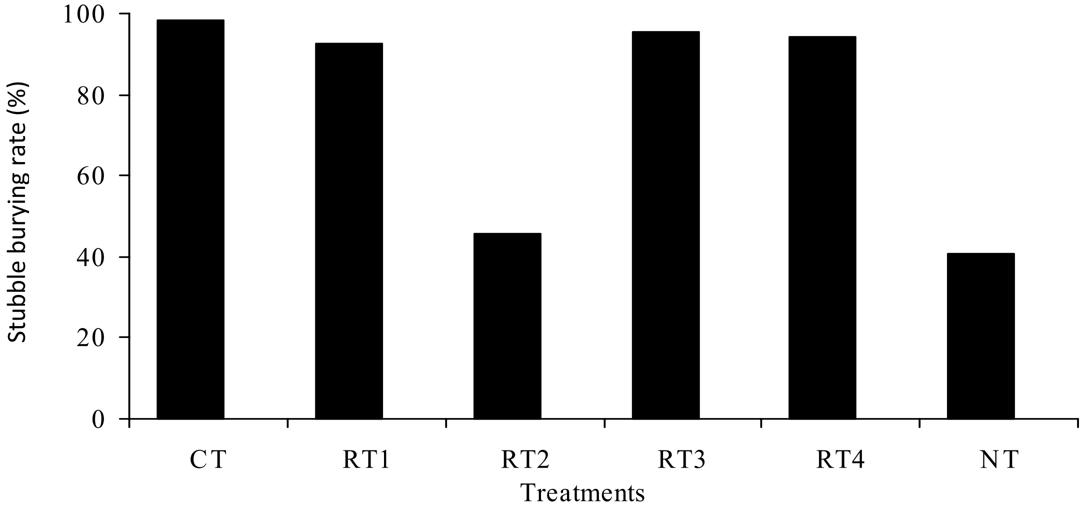

Fig.2. Stubble burying rate(%) as affected by tillage methods (2004-2005).

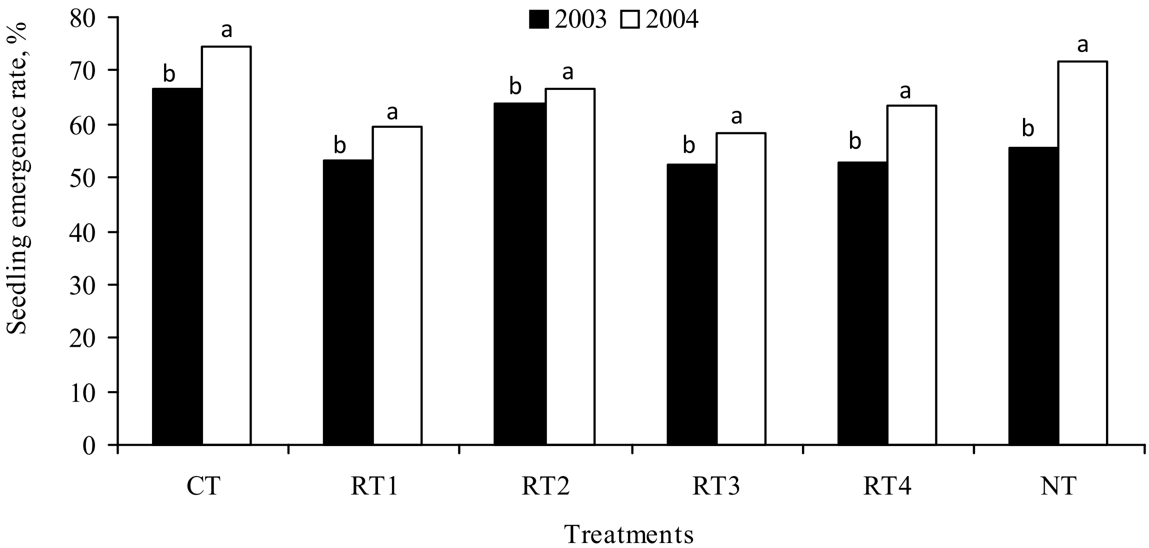

Fig.3. Effect of different soil tillage methods on seedling emergence rate(%)emergence

depth for both years before tillage. Osunbitan et al. (2005) reported that the soil penetration resistance increased with increase in depth for all treatment.

The soil PR varied significantly between the method of NT and the others. PR in NT was found to be higher than that of the other treatments. The highest resistance was recorded as 340 N cm^{-2} under NT at 20 cm depth. In direct planting method, as the soil was not tillage, similar values close to the measurements before tillage. Before tillage PR values were higher than after tillage at 5, 10, 15 and 20 cm depths. Before soil tillage, these values were change between 240-350 N cm^{-2} depending on soil depth. In other methods, however, there has been a decrease compared to before treatment. Measured values for all methods, have shown similarities. PR has been observed to be more sensitive than bulk density to detect effects of tillage management [7], several authors have concluded that high penetration resistance in conventional systems reduced rot growth affecting water nutrient up take by crops

Wilkins et al. (2002) suggested that cone index is affected by moisture and bulk density. Bulk density was calculated from the soil water content samples, but bulk density was highly variable and there were no clear relationship between bulk density and cone index for these data. Since high water content tends to reduce cone index, when cone index values were adjusted for soil water content.

Fabrizzi et al. (2005) and Bayhan et al. (2006) have shown increases of PR under NT compared with conventional tillage. Similar results were found differences in PR between the tillage systems below 5-20 cm soil depth.

Surface Residue Cover

The distribution of residue on the surface and in the soil is affected by tillage methods. By maintaining the crop residue on the surface, no-tillage system has shown considerable potential for controlling wind erosion. When compared with the residue cover in NT, the tillage operations significantly reduced the residue cover by incorporating the residue in to the soil. In the both years, effects of tillage treatment on residue cover showed similar trends. The Only RT2 and NT tillage treatments approximately left initial residue cover of 60 % (Fig. 2). Disk type and chisel type implements burned more residue according to rotary tillage implement and NT. The other treatments left significantly lower residue cover. These results are similar with the results obtained by of Raper (2002) that minimum values of residue coverage were found as 74 % in the CT methods. Chen et al. (2004) observed that the initial residue cover (barley) in the fall, represented by NT, was approximately 70 %. According to Vyn et al. (1998) surface reduce cover of fall zone-till and fall disk systems were reduced to about 50 %, due to partial incorporation during fall tillage, while no-till maintained more than 70 %. According to Morrison (2002) as conservation –tillage practice, strip tillage is defined as any row-crop cultural practice that restricts soil and residue disturbance to less than 25 % of the field area.

Seedling Emergence Rates

Sunflower seedling emergence rates of tillage methods are given in Fig. 3. Fig shows that seedling emergence rate was found statistically significant difference in both

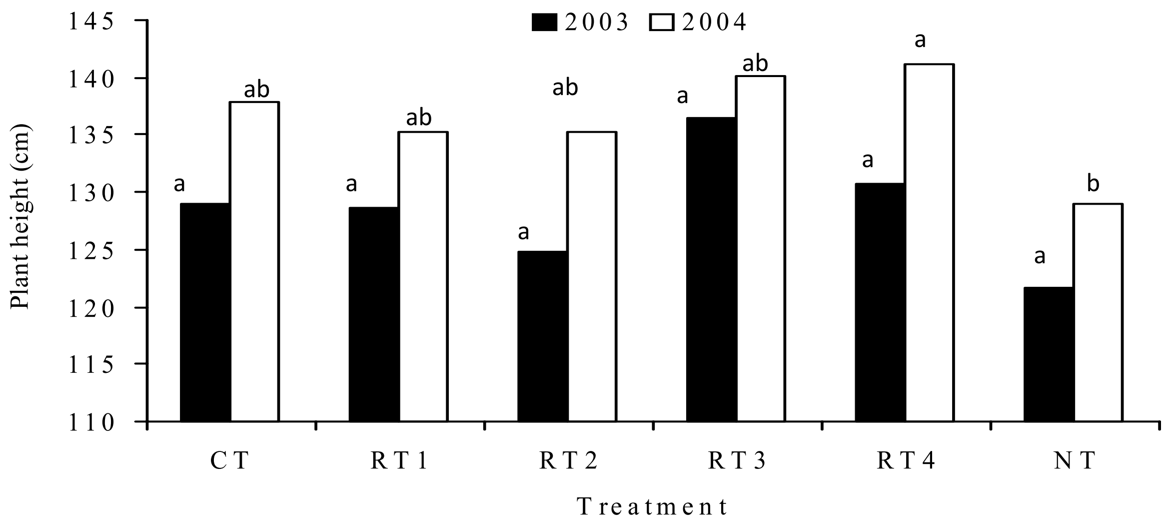

Fig.4. Effect of soil tillage methods on plant height (cm).

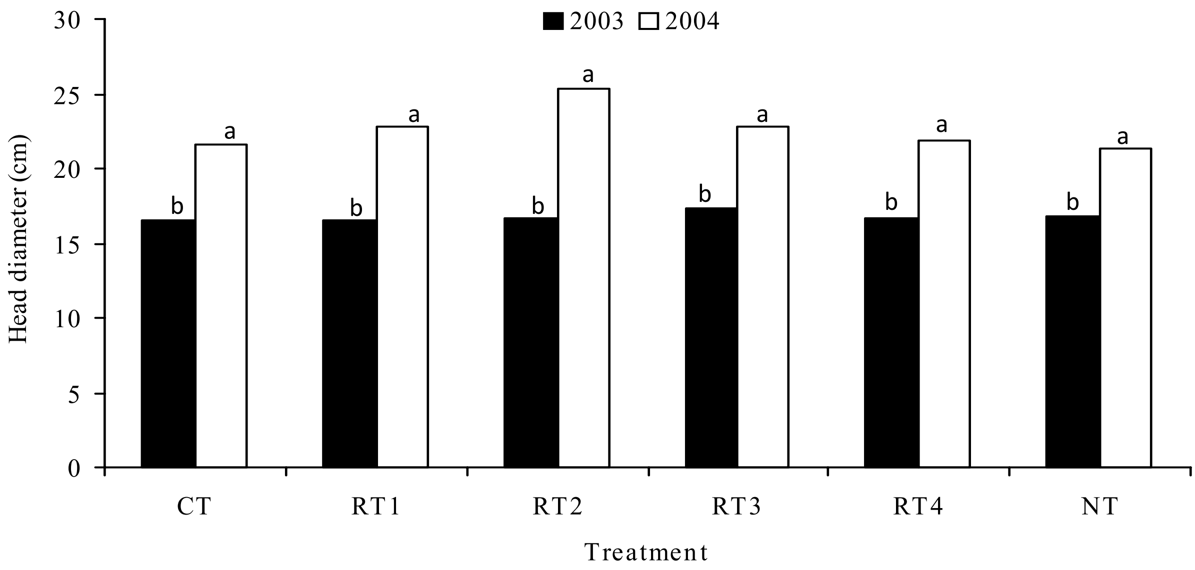

Fig. 5. Head diameter (cm) for soil tillage method.

years and treatments. Generally seedling rate was found to be low for all methods both in 2003 and in 2004. It changes between 52.2.–74.3 %. It was found low in all RT methods in the both years, the best results were obtained in CT and NT methods as compared to the other methods.

Agronomic Properties

Plant Height

While the difference ($p<0.05$) between years in terms of plant height was found significant, the difference ($p>0.05$) between treatments was not found statistically significant. The best results for plant height were obtained in 2004 year. In 2004, plant height of sunflower was greatest under RT4 as 14.1 t ha^{-1} (Fig. 4).

Head Diameter

The results showed that the differences between years in terms of head diameter were found significant ($p<0.05$). However differences between tillage methods were not found significant. There were no significance differences between the NT and other treatments (Fig. 5).

Stalk Diameter

The effect of tillage methods on stalk diameter is given in Fig 6. The differences between years in terms of stalk diameter were found significant ($p<0.05$). However, differences between tillage methods were not found significant ($p<0.05$).

Seed Yield

The effect of tillage methods on sunflower yield is given in Fig 7. The differences between years and treatment in terms of yield were found significant. Similar results were observed by Fernandez et al. (2007). However, the second year results were found higher as compared to the first year due to the heat stress and water problem occurred the first year [26]. In this study, the yield was mainly influenced by irrigated, the first year after sowing, soil was irrigated, the second year soil irrigated before sowing. Also, in the second year soil condition was more suitable than first year. Both the first year and the second year of the study, the highest yield was found in RT2 (33.9 t ha^{-1} in 2003 and 54. 3 t ha^{-1} in 2004) and RT3 methods (41.7 t ha^{-1} in 2003 and 55.5 t ha^{-1} in 2004) and the lowest yield was found in RT1 method as 33.9 t ha^{-1} in year 2003 and 42.0 t ha^{-1} in 2004. Also there was not found difference between CT and NT methods. Hatfield et al (1998) observed that, sunflower yield were improved under ridge tillage on a silt loam soil. However, similar results were reported by Yalcin and Cakir (2006).

Effect of tillage method on protein, oil and ash content

The effect of tillage on sunflower protein, oil and ash content are shown in Fig 8. As can be seen in the figure 8, protein, oil and ash content of sunflower were not affected statistically ($p>0.05$) by tillage method.

Yusuf et al. (1999) reported that soybean grain oil and protein content were not affected by soil tillage system, but significantly affected by years. De la Vega and Hall. (2002) reported that oil yield was calculated as a function of oil content and grain yield. According to De Vita et al. (2007), grain protein content is a function of tillage system, reporting no significant differences. Lopez et al. (2003) reported higher grain protein content for CT than NT. They also recorded differences in oleograph parameters between the CT and NT.

Working Characteristics of Methods

Operating data about tools and machinery used in research are given in Table 5. As can be seen in table, fuel consumption has occurred most in using plough as compared to the other tools. Average values of fuel consumption and field efficiency of tillage methods are given in table 6. The highest fuel consumption was observed in conventional tillage, CT, where as the lowest value was found in the direct seeding method, NT as 33.48 L ha^{-1} and 6.6 L ha^{-1} respectively (Table 6). The conventional method requires five times more fuel as compared to the NT method. For field efficiencies as parallel to the findings of fuel consumption, the lowest values were 0.29 ha h^{-1} in CT while the highest value was 1.87 ha h^{-1} in NT, so NT methods six times more field efficiency comparing the conventional method. When these results have been considered in terms of the treatments, the lowest result has been found directly in stubble cultivation method. The findings are also in

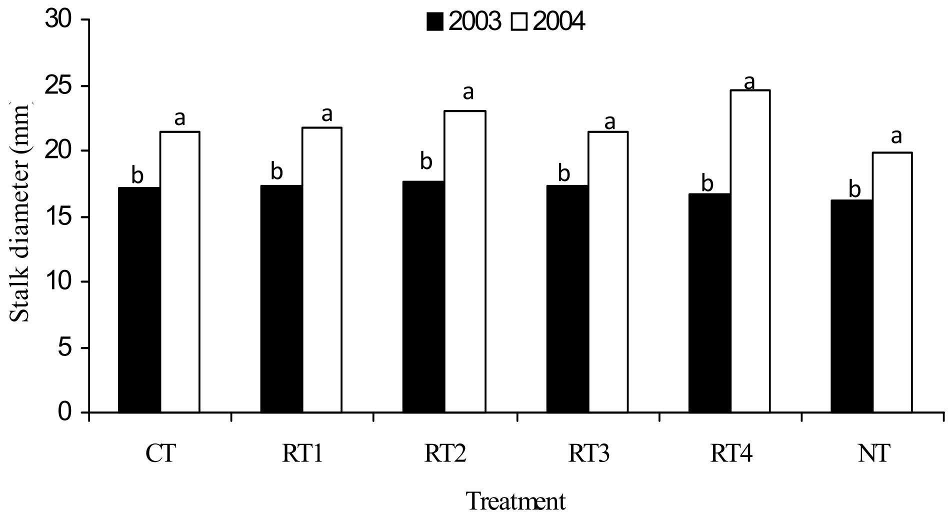

Fig 6. Stalk diameter (mm) values for soil tillage method.

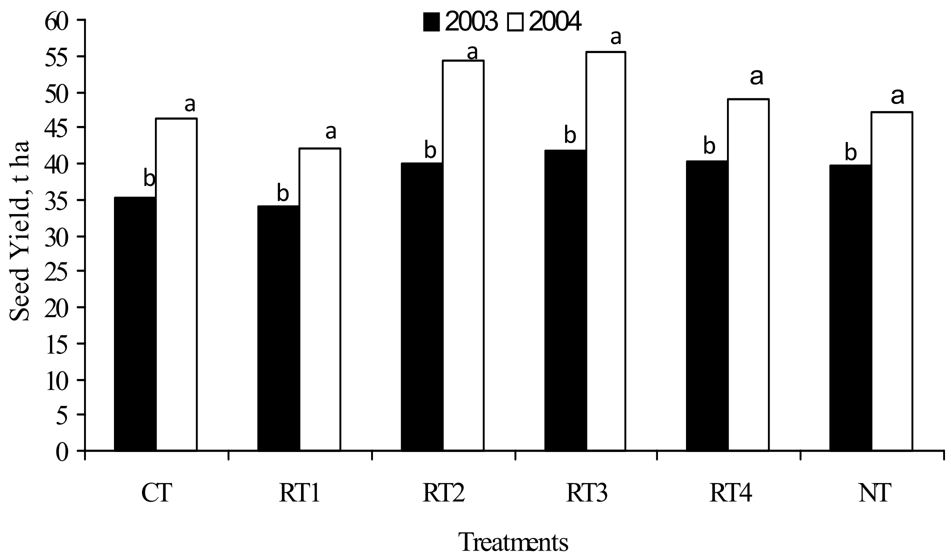

Figure 7. Seed Yield (t ha-1) as function of different soil tillage methods.

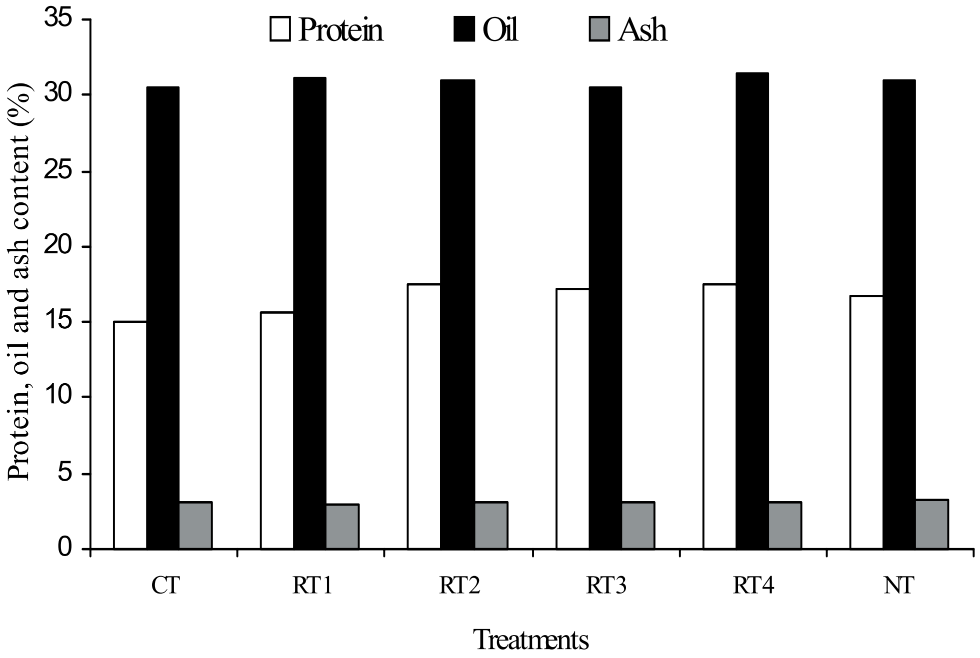

Figure 8. Protein, oil and crude ash values (%) as a function of different soil tillage method.

agreement with the research results of Yalcin and Cakir (2006).

CONCLUSIONS

The soil PR varied significantly between the method of NT and the others. PR in NT was found to be higher than that of the other treatments. The highest resistance was recorded as 340 N cm^{-2} under NT at 20 cm depth. In direct planting method, as the soil was not tillage, similar values close to the measurements before tillage. Before tillage PR values were higher than after tillage at 5, 10, 15 and 20 cm depths in other methods, however, there has been a decrease compared to before treatment. Measured values for all methods, have shown similarities. PR has been observed to be more sensitive than bulk density to detect effects of tillage management.

The δd had decreased with increase in depth at all methods but there was no significant difference in porosity between tillage methods. Total porosity increased with increase in depth at all tillage methods. The higher value was found at under NT methods as 47-55 % at 20-30 cm depth. Soil water content was significantly greater after tillage than before tillage in all treatments. Tillage methods were a significant effect on penetration resistance. The soil penetration resistance generally increased with the increase in depth for both years before tillage treatment PR in NT was found higher than that of the other treatments.

The highest seedling emergence rate was obtained in RT4 and CT methods. The differences of the methods between two years were found statistical significant for seedling rate.

Sunflower yield and agronomic properties were significantly affected by tillage methods. It was found to be higher in the second year than in the first year in all tillage treatments. The highest yield was found in CT methods and lowest yield was found in RT4 method both in year 2003 and year 2004. From the results, it can also be concluded that conservation tillage and direct seeding can be easily applied after lentil for second crop soybean. Protein, oil and ash content of soybean were not affected statistically ($p>0.05$) by tillage method.

According to our results, conventional tillage method, CT had the highest fuel consumption and lowest field efficiency as compared to the other tillage method. Direct, seeding method, NT had the lowest fuel consumption with maximum field efficiency. The conventional method requires five times more fuel comparing the NT method. Beside this, NT methods had six times more field efficiency comparing the conventional method.

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