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CONSERVATION AND CONVENTIONAL TILLAGE METHODS ON SELECTED SOIL PHYSICAL PROPERTIES AND CORN (*ZEA MAYS* L.) YIELD AND QUALITY UNDER CROPPIN SYSTEM IN TURKEY

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Abstarct

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This study was conducted to determine the effects of conventional and conservation tillage on the some soil physical properties, penetration resistance (PR), seedling emergence rate, yield and yield components under southestern of Turkey conditions. The experiments were carried out at 2003 and 2004 years in a clay loam soil. Six different soil tillage methods in corn production were tested. The experiment was performed in randomized block design with six treatments and each treatment consists of three replications. No significant ($p>0.05$) treatment differences in seedling emergence were found between the tillage treatments for both years. Plant height was found significant between years while treatment effects were not significant. However, the highest plant height was obtained in 2004 under CT tillage method. The stalk thickness was found significant between years while treatment effects were not significant. The cob length was not found significant between years and treatments. The lowest cob length was obtained under NT method. It was found that yield was significantly ($p<0.01$) different between years. The yield in the second year was found to be higher than that of the first year. The highest yield was found in CT method as 678.00 kg/da and the lowest yield was found in RT4 method as 535.66 kg/ha in year 2003. The highest yield was found in CT method as 778.66 kg/da and the lowest yield was found in RT4 method as 642.33 kg/ha in year 2004. The highest fuel comsumption was obsorved as 33.48 Lha^{-1} in conventional method (CT) whereas the lowest value was found in direct seeding method as 6.6 Lha^{-1}.

Key words: Tillage, second crop corn, yield, emergence rate, fuel consumption, field efficiency

Introduction

Use of Agricultural mechanization is considered the main factor contributing to the total energy inputs in agricultural system. Tillage represents half of the operations carried out annually in the field. Consequently, there is a potential to reduce energy inputs and production costs by reducing tillage (Osunbitan et al., 2005; Ozturk et al., 2006)

The main objective in agriculture production, so

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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 resourses, and environmental awerness gain importance (Ulusoy, 2001). Tillage practices are needed to increase agronomic stability and productivity while enhancing the environment (Hatfield et al., 1998). Since land preparation for double-cropping systems requires timeliness, especially when a moldboard plow is used, reduced tillage, mainly NT systems, are becoming widespread. Beneficial effects of the crop residue maintenance on the soil surface include a reduction of soil erosion and runoff, an increase soil water conservation and soil aggregation, and a less use of fossil fuel is not direct effect of crop residue management (Nesmith et al., 1987; Nakamoto et al., 2006).

In order to combat soil loss and preserve soil moisture, a more attention has been focused on conservative tillage involving soil management practices that minimize the disruption of the soil structure (Samarajeewa et al., 2006). Soil erosion and loss of valuable soil organic mater seem to be reduced under no-till system. Under a wide range of environment conditions crop yield obtained by no-till, reduced tillage, and stubble retention systems were equivalent or even a higher than those recorded under conventional tillage (Barzegar et al., 2003). Soil organic matter is conserved with no-till because of reduced oxidation of organic matter (Wilkins et al., 2002), while at the maintenance of crop residues on the soil surface has been recognized an important role in reducing soil erosion and on its positive effects on soil and water conservation. Benefits of residue cover include improved soil water storage, enhanced soil organic matter content, nutrient recycling and protection against water and wind erosion (Lopez et al., 2003).

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 (Fabrizzi et al., 2005; Osunbitan et al., 2005). Considerable research has been performed on different tillage systems in agricultural production methods and tillage systems in corn 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 corn. Yalcin and Cakir (2006) observed the effect of different tillage methods on yield and wedding for corn. The higest yield was found in two passes subsoil tillage methods as 72.6 $Mgha^{-1}$ and 61.6 $Mgha^{-1}$, whereas direct seeding gave lowest yield as 64.7 $Mgha^{-1}$ and 37.2 $Mgha^{-1}$ in the first and the second year, respectively.

Fabrizzi et al. (2005) studied soil water dynamics, physical properties and corn 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 vares CT, RT and NT. The three treatments were compared under the tradional 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.

Tillage is one of the higest power-required processes of agricultural production. In addition, the high cost of energy today forces farmers to find alternative economic tillage. It is clearly recognized that application of energy-saving methods can make effective contributions to economy (Bayhan et al., 2006). For this reason, conservation tillage is becaming increasingly attractive to farmers because clearly reduces production cost relative to conventional tillage (Vita et al., 2007).

In recent years in Turkey, especially due to introduction of irrigation agricultural in Southeastern Anatolian region, there been dramatic increase in irrigation farming and thus second crop farming have gained importance. Conventional tillage is mainly system used by farmers in this region, this result turns into physical dergredation of soil and increased soil erosion, labour, time, energy and production cost.

The objective of this work was to evaluate the effects of different tillage methods on selected some physical soil properties, seedling emergence, fuel and time consumption and yield and yield components of second crop (*Zea mays* L.) in soutestern part of Turkey. Also the effect of tillage on protein, oil and ash content were considered in this study.

Material and Methods

Study sites

Field studies were conducted during the summers of 2003 and 2004 at the Diyarbakir Province (latitude 37°53´N and longitude 40°16´E, 680 m altitude), and southeastern part of Turkey. The soil in the experiment field was a clay loam with pH of 7.7 and organic matter content of 2.0%. The average weather conditions such as annual temperatures, relative humidity, and rainfall are summarized in Table 1.

Field methods

Experimental field consisted of 18 plots with each measuring 15 m x 5 m with an inter row spacing of 0.7 m distance. After emergence of seedling, the plant rows were harrowed with row harrower for fertilizing and watering for all trails. Planting was performed by pneumatic planting machine. The planter was modified for direct seeding. The planter consists of flat double discs + 8 wave coulter. Also, extra weights were loaded on the top of seeder for a better penetration of coulter into the soil. Ford 7740 tractor was used in the experiments. Corn seeds, hybrid Agro May Bora, were planted as second crop just after harvest

Table 1

Monthly means of temperature and humidity and monthly sum of rainfall at the site of experimentation for 2003-2004 growing seasons in comparison with climate data of a long-term (average 62 years) period

Months	62			2003			2004		
	T°C	RH, %	Rainfall, mm	T°C	RH, %	Rainfall, mm	T°C	RH, %	Rainfall, mm
January	1.6	76	73.5	4	78	68.4	3.3	82	84.6
February	3.6	72	67.1	2.5	76	151.8	2.7	80	93.4
March	8.1	65	67.9	6.5	64	80.7	9.6	54	1.5
April	13.8	63	70.5	13.4	66	80.6	12.8	50	54.9
May	19.3	56	42.1	20.4	45	5.4	18	54	97.5
June	25.9	37	7	26.4	25	26.9	26.4	23	16
July	31	27	0.7	31.7	14	0	31.1	12	0
August	30.3	27	0.5	31.5	15	0.3	30	14	0
September	24.8	32	2.7	25	21	0.9	25	19	0
October	17	48	31.1	19	40	33.3	18.2	41	0.7
November	9.6	67	54	9	68	62.5	8.2	60	123.1
December	4.1	67	71.5	4	76	87.9	1.4	73	4.7
Sum			488.6			600.7			476.4

Source: Diyarbakır Meteorology Bulletin (2004)

T: temperature, RH: relative humidity

of lentil on June 23, 2003 and June 25, 2004. No herbicide was applied to the field both before and after tillage (Table 2).

Observations and data collection

Before and after tillage, soil was collected from the field with three replications on each plot before tillage and after tillage at 0–30 cm. Samples were transported to the laboratory and then oven dried at 105° C for 24 hours to determine dry-basis gravimetric soil water content. Also, bulk density and porosity were evaluated.

Soil bulk density (äb) was determined on an oven-dry basis by the core method. The undisturbed soil cores of 100 cm^3, 5 cm diameter (three replicates) were taken between rows from 0-10 cm, 10-20 cm and 20-30 cm soil depth to measure the soil bulk density, soil water retention and total porosity (Grossman and Reinsch, 2002; Fabrizzi et al., 2005).

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

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

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

Before tillage and after tillage, the penetration resistance (PR) of soil was measured at random sites in each plot, using a recorder penetrografy (Eijkelkamp Agrisearch Equipment, Eijkelkamp Giesbeek, The Netherlands). This instrument recorded the values at 5 cm increments from soil surface to 20 cm deep; penetrografy had a 30° cone as angle and a base of diameter 11.28 mm.

The surface lentil residues were determined just following harvesting and 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 (Lopez et al., 2003). The percentage of crop residues on soil surface was determined by the following equation.

$$CR = \left[\frac{(B - A)}{B}\right] \times 100 \qquad (2)$$

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

For each plat, emerged seedling on the 2 rows with 5 m length were counted 3 times at 3 days in intervals during emergence, calculating the rate of emerged seedling (PE) through the following formula (Bilbro and Wanjure, 1982; Bayhan et al., 2006):

PE=(Total emerged seeds/m)/(Number of planted seeds/m)x100

In order to compare the tillage methods, the fuel consumption per area was used as a measure for calculating the effectiveness of each method (Yalcin and Cakir, 2006). 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 and the amount of the fuel added to the tank represented fuel consumption. Time consumption was determined by using a stopwatch. Standard plots were used in the study for fuel and time consumption (66.5 m x 105 m)

Table 2
Soil tillage methods utilized in experiments

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 (NT)	Seeding by direct drill

(Kasap, 2001; Sessiz et al., 2008) (Table 3).

For crop yield determination, the mature corn plants were harvested and threshed by hand, adjusting to 14-15 % moisture the seed yield. At harvesting time, some plant agronomic properties such as mean plant height, stalk thickness, cob length and yield were measured in samples taken from 3.5 m^2 area in two middle rows for each plots (Korucu and Kirisci, 2001; Yalcin and Cakir, 2006; Samarajeewa et al., 2006 ; DeVita et al., 2007).

Several hundred seeds were selected randomly from the threshed grain of each plot and dried in a forced-air oven at 60° C for 24 h (Yusuf et al., 1999). 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.

Obtained data were subjected to analysis of variance using GLM-PROC. When the significant difference detected ($p<0.05$), means were compared by Tukey' HSD test. All analysis was done by using SPPS 15.0 (Anonymous, 2005).

Results and Discussion

Field Conditions

The values of soil moisture content, soil bulk density and total porosity measured before tillage treatments are given in Table 4.

Pre-tillage bulk density and gravimetric moisture content were higher at the three depths studied in the second planting season when compared to the first planting season. Soil dry bulk density decreased with increase in soil depth. The äb had decreased from 1.29 to 1.09 Mgm^{-3} in the first year and from 1.41 to 1.23 Mgm^{-3} in the second year (Table 4). The difference found in bulk density values between both growing seasons may be due to the influence of irrigation after tillage in the second year (Olaoye, 2002) that probably caused a higher compaction due to cultivation (Roscoe and Buurman, 2003). 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 quality (Logsdon and Karlen, 2004). In Table 5 are shown for the six tillage methods the mean values of soil properties at three depths after tillage treatments. These results are in agreement with to those found by Osunbitan et al. (2005).

Contrarily, total porosity increased with increase soil depth all tillage methods used, the highest value of porosity was found under NT method (55.47%) at 20-30 cm depth. In general, soil water content resulted to be greater after tillage than before tillage in all treatments (Table 5). Fabrizzi et al. (2005) found greater soil bulk density under conservation tillage than conventional tillage. Even though among tillage treatments there were not significant differences, the $ä_b$ values found under NT were the lowest, passing from 1.26 to 1.18 Mgm^{-3} at 10-30 cm, as increasing soil

Table 3
The specification of the tools used in experiment

Tool	Type	Working depth, cm	Working width, m	Working speed, m/s
Moldboard plough	Four bootom	25-30	1.42	0.5
Heavy disk harrow	24 disk -tandem	15	2.5	0.45
Cultivator	11 sweeps	15	3.1	0.45
Rotary tillage	Four row	12	2.8	0.45
Ridge tool	-	-	0.7	0.4
Float	-	-	2.9	0.6
Direct planter	Four row	4-6	2.8	0.4

Table 4
Soil properties before soil tillage treatments

Depth, cm	Moisture content, %		Bulk density, Mgm^{-3}		Porosity,%	
	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

depth. Nevertheless the values of äb were below the range of the 1.4-1.5 Mg m^{-3} (Fabrizzi et al., 2005) or 1.55 Mgm^{-3} (Logsdon and Karlen, 2004), limit values for plant affecting root growth.

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 also in agreement with Hammad and Davelbeit (2001) and Olaoye (2002).

Penetration Resistance

Before and after tillage treatment, soil penetration resistance at different depths is presented in Figures 1 and 2. As it can be seen from the Figure 1, NT plots had higher values of PR for both two years. Tillage

Table 5
Profile soil properties after soil tillage treatments

Treatment	Depth, cm	Moisture content, %	Bulk density, Mgm^{-3}	Porosity, %
	0-10	15.78	1.29	51.32
CT	10-20	19.79	1.27	52
	20-30	23.15	1.23	53.58
	0-10	13.81	1.28	51.69
RT1	10-20	19.66	1.25	52.83
	20-30	21.73	1.24	53.2
	0-10	11.08	1.31	50
RT2	0-10	22.74	1.27	52
	20-30	23.38	1.25	52.83
	0-10	15.62	1.3	50.94
RT3	10-20	22.54	1.26	52.45
	20-30	22.4	1.2	54.72
	0-10	12.15	1.4	47.16
RT4	10-20	16.44	1.27	52
	20-30	20.42	1.2	54.72
	0-10	12.52	1.26	52.45
NT	10-20	17.58	1.2	54.72
	20-30	20.77	1.18	55.47

methods did not significantly affect penetration resistance. The soil PR values generally increased with increase in depth for both years before tillage. Osiunbitan et al. (2005) reported soil penetration resistance increased with increase in depth for all treatments.

Instead, penetration resistances measured for all treatment after soil tillage (Figure 2) showed significant variation only between the method of NT and all other treatments. In the direct planting method, the soil was not tillage; PR values were to measurements before tillage.

PR has been observed to be more sensitive than bulk density to detect effects of tillage management (Fabrizzi et al., 2005). Several authors concluded that a high penetration resistance in conventional systems turned in a lower root growth, affecting water and nutrient uptake by crops.

Results from the work of Fabrizzi et al. (2005) and Bayhan et al. (2006) have shown increases of PR values under NT compared with that in conventional tillage. Similar differences in PR values were recorded among tillage systems below 5-20 cm soil depth.

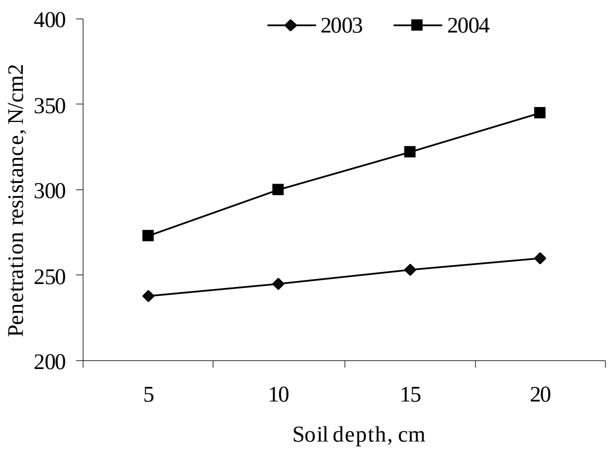

Fig. 1. The main values of penetration resistance before soil tillage treatment

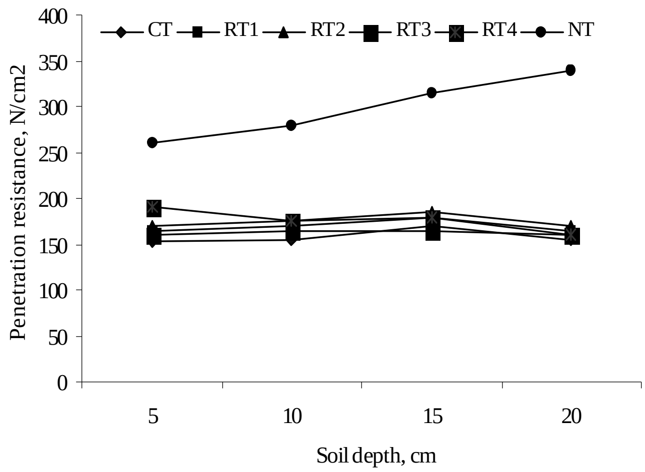

Fig. 2. Penetration resistance after soil tillage treatment (two years average)

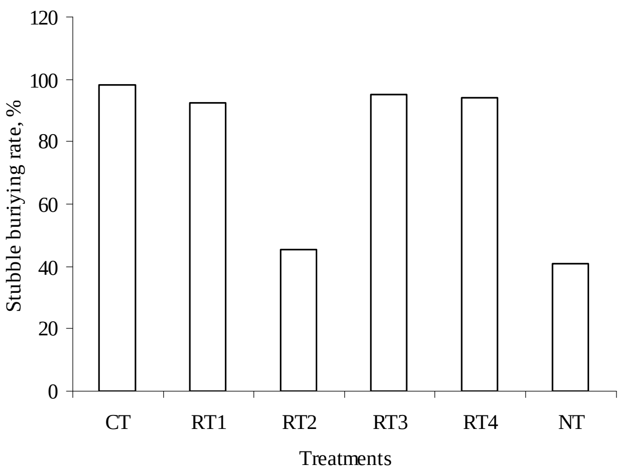

Fig. 3. Stubble buriying rate as affected by tillage methods

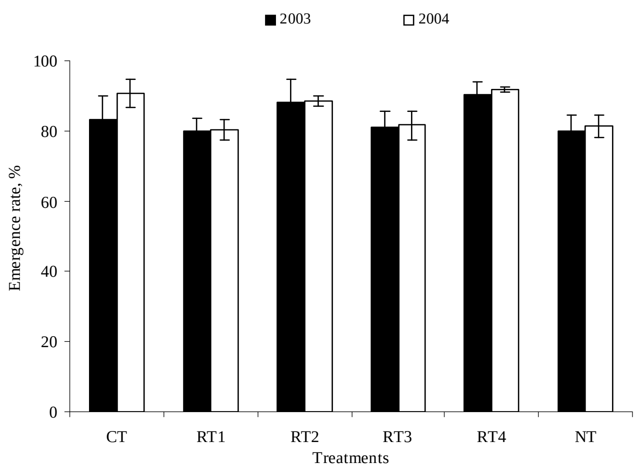

Fig. 4. Seedling emergence rate as affected by tillage methods

Surface Residue Cover

The distribution of resude 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 consdirable potential for controlling wind eresion. When compared with the resudue 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 % (Figure 3). The other treatments left significantly lower residue cover. 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 (Figure 3). Stubble buriying rate as affected by tillage methods.

The no-tillage plot was founded to have 40.87 % residue according to the line-transect method. This value was assumed to be the present residue and present on all plots to tillage. This was significiantly greater than any of the five tillage treatments. These results are similar with the results obtained by of Raper (2002) that minimum values of residue coverage were found in the CT methods. Chen et al. (2004) observed that the initial resude 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 tu partial incorporation during fall tillage, while no-till maintained more than 70 %.

Seedling emergence rates

No significant ($p>0.05$) treatment differences in seedling emergence were found between the tillage treatments for both years ($F_{treatment}=2.48$, df=5.36, $p=0.06$). Generally, seedling emergence rates were found to be high for all methods both 2003 and 2004 growing seasons. It changes between 80.20–91.6 % (Figure 3) and the highest emergence rate was obtained under RT4 (91.60%) and CT (90.6) % methods.

Agronomic Properties

Results showed that the plant height was found significant between years ($F_{year}=42.53$, df=1, 36, $p=0.000$) while treatment effects were not significant ($F_{treatment}= 0.96$; df=5.36 $p=0.482$). The interaction effect of both factors were not significant $F_{year\ x\ treatment} = 0.565$; df=5, 36 $p=0.726$). However, the highest plant height was obtained as 214 cm in 2004 under CT tillage method. The stalk thickness was found significant between years ($F_{year}=70.18$, df=1.36, $p=0.000$) while treatment effects were not significant ($F_{treatment}= 0.498$; df=5. 36 $p=0.774$) (Table 6). The interaction effect of both factors were not significant $F_{year\ x\ treatment} = 0.633$; df=5.36; $p=0.677$). The cob length was not found significant between years ($F_{year}=7.239$, df=1.36; $p=0.013$) and treatments ($F_{treatment}=3.47$, df=5, 36; $p=0.017$). The interaction effect of both factors were not significant $F_{year\ x\ treatment} = 0.086$; df=5.36; $p=0.994$). The lowest cob length was obtained under NT method.

Similar effects were reported by Yalcin and Cakir

Table 6
Mean of some agronomic properties of corn as affected by tillage methods

	Plant height, cm		Stalk thickness, mm		Cob length, cm	
	2003	2004	2003	2004	2003	2004
CT	181.13±11.0	214.00 ± 3.2	19.32±1.1	26.55±3.1	16.36±0.3	17.86±0.8
RT1	183.63±9.05	207.33 ±2.4	18.64±0.3	30.30±3.3	15.00±0.4	16.23±0.6
RT2	183.83±3.4	207.66±1.8	19.67±0.2	29.01±3.1	17.10±0.8	17.86±1.1
RT3	183.23±10.5	203.33±4.8	18.77±0.4	32.81±3.1	17.33±0.5	18.33±0.4
RT4	191.20±2.1	205.20±7.3	19.70±0.3	30.23±2.7	15.96±0.06	17.03±0.3
NT	171.20±6.7	201.33±4.1	18.90±0.7	27.67±1.8	14.80±1.0	16.16±0.9

(2006), during the first year of study, irrigation problem was occurred in 2003. For this year, plant height, stalk thickness and cob length were found low. In the second year this effect was not observed due to the irrigation problem. Also, the second year before tillage soil was irrigated. After irrigation the seeding was made. The wet soil conditation for planting increased the agronomic properties in the second year (Figure 4).

Yield

A summary of the effect of tillage methods on corn yield is given in Figure 5. It was found that yield was significantly ($p<0.01$) different between years ($F_{year}=21.88$, df=1, 36; p=0.000). The yield in the second year was found to be higher than that of the first year. Analaysis of variance that corn yield was not significantly affected by tillage treatments for both years ($F_{treatment}=3.76$, df=5, 36; p=0.122). The interaction effect of both factors were not significant $F_{year\ x\ treatment} = 0.288$; df=5.36; p=0.915). In the present study, it was found to be higher in the second year than that in the first year in all tillage treatments (Figure 5). In the first year of the study, the highest yield was found in CT method as 678.00 kg/da and the lowest yield was found in RT4 method as 535.66 kg/ha in year 2003. The highest yield was found in CT method as 778.66 kg/da and the lowest yield was found in RT4 method as 642.33 kg/ha in year 2004. The reason for this is probably the soil irrigation before the seeding in the second year. Also, in the second year soil condition was more suitable than the first year. Hatfield et al. (1998) observed that, corn yield were improved under ridge tillage on a silt loam soil. Similar yield results were reported by Yalcin and Cakir (2006).

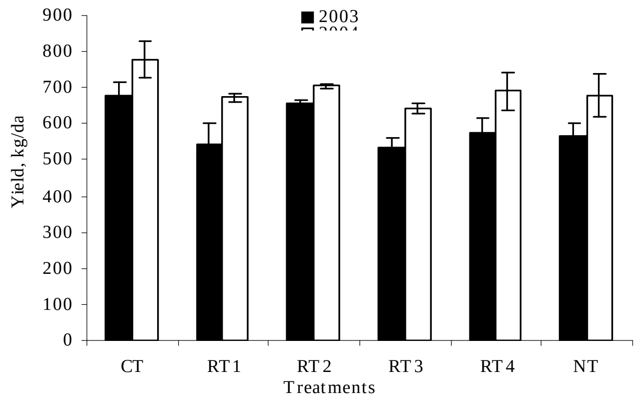

Fig. 5. Yield values for soil tillage method

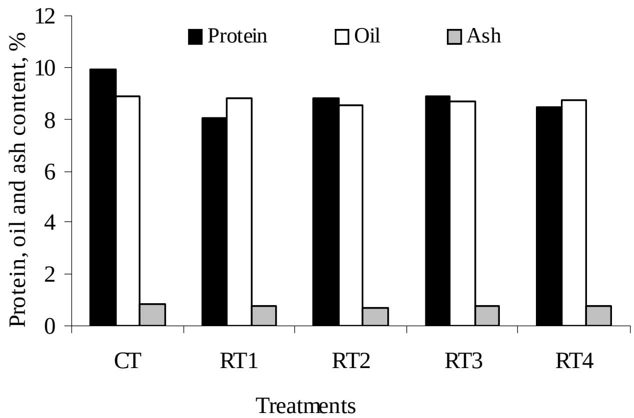

Fig. 6. Protein, oil and crude ash values for soil tillage method

Table 7

Fuel and time consumption about tools and machinery used in the study

Tool/machinery	Fuel consumption, L ha^{-1}	Field efficiency, hah^{-1}
Mouldbord plough	13.38	0.72
Heavy diskharrow	5.7	1.76
Field cultivator	6.05	2.2
Rotary tillage	2.9	2.4
Float	2.1	2.6
Ridge tool	1.85	1.66
Direct seeding machine	6.6	1.87

Table 8
Average values of fuel consumption of tillage methods

Tillage methods	Fuel consumption, L ha^{-1}	Field efficiency, hah^{-1}
CT	33.48	0.29
RT1	14.4	0.67
RT2	11.6	1.04
RT3	16.6	0.5
RT4	14.75	0.73
NT (Direct seeding)	6.6	1.87

Effect of Tillage Method on Protein, Oil and Ash Content

Protein, oil and ash content of corn were not affected statistically (p>0.05) by tillage method ($F_{treatment\ protein}$=1.79, df=5, 17; p=0.188; $F_{treatment\ oil}$=0.917, df=5.17; p=0.503; $F_{treatment\ ash}$=0.643, df=5.17; p=0.672). However, the highest protein content was obtained in CT and NT methods (Figure 6).

According to DeVita et al. (2007), grain protein content is a function of tillage system, reporting no significant differences. Lopez et al. (1998) reported higher grain protein content for CT than NT. They also recorded differences in alveograph parameters between the CT and NT. Yusuf et al. (1999) reported that soybean grain oil and protein content were not affected by soil tillage system, but significantly affected by years.

Fuel Consumption and Field Efficiency

Operating data about tools and machinery used in the study are given in Table 7. The highest fuel consumption occurre using plough respect to the other tools. Average values of fuel consumption and field efficiency for each tillage method are given in Table 8. The highest fuel consumption 33.48 Lha^{-1} was observed in convential tillage whereas the lowest value 6.6 L ha^{-1} was found in the direct seeding method, requiring a consumption of energy five times higher than NT method. Similarly, the field efficiency was the lowest 0.29 L ha^{-1} in CT and the highest 1.87 ha h^{-1} in NT, showing the latter a field efficiency six times more higher compared to the conventional method. Regard to the other treatments, the lowest field efficiency was found in stubble cultivation method. These results were also in agreement with those obtained by Yalcin and Cakir (2006).

Conclusions

The bulk density was greater before treatment than after tillage for all treatments. The first year the äb had decreased from 1.29 to 1.09 Mg m^{-3}, the second year the äb had decreased from 1.41 to 1.23 Mg m^{-3}. The äb had decreased with depth increase at all methods. Total porosity increased with depth increase all tillage methods. But the higher value was found at under NT methods as 55.47 % at 20-30 cm depth. Soil water content was greater after tillage than before tillage in all treatments.

No significant (p>0.05) treatment differences in seedling emergence rate were found between the tillage treatments for both years ($F_{treatment}$=2.48, df=5.36, p=0.06). It changes between 80.20–91.6 % and the highest emergence rate was obtained under RT4 (91.60%) and CT (90.6) % methods. Corn yield and agronomic properties were significiantly 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. Protein, oil and ash content of corn were not affected statistically (p>0.05) by tillage method.

According to our results, conventional tillage method, CT had the higest 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. From the results, it can also be concluded that conservation tillage and direct seeding can be easily applied after lentil for second crop corn.

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