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Management Effect on Soil Characteristics and Yield in Second Crop Corn Grown in Tokat, Turkey

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Abstract: This study was conducted to understand the status of farmers who produce silage corn as second crop in Tokat. Three different farms were selected for the study. Gravimetric water content, bulk density and penetration resistance were determined at three different depths (0-10, 10-20 and 20-30 cm) before and after soil tillage and after harvest. Mean emergence dates, percentage of emerged seedlings, plant height, stem diameter, leaf number, dry matter and silage corn yield were also determined. Bulk density and penetration resistance values measured after tillage and harvest were below the plant growth restriction limit (3 MPa). Mean emergence dates, the percentage of emerged seedlings, plant height, stem diameter, leaf number, dry mater and silage corn yield were ranged between 13.27 to 19.38 day, 59.37 to 79.26%, 133.6 to 276.5 cm, 19.3 to 23.8 mm, 12.3 to 14.3 number per plant, 825.8 to 1015.7 kg da^{-1} and 6201.3 to 7446.3 kg da^{-1}, respectively.

Key words: Second crop silage corn, soil tillage, yield

INTRODUCTION

Following the winter creal harvest, silage corn as second crop has been widely grown as an animal food in Turkey. Different tillage systems are used to allow rapid establishment of the second crop in areas constrained by a short growing season. A conservational tillage system has found application in areas of silage corn production where conventional systems retard the seedling emergence date in Turkey (Altuntas *et al*., 2005).

Corn is the seventh most widely planted field crops (570000-600000 ha) and its ranked the third in terms of production capacity. In Tokat, 26 680 da silage corn was planted in 2003 and 115 342 ton corn, was obtained in the same year. The average silage corn as the first crop in 2004 was 5 and 4 ton da^{-1} as the second crop (Anonymous, 2003, 2004).

Farmers irrigate the field to be able to easily prepare the seedbed in conventional production system for second crop corn. But this method has some disadvantages, such as excessive field traffic and high-energy cost. In addition, time is very important factor in second crops. Therefore, alternative production methods, which have low energy cost and short applying time, should be applied in Trakya region (Bayhan *et al*., 2006).

Different soil tillage systems and their effects on crop yield were investigated by many researchers (Özgüven *et al*., 1995; Özmerzi and Barut, 1996; Çarman, 1997; Aykas and Önal, 1999; Tapela and Colvin, 2002; Nevens and Reheul, 2003; Chen *et al*., 2005) throughout the world. Yalcin and Cakir (2006) compared the effects of conventional and reduced tillage systems with single and cross pass subsoiling and direct seeding applications on corn yield. Direct seeding method was nine fold field effective as compared to that of conventional method. The highest yield was obtained with cross pass subsoiling method as 72.6 and 61.6 Mg ha^{-1} in the first and the second year.

Bayhan *et al*. (2006) conducted a study to compare five tillage methods with no-tillage. All tillage methods and direct seeding were applied in dry soil conditions except conventional method. The tillage methods used were heavy-duty disc harrow, plough, rotary tiler, tillage combination of tine, rotor and roller and conventional tillage method in which plough was used in wet soil conditions. The parameters tested were statistically significant. Direct seeding method gave the best result for mean of emergence dates (4.93 days) and percentage of emerged seedlings (95.48%). The best result for silage yield (69.32 Mg ha^{-1}) was found in tillage combination and the lowest yield (58.92 Mg ha^{-1}) was obtained in heavy-duty disc harrow tillage method.

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Cassel *et al*. (1995) evaluated the effects of four tillage practices on corn growth and soil properties on two crust-prone soils. The interactions between tillage, soil properties and plant performance were complex. Mean corn grain yield for the four year-locations was the least, 1.23 Mg ha^{-1}, for moldboard plow-disc, compared with 2.97 Mg ha^{-1} for no-till and 2.44 Mg ha^{-1} for chisel plow; mean yield for in-row subsoiling in 1987 was 3.69 Mg ha^{-1}.

Due to the increase in silage corn production in recent years, appropriate soil tillage methods suitable for the climate and the soil characteristics of the region are needed. In this study, the status of farmers who produce silage corn as second crop in Tokat was primarily evaluated. Therefore, gravimetric water content, bulk density and penetration resistance, mean emergence dates, the percentage of emerged seedlings, plant height, stem diameter, leaf number, dry matter and silage corn yield were determined at the end of the growing season in 2004 in selected farms.

MATERIALS AND METHODS

Site description and treatments: The research was conducted in 2004 at Tokat Province in middle Black sea region of Turkey. Tokat province was located between 35° 27'-37° 39' eastern and 39° 52'-40° 55' northern latitudes. The elevation is 623 m, average annual precipitation is 444 mm and air temperature is 12°C.

The experiments were conducted after growing season of wheat at three different experimental sites. Some initial physical and chemical properties of soils of the experimental sites were presented in Table 1. All management practices applied by farmers during growing season were given in Table 2, 3 and 4.

Gravimetric Water Content (GWC), Bulk Density (BD) and Penetration Resistance (PR), was determined before and after tillage and after harvest. From each location, GWC and BD samples were taken from three soil depths (0-10, 10-20 and 20-30 cm). GWC and BD were determined as described by Blake and Hartge (1986). GWC and BD were measured on duplicate undisturbed samples in 100 cm^3 cylinders, following 24 h in 105°C oven drying.

PR was measured by a hand penetrometer (Eijkelkamp Co.). The measuring range of the penetrometer used is up to 5000 kPa and maximum depth is 80 cm. The measurements were made with a cone with angle of 30° and base area of 1 cm^2. The penetrometer was pushed into the soil with a speed of 2 cm sec^{-1} and measurements were conducted at every 1 cm up to 60 cm of soil depth at six positions (Anonymous, 1990).

Table 1: Soil physical and chemical properties (0-30 cm) of the experimental sites

	Experimental site		
Soil properties	A	B	C
Particle size distribution, sand/silt/clay (%)	39.3/30/30.7	1.3/66/32.7	85.3/8/6.7
Soil texture	Clay loam	Silty clay loam	Sand
Organic matter (%)	1.65	1.84	1.41
Lime (%)	6.3	8.9	10.3
Total saline (%)	0.023	0.021	0.013
Total phosphorous (%)	12.37	12.14	3.89
pH	7.72	7.96	8.05
Gravimetric water content (%)			
0-10 cm	18.14	9.88	16.98
10-20 cm	17.53	14.84	19.03
20-30 cm	20.66	12.74	20.40
Bulk density (g cm^{-3})			
0-10 cm	1.39	1.46	1.40
10-20 cm	1.42	1.48	1.49
20-30 cm	1.49	1.51	1.48
Penetration resistance (MPa)			
0-10 cm	2.28	3.33	0.70
10-20 cm	2.58	4.05	1.03
20-30 cm	2.69	4.15	1.16

To determine the Mean Emergence Dates (MED) and the Percentage of Emerged seedlings (PE), emerged silage corn was counted on several dates during the emergence period in 6 m length rows. MED and PE were calculated using the equations given by Bilbro and Wanjura (1982);

$$MED = (N_1D_1 + N_2D_2 + \dots + N_nD_n)/(N_1 + N_2 + \dots + N_n) \quad (1)$$

$$PE = \{(\text{total emerged seedlings/m})/(\text{number of seed planted/m})\} \times 100 \quad (2)$$

where $N_{1...n}$ is the increase in the number of emerged plant compared to the previous count and $D_{1...n}$ is the number of days after planting.

Growth rate was determined at harvest time by measuring plant height, stem diameter, leaf number, Dry Matter (DM) and silage corn yield. Data for plant height, stem diameter and leaf number were obtained with 20 randomly selected plants in different rows for each field. Plants were cut and dried in an oven to determine the dry matter yield at 65°C until reaching the constant weight (Ngunjiri and Siemens, 1995). Plants were harvested from centre of the 3 rows and weighted to determine the silage corn yield.

The experiments were designed as a randomized block design with three replications. In order to determine the effect of measurement time and experimental site on soil and plant properties, data were subjected to analysis of variance and significant means separated by the Duncan Multiple Range Test. The statistical analyses were performed using SPSS 10.0 software (SPSS, 2000).

Table 2: Operations applied by farmers in the experimental site A

	Tillage			
	Working width (cm)	Working depth (cm)		Operation date
Moulboard plow	120	30		19.07.2004
Rotary tiller	160	15		20.07.2004
Single packer roller	300	-		20.07.2004
	Planting			
	Seed rate (kg da^{-1})	Space in the inter-rows (cm)	Space on the row (cm)	Operation data
Pneumatic planter	1.4	70	15	20.07.2004
	Fertilization (Urea 25×25)			
Pneumatic planter	20	70	15	20.07.2004
	Other operation			
First irrigation	Surface flooding irrigation			04.08.2004
First hoeing	Rotary cultivator			17.08.2004
Second irrigation	Surface flooding irrigation			23.08.2004
Second hoeing	Rotary cultivator			28.08.2004
Third irrigation	Surface flooding irrigation			10.09.2004
Harvest	Silage maize harvester			08.10.2004

Table 3: Operations applied by farmers in the experimental site B

	Tillage			
	Working width (cm)	Working depth (cm)		Operation date
Chisel	180	20		15.07.2004
	Planting			
	Seed rate (kg da^{-1})	Space in the inter-rows (cm)	Space on the row (cm)	Operation date
Pneumatic planter	2.2	70	13	18.07.2004
	Fertilization (NPK 18×24×12)			
Pneumatic planter	20	70	13	18.07.2004
	Other operation			
First irrigation	Overhead irrigation			19.07.2004
First hoeing	Rotary cultivator			02.08.2004
Second irrigation	Surface flooding irrigation			05-06.08.2004
Second hoeing and fertilization	Rotary cultivator+fertilizer applicator			16.08.2004
Third irrigation	Surface flooding irrigation			17-18.08.2004
Fourth irrigation	Surface flooding irrigation			24-25.08.2004
Harvest	Silage maize harvester			08.10.2004

Table 4: Operations applied by farmers in the experimental site C

	Tillage			
	Working width (cm)	Working depth (cm)		Operation date
Mouldboard plow	85	27		03.08.2004
Rotary tiller	200	15		03.08.2004
Single packer roller	198	-		04.08.2004
	Planting			
	Seed rate (kg da^{-1})	Space in the inter-rows (cm)	Space on the row (cm)	Operation date
Pneumatic planter	10	70	4.5	04.08.2004
	Other operation			
First irrigation	Surface flooding irrigation			08.09.2004
Harvest	Silage maize harvester			10.10.2004

RESULTS AND DISCUSSION

The effects of measurement time and experimental site on soil characteristics: The effects of measurement time and site on gravimetric water content, bulk density and penetration resistance were presented in Table 5. Measurement time had a significant effect ($p<0.01$) on BD at 0-10 cm and on PR, at 0-10 and 10-20 cm. However, measurement time had a significant effect ($p<0.05$) on BD at 10-20 cm and on PR at 20-30 cm depths. Measurement time did not significant effect the GWC at 3 depths and BD at 10-20 cm depth. Although, the experimental site had a significant effect ($p<0.01$) on GWC at 0-10 and 20-30 cm depth and on PR at 3 depths, it had a significant effect

Table 5: ANOVA of the effect of measurement time and experimental site on gravimetric water content, bulk density and penetration resistance

Source of variation	df.	Gravimetric water content			Bulk density			Penetration resistance		
		0-10 cm	10-20 cm	20-30 cm	0-10 cm	10-20 cm	20-30 cm	0-10 cm	10-20 cm	20-30 cm
Measurement Time (MT)	2	NS	NS	NS	**	*	NS	**	**	*
Site (S)	2	**	*	**	*	NS	NS	**	**	**
MT X S	4	**	NS	**	*	NS	NS	**	**	**

**: Significance of the 0.01 probability level; *: Significance of the 0.05 probability level; NS: Not Significant at the 0.05 probability level

Table 6: Mean comparisons by the Duncan Multiple Range Test of gravimetric water content, bulk density and penetration resistance

Measurement time	Site	Gravimetric water content (%)*			Bulk density (g cm^{-3})*			Penetration resistance (MPa)*		
		0-10 cm	10-20 cm	20-30 cm	0-10 cm	10-20 cm	20-30 cm	0-10 cm	10-20 cm	20-30 cm
Before tillage	A	18.14a	17.53	20.66a	1.39	1.42	1.49	2.28b	2.58b	2.69b
	B	9.88b	14.84	12.74b	1.46	1.48	1.51	3.33a	4.05a	4.15a
	C	16.98a	19.03	20.40a	1.40	1.49	1.48	0.70c	1.03c	1.16c
	Mean	15	17.12	17.93A	1.42A	1.46A	1.49A	2.10A	2.55A	2.67A
After tillage	A	18.70a	18.32a	19.51a	1.22b	1.30	1.30b	1.38	1.45	1.83
	B	7.55b	9.19b	9.94b	1.39a	1.37	1.48a	1.57	2.12	2.40
	C	18.96a	16.39ab	19.91a	1.08b	1.24	1.34b	0.43	0.80	1.20
	Mean	15.07	14.63	16.45AB	1.23B	1.30B	1.37B	1.13B	1.46B	1.81B
After harvest	A	18.60a	19.19a	19.20a	1.40	1.39	1.49	1.48	1.75b	1.92
	B	14.62a	15.25ab	15.37ab	1.35	1.50	1.51	1.23	1.68b	2.27
	C	7.02b	10.53b	10.09b	1.38	1.38	1.38	1.60	2.93a	3.03
	Mean	13.41	14.99	14.89B	1.38A	1.42A	1.46AB	1.44AB	2.12A	2.41AB

*For each column, the values followed by the same letter(s) are not significantly different at the 0.05 probability level

($p<0.05$) on GWC only at 10-20 cm depth and on BD at 0-10 cm depth. The experimental site had no significant effect on BD at 10-20 and 20-30 cm depth (Table 5).

Gravimetric water content: Before and after tillage, GWC values obtained in the experimental site A and C at each soil depth were higher than those obtained for the experimental site B. However, GWC values in experimental site C were lower than the experimental site A and B at all depths following the harvest (Table 3). Change in GWC was evidence to the lack of irrigation during growing season (Tables 2, 3 and 4). Sandy particle size of soils in the experimental site C may also affect the decrease in GWC. GWC in the experimental site B after harvest increased (93.64%) as compared to that of after tillage (Table 6). The mean comparisons of GWC exhibited no significant differences for measurement time at 0-10 and 10-20 cm depths (Table 6).

Bulk density: The differences in BD before tillage between experimental sites were not statistically significant at 0-10 cm. Values of BD at 0-10 cm soil depth ranged from 1.39 to 1.46 g cm^{-3}, with a mean value of 1.42 g cm^{-3}. After tillage, BD of 0-10 cm ranged from 1.08 to 1.39 g cm^{-3} and the differences in BD between experimental sites were statistically significant. After tillage, BD values obtained in the experimental sites A and C tilled by rotary tiller at 0-10 cm depth were lower than that of the experimental site B. The mean comparisons of BD exhibited no significant differences between experimental sites for all measurement times at 10-20 cm depth. Although, the differences in BD between experimental sites were not statistically significant before tillage, it was statistically significant at 20-30 cm depth after tillage. Due to the effect of mouldboard plow used in soil tillage, the mean BD values in the experimental sites A and C at 20-30 cm depth decreased by 12.75 and 9.46%, respectively as compared to the experimental site B (1.99%). After harvest, values of BD at all depths ranged from 1.35 to 1.51 g cm^{-3}. The BD values determined after harvest were affected by the agricultural operations applied during the growing season. Values of BD at all depths after tillage and harvest ranged from 1.08 to 1.51 g cm^{-3} (Table 6). Bowen (1981) suggested a general rule (with many exceptions) that bulk density measurements of 1.55, 1.65, 1.80 and 1.85 Mg m^{-3} can restrict root growth and thus will reduce crop yields on clay loams, silt loams, fine sandy loams and loamy fine sands, respectively (Fulton *et al*., 1996).

Penetration resistance: Values of PR in all depths and experimental sites before tillage, after tillage and after harvest ranged from 0.70 to 4.15 MPa, 0.43 to 2.40 MPa and 1.23 to 3.03 MPa, respectively. Before and after tillage, the highest PR mean values occurred in site B while the lowest values obtained in experimental site C at

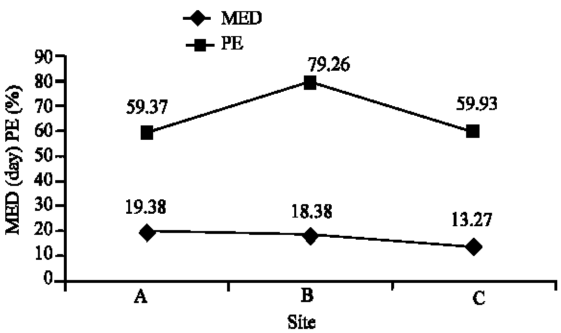

Fig. 1: The mean emerged dates (MED) and percentage of emerged seedlings (PE) values obtained for experimental sites

all depths. Based on the Duncan test, experimental sites after tillage fall in the same group, however, they grouped into different categories before tillage at all depths. After harvest, the differences in PR between experimental sites were not statistically significant at 0-10 and 20-30 cm, it was significant at 10-20 cm depth (Table 6). PR values decreased with the tillage. Before tillage and after harvest, the maximum PR mean values in all depths and experimental sites were lower than 3 Mpa, indicating that root growth was not restricted by soil strength. Boone *et al.* (1986) reported the upper critical mechanical limit for corn as 3.0 and 1.5 MPa for the lower critical mechanical limit (Abu-Hamdeh, 2003).

Mean emergence dates (MED) and Percentage of emerged seedlings (PE): The mean MED and PE values were obtained as 19.38, 18.38 and 13.27 days, 59.37, 79.26 and 59.93% for the experimental site A, B and C, respectively. The lowest MED and PE (13.27 day and 59.37%, respectively) mean value were obtained at experimental site C (Fig. 1). Yalcın and Cakır (2006) found greater PE values for moist soils in silage corn production at subsoiler (two passes) plus direct sowing application. Researchers reported the lowest PE values (66%) at conventional tillage method with mouldboard plow. Bayhan *et al.* (2006) also reported that soil tillage practices had significant effect on MED and PE values of silage corn grown secondary crop. They found that MED value was the highest when the seed and soil contact at maximum and the PE was the highest when the soil moisture content at seeding depth was high.

Plant height, stem diameter, leaf number: Plant height, stem diameter and leaf number of silage corn were presented in Fig. 2. Based on the Duncan test, plant

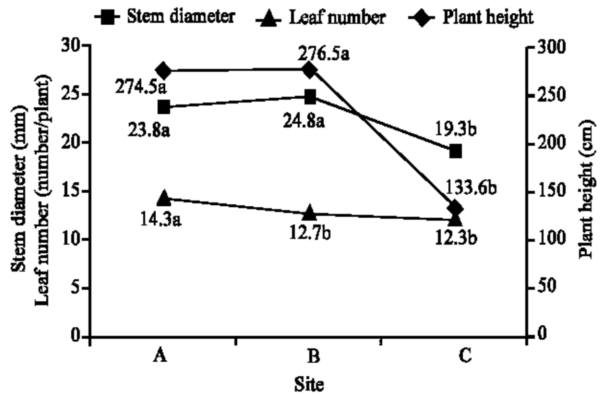

Fig. 2: Plant height, stem diameter and leaf number values of silage corn obtained for experimental sites (For each curve, the values followed by the same letter are not significantly different at the 0.05 probability level)

height and stem diameter in experimental sites A and B fall in the same group and the leaf number in experimental sites B and C fall in the same group. The lowest plant height, stem diameter and leaf number values were obtained in the experimental site C as 133.6 cm, 19.3 mm and 12.3 numbers per plant, respectively. The highest plant height and stem diameter values were obtained in experimental site B (276.5 cm and 24.8 mm, respectively) and the highest leaf number value was obtained in experimental site A (14.3 number per plant) (Fig. 2). Bayhan *et al.* (2006) reported that soil tillage practices influenced the plant height and stem diameter in silage corn as grown secondary crop.

Dry matter yield and silage corn yield: Values of dry matter and silage corn in experimental sites ranged from 825.8 to 1015.7 kg da^{-1} and 6201.3 to 7446.3 kg da^{-1}, respectively. The differences in silage corn yield between experimental sites were not statistically significant while in dry matter yield were statistically significant ($p<0.01$). Based on Duncan test, dry matter yields in experimental sites A and C fall in the same group. The highest dry matter yield and silage corn yield values were obtained in the experimental site B as 1015.7 kg da^{-1} and 7446.3 kg da^{-1}, respectively. The lowest dry matter yield and silage corn yield values were obtained in the experimental site B (825.8 kg da^{-1}) and A (6201.3 kg da^{-1}), respectively (Fig. 3). Depending on high PE values, silage corn was also quite high in experimental site B. Yalcın and Cakır (2006) indicated that second crop silage corn yield was significantly affected by soil tillage and cilimatic characteristics. They also reported that highest

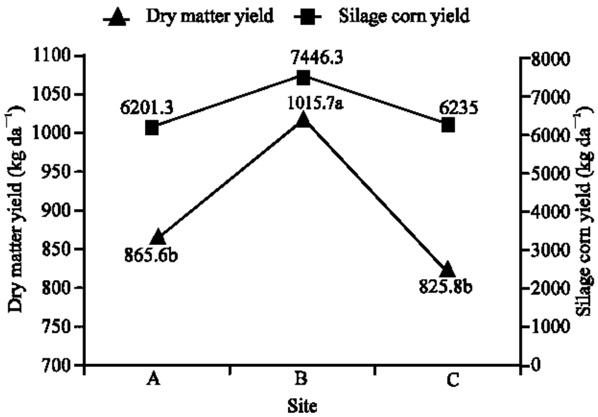

Fig. 3: Values of dry matter and silage corn yield obtained for experimental sites (For each curve, the values followed by the same letter are not significantly different at the 0.05 probability level)

yield was obtained with cross pass subsoiling method as 72.6 and 61.6 Mg ha^{-1} in the first and second year, respectively. Bayhan *et al.* (2006) also reported similar results and indicated that PE values had significant effect on yield.

CONCLUSIONS

Bulk density and penetration resistance values measured after tillage and after harvest in the experimental sites studied were not high to restrict the plant growth. Fields were not irrigated before tillage. Seed beds in A and C sites were prepared following mouldboard plough and rotatiller applications. Single packer roller was used to provide better contact between soil and seeds in these sites. Sprinkler irrigation was used in site B following seed bed preparation with chisel. The irrigation application right after planting might probably contribute to the high PE values obtained in site B. Plant height and stem diameter values in C site were lower as compared to that of A and B sites. The highest silage yield was obtained in site B and lowest in site A. A negative relationship occurred between silage yield and other plant related parameters. Small distance between rows caused great seed rate and this probably resulted in such relationship.

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