Emergence of Silage Maize as Affected by Conservation Tillage and Ridge Planting Systems

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ABSTRACT

In this study, the effects of tillage and planting systems on physical properties of soil and plant characteristics of second crop silage maize (seedling emergence) grown in a Transition Climate Belt of Turkey were investigated. Experiment was conducted on a sandy clay loam soil at Erbaa Karayaka Plain. The tillage systems evaluated were conventional with a mouldboard plough+cultivator+toothed harrow and conservational with chisel and toothed harrow. The three planting systems studied were flat with no-ridging, ridge planting, and direct planting system with no tilling. Soil moisture content, bulk density, penetration resistance, maize mean emergence dates, emerged rate index and percentage of emerged seedlings were measured to assess the effect of different tillage and planting system on emergence of silage maize. Soil moisture content, bulk density and penetration resistance in conventional tillage and ridge planting systems were higher than those of conservational tillage and flat planting systems. The percentage emerged of seedling was slightly higher in ridge planting than flat planting. Silage maize emergence was higher in conservational tillage system than the conventional tillage system. The ridge planting system reduced the mean emerged date, and increased the percentage emerged of seedling, and produced higher percentage of emerged seedling as compared to flat and direct planting systems.

Keywords: Conservational tillage, ridge planting, soil properties, emergence rate index, percentage of emerged seedlings, silage maize

1. INTRODUCTION

The silage maize (*Zea mays* L.) has been widely grown as an animal food in Turkey. Silage maize production in Mid-Blacksea Transition Climate Belt of Turkey gradual increases. Turkey has approximately 29.500 ha of land harvested for silage maize production (FAO, 2006). Different tillage systems are sometimes used to allow rapid establishment of the second crop in the area constrained by a short growing season. One of the difficulties in increasing the silage maize sowed area as a crop is insufficient water for irrigation in summer. Conservational tillage system, therefore, has been widely applied in silage maize production where conventional systems retarded the seedling emergence date in Turkey (Altuntas et al., 2005).

Tillage and planting methods might vary from one region to another depending on climate, topography, and soil properties. Ridge tillage and planting are used in different crops and climates in order to provide labor saving, enhance soil fertility, better water management, improve water and wind erosion control, enhance rooting depth and improve pest management (Lal, 1990). The ridge tillage is one of the most common non-inversion tillage systems in the corn belt of the USA. Many experiments have demonstrated that ridge tillage maintains or increases yield and economic return while reducing the use of fertilizers and pesticides. (Blaylock and Cruse, 1992). The conventional tillage system in the second crop silage maize seedbed preparation involves mouldboard plough, cultivator or harrowing. Most operations following the initial ploughing tend to compact the soil, reduce water infiltration, soil oxygen and organic matter content, and increase fuel consumption (Tebrügge, 2002). Conservational (reduced) tillage using chisel implements ridge tillage, and no till might improve water infiltration, performance and yield of maize (Cassel et al., 1995). Pikul et al. (2001) reported that corn yield, averaged across 11 years was 3.5% greater under conventional tillage than under ridge tillage and they also explained that ridge tillage protected soil from erosion, without sacrificing crop yield. Laszlo and Gyuricza (2004) reported that ridge tillage resulted in lower penetration resistance and bulk density values in the upper 20 cm compared to conventional tillage and no-tillage.

Alternative tillage practices such as conservational tillage system, ridge and direct planting systems are needed to maintain more surface cover, reduce erosion, increase crop yield and economic return. It is important to measure the long term impact on soil quality, crop growth and yield to evaluate different tillage systems and planting systems. Alternative tillage and planting practices are being experiment by farmers in Turkey on row crops (cotton, maize, soybean etc.). The current requirements to improve soil and crop qualities have increased the interest in conservational tillage systems and alternative planting systems (ridge and direct planting) for wheat and silage maize crop rotation.

2. OBJECTIVES

The objectives of this study were to investigate the effects of conventional and conservational tillage systems and flat, ridge and direct planting systems on soil properties and emergence of silage maize, and to gather information supporting the development of silage maize production systems in the region.

3. MATERIALS AND METHODS

The experiment was conducted in a research field during 2005 at Erbaa Plain located in 56 km North of Tokat (37° 07' N latitude; 38° 52' E longitude), Mid-Blacksea Transition Climate Belt of Turkey. The region has an altitude of 375 m and slope between 0 and 10 %. The soil texture is sandy clay loam (57.5% sand, 14.9% silt and 28.6% clay), and slope of the experimental plot is 4%. The soils have 1.94% of organic matter, 0.025% of total salt, 0.94 kg/da P_2O_5, 108.96 kg/da K_2O, 22% $CaCO_3$

and 7.45 pH. The annual average of precipitation, temperature and relative humidity are 495.8 mm, 12.9°C, and 63.4%, respectively. Those averages during the experiment conducted in July 2005 were 27.4 mm, 23.7 °C, and 56.6%, respectively (Anonymous, 2006).

The experiment was conducted in the third week of July following the wheat harvest. The experiment was designed in a randomized complete block design with three replicates with a main factor of tillage and a sub-factor of planting system. Plots were 10 m wide and 10 m long. The experimental area comprised two adjacent sites which were used as wheat and silage maize rotation for several years. Silage maize variety (TTM-813) was planted in rows spaced 70 cm apart at a rate of 7.14. 10^4 seeds/ha. Weights of standard tractor and pneumatic precision planter were 1.82 Mg and 0.65 Mg, respectively. A planter consisting of vacuum pressure, perforated disc and 4 rows was used for flat, ridge planting, and direct planting systems. Planting depth was 0.07 m, and working speed was 6 km/h. The mouldboard plough and chisel were used for primary tillage. The seedbed preparation operations followed the normal practices for the conventional and conservational systems, and a lister was used for the ridge planting system. All management practices for silage maize were the same as those used by local farmers. The list of tillage equipment and planter used in the experiments and their specifications was given in Table 1.

Table 1. Characteristics of the tillage equipment and planter.

Tool type	Unit number	Weight (Mg)	Working width (mm)	Working depth (mm)	Hitch type
Mouldboard plough	3	0.32	900	300	Mounted
Cultivator	9	0.27	2150	150-200	Mounted
Chisel	5	0.33	1300	450	Mounted
Toothed harrow	37	0.22	2250	100-150	Mounted
Lister	3	0.13	2100	250-300	Mounted
Pneumatic planter	4	0.65	2100	50-150	Mounted

After planting the silage maize, the experimental area was irrigated in flat and ridge planting systems, whereas the plots used for direct planting system were irrigated prior the planting. In this study, for the main factor of the tillage, conventional and conservational tillage systems were as follows:

MCT: Mouldboard plough, cultivator and toothed harrow.
CT : Chisel plough with toothed harrow.

The sub-factor of planting systems was as follows:

FP: Flat planting system with no-ridging,
RP: Ridge planting system in which a lister was used to form ridges (15 x 30 cm sizes),
DP: Direct planting system with pneumatic planter was used in no tilling.

Soil bulk density and penetration resistance were determined before tillage, after tillage, and after the planting operation. Six samples were taken for soil bulk density and penetration resistance per plot. Bulk density and gravimetric water content were determined in 100 cm^3 cylinders, after oven drying for 24 h at 105°C (Blake and Hartge, 1986). Soil penetration resistance was measured with a manual penetrometer (Eijkelkamp Co.) with maximum measurement range of 5000 kPa and 80 cm depth. The standard setting of a cone penetrometer has a cone with a 30° tip angle, a standard cone base area (1 cm^2) and shaft diameter (8 mm). Soil penetrometer measurements were made by pushing the penetrometer vertically into the soil at an approximated speed of 2 cm/s (Eijkelkamp, 1990).

Emerged seeds were counted several times during the emergence period in the rows with 6 m length for each treatment to determine mean emergence dates (MED), emerged rate index (ERI) and percentage of emerged seedlings (PE). MED, ERI and PE were calculated as (Bilbro and Wanjura, 1982):

MED= (N1.D1)+(N2.D2)+…….+(Nn.Dn) / (N1+N2+………….+Nn) . ….(1)

ERI= [(emerged seedlings /m) /MED)] …………………………………….(2)

PE = [(total emerged seedlings /m)/(number of seeds planted)] x 100 ..….(3)

where N is the number of seedlings emerging since the previous count, and D is the number of days after planting.

Analysis of variance and LSD analysis for mean comparisons were conducted as outlined by Gomez and Gomez (1984).

4. RESULTS AND DISCUSSION

4.1. Soil moisture, bulk density and penetration resistance

Soil moisture contents were 14.82% at 0- 10 cm and 17.75% at 10- 20 cm soil depths before tillage. Bulk density values were 1.29 g/cm^3, and 1.35 g/cm^3 at 0- 10 cm and 10- 20 cm soil depths, respectively. Soil penetration resistance values were 2.36 MPa and 2.68 MPa at 0-10 cm and 10-20 cm soil depth, respectively.
Results of soil moisture content, bulk density and penetration resistance measurements in the two tillage systems and three planting systems after tillage and post planting are presented in Tables 2. There were no significant differences in soil moisture content, bulk density and penetration resistance of conventional tillage system (MCT) and conservational tillage system (CT), and flat planting system (FP) and ridge planting system (RP) in both 0-10 cm and 10-20 cm depths after tillage. However, in both tillage and planting treatments, the 0-10 cm depth had lower soil moisture content, bulk density and penetration resistance values than those obtained for 10-20 depth.

Soil moisture content in flat planting (14.54% and 17.22% for depth 0-10 cm and 10-20 cm, respectively) was higher than that of ridge planting after tillage. Moisture content values of MCT at 0-10 cm and 10-20 cm soil depth were 14.11% and 17.12%, after tillage, respectively. The moisture contents of MCT, on the other hand, were 16.52% and 18.58% at the 0-10 cm and 10-20 cm soil depths after planting, respectively. Planting system had significant effect ($P < 0.01$) on soil moisture content in both soil depths, but there was no significant effect of tillage system on moisture content (Table 2). Moisture content values obtained from CT were higher than MCT after tillage (14.64% and 17.13% at 0-10 cm and 10-20 cm, respectively) and after planting (16.87% and 19.01% at 0-10 cm and 10-20 cm, respectively). The highest soil moisture content values obtained for direct planting system (DP) were 21.44% and 22.83% at 0-10 cm and 10-20 cm soil depths for after planting, respectively. The increase in DP may be related to irrigation before planting (Table 2). However, in ridge planting system, ridges were drier and warmer and caused changes in soil moisture content and bulk density.

Soil bulk density values increased in both soil depths in all treatments, compared to after planting. Soil bulk density was higher in the CT tillage system than that of MCT tillage system. Soil bulk density values in CT tillage system were obtained as 1.16 and 1.20 g/cm^3 at 0-10 cm and 10-20 cm soil depths after tillage. After tillage and post planting, soil bulk density values obtained in MCT at 0-10 cm and 10-20 cm soil depth were as 1.07 and 1.12 g/cm^3; 1.18 and 1.21 g/cm^3, respectively. Soil bulk density values in RP planting (1.08 and 1.14 g/cm^3 at 0-10 cm and 10-20 cm) were lower than those of flat planting (1.16 and 1.18 g/cm^3 at 0-10 cm and 10-20 cm) after tillage. The highest mean values of soil bulk density were obtained in the DP planting system as 1.23 and 1.27 g/cm^3 respectively at 0-10 cm and 10-20 cm soil depths after planting, respectively (Table 2). When compared with the flat and direct planting, ridge planting system reduced the soil bulk density, resulting in lower soil penetration resistance for ridges at each soil depth.

Penetration resistance as a function of tillage and planting systems is shown in Table 2. The effect of planting system on penetration resistance was found statistically significant ($P<0.05$) after planting. Penetration resistance of tillage and planting systems showed an increasing trend with the soil depth. Penetration resistance mean values obtained from CT system were recorded as 1.34 MPa (0-10 cm soil depth) and 1.35 MPa (10-20 cm soil depth) after tillage; and as 1.35 MPa (0-10 cm) and 1.42 MPa (10-20 cm) post planting. Soil penetration resistance values obtained from MCT tillage system were lower than those of CT after tillage. The highest soil penetration resistance mean values were obtained in the DP with 1.39 and 1.48 MPa at 0-10 cm and 10-20 cm soil depths post- planting, respectively. The planting systems considerably affected the soil moisture content and penetration resistance ($P<0.01$ and $P<0.05$, respectively).

Soil moisture content, bulk density and penetration resistance were higher in conservational tillage system consisting of chisel and toothed harrow applications than those of the conventional system with mouldboard plough, cultivator and toothed harrow applications. There were significant differences in penetration resistance between MCT and CT in 10-20 cm depth. In both depths (0-10 cm and 10-20 cm), CT had higher penetration resistance than MCT at 10-20 cm depth. Differences in penetration resistance were greater in the subsoil (10-20 cm) than topsoil (0-10 cm) post planting.

Soil parameters measured in flat planting were higher than those of ridge planting after tillage and post planting. Ridge planting system resulted in lower soil bulk density and penetration resistance at each soil depth than flat and direct planting systems after planting. Ridge planting appears to be capable of reducing bulk density and soil compaction. It can be concluded from the results that ridge tillage is capable of maintaining and improving favorable soil physical conditions for plant growth (Table 2).

Altuntas et al. (2005) reported that soil bulk density and penetration resistance values in conservational tillage system with mouldboard plough and disc harrow were higher than conventional tillage system having chisel and toothed harrow. Fahong et al. (2004) reported the soil bulk density values both flat and bed planting systems were generally between 1.18 and 1.35 g/cm^3 and 1.11 and 1.29 g/cm^3 at 0-10 cm and 10-20 cm depth, respectively. Husnjak et al. (2002) reported that the soil moisture content and bulk density values were higher in conservational tillage system having chisel and harrowing as 20.95 % and 1.51 g/cm^3 than the conventional tillage system consisting of mouldboard plough and disc harrow as 19.35% and 1.48 g/cm^3. Materechera and Mloza-Banda (1997) reported that bulk density and soil penetration on ridges were lower under conventional tillage system than minimum tillage. They also found that soil density and penetration resistance values were 1.16 g/cm^3 and 0.59 MPa for conventional tillage system, and 1.14 g/cm^3 and 0.623 MPa for minimum tillage system at 0-20 cm soil depth.

4.2. Mean emergence dates, emerged rate index and percentage of emerged seedlings

The effect of tillage systems on mean emergence dates (MED) was statistically significant ($P<0.05$) but the effect of the planting systems on emerged seedling rate (ERI) and percentage of emerged seedling (PE) was not statistically significant. The lowest and highest MED mean values of RP and FP planting systems were recorded as 15.38 days and 15.54 days, respectively (Figure 1). The lowest and the highest MED values of CT and MCT tillage systems were recorded as 15.42 days and 15.46 days, respectively. The effects of planting systems and tillage systems on mean emergence dates, emerged seedling rate and percentage of emerged seedlings were presented in Fig. 1.

Statistical analysis revealed that the emerged seedling rate differences among flat, ridge and direct systems were significant ($P< 0.05$). The effect of tillage system on percentage of emerged seedling (PE) was not significant. Mean emerged dates obtained from ridge planting and direct planting applications were lower than those of the flat planting systems. Mean emerged dates in CT tillage system were lower than those of the MCT tillage system. However, silage maize emergence rate in conservational tillage system was higher than the conventional tillage system. The higher seedling emergence rates were determined for conventional and conservational tillage systems for flat and ridge planting systems as 0.199 and 0.196 seedling/m day, respectively. The lowest PE value was obtained in direct planting system as 58.06%.

Table 2. Soil moisture content (%), soil bulk density (g/cm^3) and soil penetration resistance (MPa) affected by tillage and planting systems after tillage and planting.

Measurement time (MT)	Soil depth (cm)	Tillage systems	Planting systems								
			FP			RP			DP		
			%	g/cm^3	MPa	%	g/cm^3	MPa	%	g/cm^3	MPa
After tillage	0-10	MCT	14.35	1.07	1.23	13.86	1.07	1.21			
		CT	14.72	1.24	1.38	14.56	1.08	1.30			
	10-20	MCT	17.20	1.15	1.30	17.03	1.09	1.26			
		CT	17.23	1.22	1.39	17.13	1.19	1.30			
After planting	0-10	MCT	14.21	1.18	1.29	13.91	1.14	1.26	21.44	1.23	1.39
		CT	14.67	1.25	1.36	14.49	1.19	1.30			
	10-20	MCT	16.78	1.19	1.33	16.14	1.18	1.26	22.83	1.27	1.48
		CT	17.13	1.27	1.43	17.06	1.21	1.35			

MCT: Mouldboard plough, cultivator and toothed harrow;
CT: Chisel plough with toothed harrow,
FP: Flat planting,
RP: Ridge planting,
DP: Direct planting.

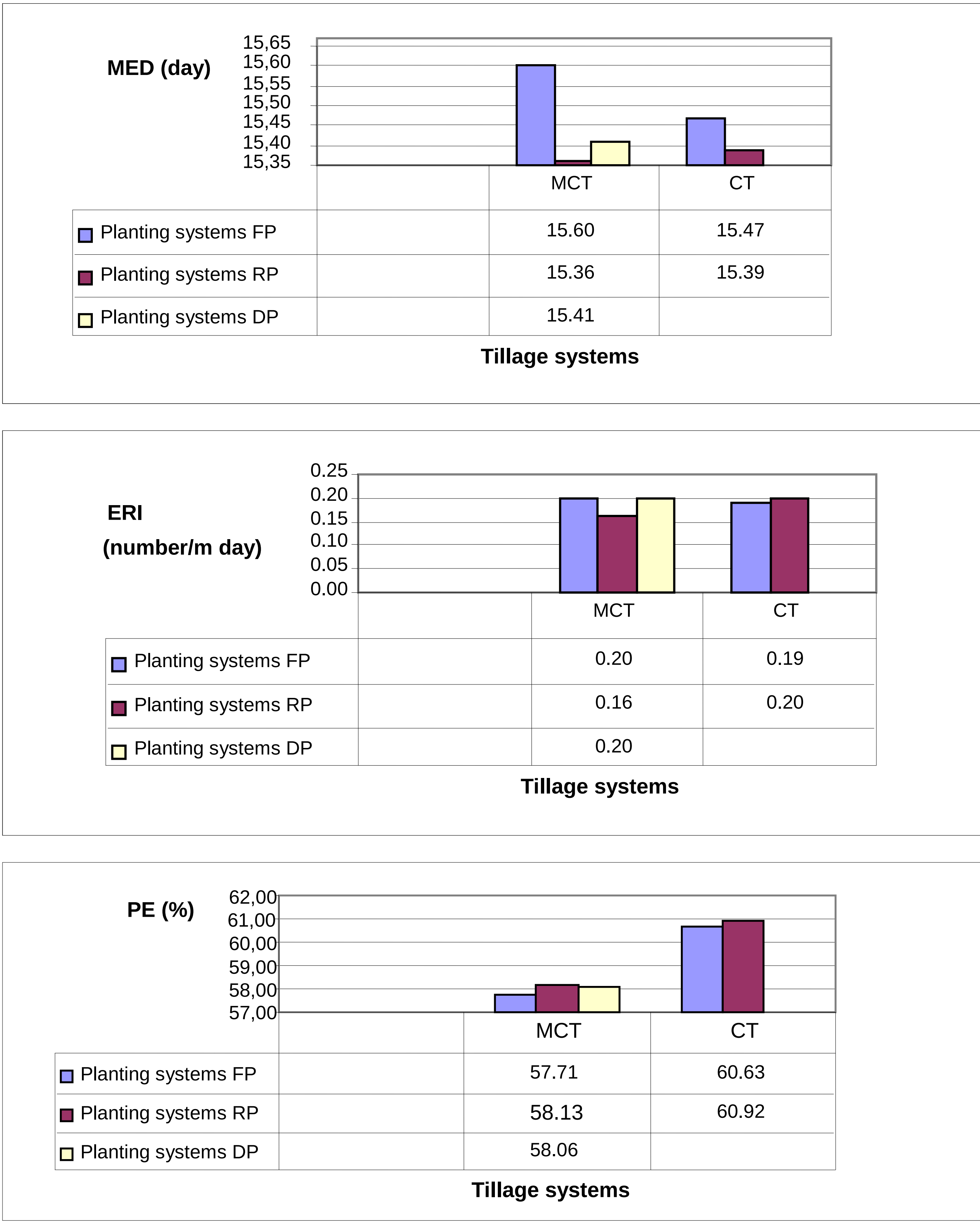
The highest PE values were as 59.87% and 59.13% in conservational tillage and ridge planting systems respectively. PE value was higher in CT tillage system than that of MCT tillage system. Ridge planting system yielded higher percentage of emerged seedling as compared to flat and direct planting system (Fig. 1).

In this study, the percentage of emerged seedlings was positively affected by ridge planting and conservational tillage systems. Seedling emergence percentage was greater in the CT tillage system which may be attributable to more suitable soil conditions for seedbed preparation.

Similarly, Sidiras et al (2000) reported high levels of residue cover increased the emergence rate of crop and explained higher seedling emergence in conservational tillage system with rotary hoe than in conventional tillage with mouldborad plough on clay loam soil. Ozpinar and Isik (2004) also reported that emerged of seedling rates in the ridge planting and chisel tillage were significantly higher than those of the flat planting and conventional tillage systems. Altuntas et al. (2005) reported that soil tillage and compaction treatments affected the MED and PE values of silage maize. They found that MED and PE values in conventional system with mouldboard plough were slightly higher than the conservational system with chisel application.

5. CONCLUSIONS

In this study, the effects of tillage and planting systems on soil physical properties and plant characteristics of the second crop silage maize grown in Transition Climate Belt were investigated. Soil physical properties were influenced by different planting systems in silage maize production on sandy clay loam soil. Soil moisture content, bulk density and penetration resistance in conventional tillage system were lower than those of the conservational tillage system after tillage and after planting, whereas moisture content and soil bulk density in ridge planting were lower than that of flat planting after tillage. Tillage system was no significant effect on soil moisture content. The planting systems affected the soil moisture content and penetration resistance. The favorable soil physical properties (the lowest bulk density and soil compaction) were obtained under conservational tillage (CT) and ridge planting (RP) systems. Mean emerged dates in CT tillage system, ridge and direct planting were lower than those of the MCT tillage and flat planting systems. Emergence rate and percentage of emerged seedling in conventional tillage system was lower than the conservational tillage system. The percentage emerged seedling was slightly higher but not statistically significant in ridge planting. The results indicated that ridge planting system reduced the mean emerged date and increased the percentage emerged of seedling. The highest percentage emerged of seedling was obtained under conservational tillage and ridge planting system, while the lowest was under conventional tillage and flat planting systems.



MED (day)	MCT	CT
Planting systems FP	15.60	15.47
Planting systems RP	15.36	15.39
Planting systems DP	15.41	

ERI (number/m day)	MCT	CT
Planting systems FP	0.20	0.19
Planting systems RP	0.16	0.20
Planting systems DP	0.20	

PE (%)	MCT	CT
Planting systems FP	57.71	60.63
Planting systems RP	58.13	60.92
Planting systems DP	58.06	

Figure 1. Mean emergence dates (MED day), emerged seedling rate (ERI seedling/m day), and percentage of emerged seedling (PE %) for tillage and planting systems.

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