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Effect of Different Tillage Methods on Grain Yield and Yield Components of Maize (*Zea mays* L.)

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ABSTRACT

Tillage practices influence soil physical, chemical and biological characteristics, which in turn may alter plant's yield and growth. Field experiments were conducted to study the effects of seven tillage methods on grain yield and yield components of maize (*Zea mays* L.) during 2004 and 2005. The soil of the experimental site was a fine, mixed, thermic, Typic Haplacambids clay-loam soil. Tillage treatments in the study were moldboard plow + two passes of disk harrow (MDD), moldboard plow + one pass of rotary tiller (MR), two passes of disk harrow (DD), one pass of tine cultivator + one pass of disk harrow (CD), one pass of rotary tiller (R), one pass of tine cultivator (C) and no-tillage (NT) as direct drilling method. Number of plants per hectare, number of cobs per plant, number of lines per cob, number of grains per line, cob diameter and cob length (yield components) were measured and consequently grain yield was determined for all treatments. The study indicated that tillage method significantly ($P \leq 0.05$) affected number of plants per hectare and number of lines per cob; the former being the major yield component explaining grain yield of maize under different tillage methods. The highest number of plants per hectare was obtained for the MDD and lowest for the NT treatment. The results suggested that tillage method significantly affected grain yield of maize in the order of MDD > MR > DD > CD > R > C > NT owing to differences in number of plants per hectare in the same order. Therefore, moldboard plow followed by two passes of disk harrow was a more appropriate and profitable tillage method in improving grain yield of maize due to reduced soil compaction, enhanced seed-soil contact, increased soil moisture storage and suppressing weed growth.

Key Words: Tillage methods; Maize; Grain yield; Yield components

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops of Iran and it ranks forth in cultivated area and production after wheat, barley and rice. It has greater nutritional value as it contains about 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 17% ash (Saif *et al.,* 2003). Due to higher yield potential, short growing period, high value for food, forage and feed for livestock, poultry and a cheaper source of raw material for agro-based industry, it is increasingly gaining an important position in the cropping system (Saif *et al.,* 2003).

A rapid increase in population in the world and subsequently higher food demands make mechanized agriculture viable. However, the recent increase in the mechanization of agriculture and intensive tillage operations are the main causes of soil compaction. Previous researchers (Lipiec *et al.,* 1991; Oussible *et al.,* 1992; Hakansson & Reeder, 1994) reported that the response of soil physical properties to soil compaction is manifested in an increase in bulk density, a decrease in total porosity, air permeability, plant-available water and crop yield. Soil compaction adversely affects soil structure, reduces crop production, increase runoff and erosion. Studies have also shown that changes in pore size distribution due to soil compaction resulted in a lower water infiltration rate (Yusuf & Yiljep, 2000; Yusuf, 2001) and slow down the downward growth of roots with restricted root systems to the upper part of the soil profile (Black & Hartge, 1986). Field experiments were conducted by Laboski *et al.* (1998) to determine if soil strength and/or available water could be the factors limiting maize rooting depth on an irrigated fine sandy soil. They found that a compacted soil layer confined roots almost entirely to the top of soil, because it had high soil strength and bulk density; the compacted layer in turn retained more water for maize use.

On the other hand, tillage practices modify soil structure by changing its physical properties such as soil moisture content, soil bulk density and soil penetration resistance. Annual disturbance and pulverizing caused by conventional tillage produce a finer and loose soil structure as compared to conservation tillage, which leaves the soil intact. The difference results in number, shape, continuity and size distribution of the pores network, which controls the ability of soil to store and transmit air, water, agricultural chemicals and crop growth. This in turn controls erosion, runoff and crop performance. Changes in soil physical properties affect the seedling emergence, plant population density, root distribution and crop yield (Khan *et al.,* 2001; Khurshid *et al.,* 2006). Conservation tillage often results in decreased pore space (Hill, 1990), increased soil strength (Bauder *et al.,* 1981) and stable aggregates (Horne *et al.,* 1992). The pore network in conservationally tilled soil is usually more continues, because of earthworms, root channels and vertical cracks (Cannel, 1985). Therefore, conservation tillage may reduce disruption of continues pores. Whereas, conventional tillage decreases bulk density of soil (Khan *et al.,* 1999) and soil penetration resistance. This also improves porosity and water holding capacity of the soil. Continuity of pore network is also interrupted by conventional tillage, which increases the tortuousity of soil. This all leads to a favorable environment for crop growth and nutrient use (Khan *et al.,* 2001). Among the crop production factors tillage contributes up to 20% and the most effective way to reduce soil compaction is tillage (Khurshid *et al.,* 2006). Despite the considerable amount of research done, which shows the negative effects of soil compaction and the positive effects of tillage methods on the crop growth and yield very limited work has been conducted to study the effects of different tillage methods on grain yield and yield components of maize and although grain yield of maize has continuously increased, especially for last decades, but still there is a gap between potential yield and actual yield of maize.

This study was planed to determine the effect of different tillage methods on grain yield and yield components of maize (*Zea mays* L.) in the arid lands of Iran.

MATERIALS AND METHODS

The field experiments pertaining to the effects of different tillage methods on grain yield and yield components of maize were carried out during 2004 and 2005 growing seasons at the experimental site of Varamin, Iran. The site is situated at latitude of 35°- 19' N and longitude of 51°- 39' E and is 1000 m above mean sea level in arid climate in the center of Iran, where the summers are dry and hot, while the winters are cool. The soil of the experimental site was a fine, mixed, thermic, Typic Haplacambids clay-loam soil. The experiments were laid out in a randomized complete block design having three replications. The size of each plot was 20.0 m long and 9.0 m wide. A buffer zone of 3.0 m spacing was provided between plots. The treatments were applied to the same plots during the 2 years (2004-05) on farm study. Tillage treatments in the study were moldboard plow + two passes of disk harrow (MDD), moldboard plow + one pass of rotary tiller (MR), two passes of disk harrow (DD), one pass of tine cultivator + one pass of disk harrow (CD), one pass of rotary tiller (R), one pass of tine cultivator (C) and no-tillage (NT) (Table II). The MDD and MR treatments are called conventional tillage and DD, CD, R and C treatments are called conservation tillage. The NT is called direct drilling method. Also, the MDD, MR, DD, CD, R and C are called tilled treatments and all except for MDD and MR would be termed non-inversion tillage treatments.

In both growing season, maize variety 704 was planted at the rate of 25 kg ha^{-1} on 20th April with the help of 4-row maize planter by keeping row to row and plant to plant distance 75 cm and 15 cm, respectively. The seed moisture and germination percentage were 15 and 95%, respectively. Recommended levels of N (400 kg ha^{-1}), P (200 kg ha^{-1}) and K (100 kg ha^{-1}) were used as Urea, TSP and SOP, respectively. All other necessary operations such as pest and weed controls were performed according to general local practices and recommendations.

Table I. Details of different tillage treatments

Treatment	Description
MDD	Moldboard plow + two passes of disk harrow
MR	Moldboard plow + one pass of rotary tiller
DD	Two passes of disk harrow
CD	One pass of tine cultivator + one pass of disk harrow
R	One pass of rotary tiller
C	One pass of tine cultivator
NT	No-tillage

Grain yield was determined by harvesting the two middle rows of each plot and the yield components (number of plants per hectare, number of cobs per plant, number of lines per cob, number of grains per line, cob diameter & cob length) were determined from the samples taken randomly from the remaining part of each plot. Data on grain yield and yield components were recorded by using standard procedures. All the data were subjected to standard analysis of variance as proposed by Steel and Torrie (1984) and treatment means were compared by Duncan's Multiple Range test at 5% probability. The SPSS software was used for statistical analysis.

RESULTS

Grain yield of maize. A significant effect of different tillage treatments on grain yield of maize was found during both the years of study (Table II). The mean grain yield of maize in different tillage treatments (mean of 2004 & 05) are presented in Table III. The highest grain yield of 13.22 t ha^{-1} was obtained for the MDD treatment and lowest (7.40 t ha^{-1}) for the NT treatment.

Number of plants per hectare. A significant effect of different tillage treatments on number of plants per hectare was also found during the years of study (Table II). The highest number of plants per hectare of 79660 was obtained for the MDD treatment and lowest (40780) for the NT treatment (Table III).

Number of cobs per plant. A non-significant effect of different tillage treatments on number of cobs per plant was found during both study years (Table II). However, the highest number of cobs per plant of 0.92 was obtained for the MDD and MR treatments and lowest (0.89) for the C treatment (Table III).

Number of lines per cob. A significant effect of different tillage treatments on number of lines per cob was also found during both the years of study (Table II). The highest number of lines per cob of 14.9 was obtained for the MR treatment and lowest (13.4) for the R treatment (Table III).

Table II. Mean squares from the analysis of variance of grain yield and yield components of maize under different tillage treatments (mean of 2004 & 2005)

Source of variation	D.f.	Grain yield	Number of plants per hectare	Number of cobs per plant	Number of lines per cob	Number of grains per line	Cob diameter	Cob length
Replications	2	199.971^{NS}	2901430^{NS}	0.0025^{NS}	0.252^{NS}	2.064^{NS}	3.607^{NS}	52.684^{NS}
Treatments	6	272.368*	497985431.7*	0.001^{NS}	1.019*	6.340^{NS}	1.282^{NS}	12.170^{NS}
Error	12	10.276	3858201.6	0.001	0.502	12.082	3.111	103.879
CV (%)	---	0.005	3.10	3.50	4.90	7.50	4.85	5.30

* = Significant at 0.05 probability level
NS = Non-significant

Table III. Comparison of the means for grain yield and yield components of maize between different tillage treatments (mean of 2004 & 2005)

Treatments	Grain yield t ha^{-1}	Number of plants per hectare	Number of cobs per plant	Number of lines per cob	Number of grains per line	Cob diameter mm	Cob Length mm
MDD	13.22 a	79660 a	0.92 a	13.7 ab	47 a	35.2 a	190.7 a
MR	13.10 a	71250 b	0.92 a	14.9 a	48 a	37.2 a	194.1 a
DD	11.27 b	71160 b	0.90 a	14.1 ab	49 a	37.0 a	193.8 a
CD	11.23 b	64520 c	0.90 a	13.5 ab	47 a	36.1 a	192.2 a
R	10.23 c	60770 d	0.90 a	13.4 b	51 a	36.2 a	191.4 a
C	9.63 c	53930 e	0.89 a	14.5 ab	50 a	36.5 a	191.1 a
NT	7.40 d	40780 f	0.90 a	14.7 ab	49 a	36.3 a	196.3 a

Means in the same column with different letters differ significantly at 0.05 probability level according to Duncan's Multiple Range test

Number of grains per line. A non-significant effect of different tillage treatments on number of grains per line was found during the years of study (Table II). However, the highest number of grains per line of 51 was obtained for the R treatment and lowest (47) for the MDD and CD treatments (Table III).

Cob diameter. The effect of different tillage treatments on the cob diameter was found non-significant during both years of study (Table II). However, the highest cob diameter of 37.2 mm was obtained for the MR treatment and lowest (35.2 mm) for the MDD treatment (Table III).

Cob length. The effect of different tillage treatments on the cob length was found non-significant during both the years of study (Table II). However, the highest cob length of 196.3 mm was obtained for the NT treatment and lowest (190.7 mm) for the MDD treatment (Table III).

DISCUSSION

In this study, the salient components of grain yield such as number of plants per hectare, number of cobs per plant, number of lines per cob, number of grains per line, cob diameter, and cob length were studied to analyze the effect of different tillage methods on grain yield of maize. Results showed a significant response to the grain yield of maize and tillage practices were beneficial in improving the growth and grain yield of maize.

This study indicates that tillage method significantly ($P \leq 0.05$) affected the number of plants per hectare and number of lines per cob, but there were no significant differences in other yield components over different tillage treatments in both the growing seasons. The highest number of plants (79660 ha^{-1}) was obtained for the MDD treatment and lowest (40780 ha^{-1}) for the NT treatment. The number of plants per hectare for other treatments was in the order of MR>DD>CD>R>C. The data further indicated that number of plants per hectare is the major yield component explaining grain yield of maize under different tillage methods. Grain yield differences among different tillage treatments occur owing to differences in number of plant per hectare. The data pertaining to average grain yield reveals that tillage treatment affected grain yield in the order of MDD>MR>DD>CD>R>C>NT. The two years data showed that the highest grain yield (13.22 t ha^{-1}) was obtained for the MDD treatment and lowest (7.40 t ha^{-1}) for the NT. The highest amount of grain yield obtained in the MDD method might be due to reduced soil compaction, enhanced seed-soil contact, increased soil moisture storage, and suppressing weed growth. In case of NT method, the lowest amount of grain yield obtained may be due to significantly greater soil bulk density and soil penetration resistance, which adversely affects seed emergence, root growth, and plant population density. These results are in agreement with those of Khan *et al.* (1999), Khan *et al.* (2001), Yusuf (2001), Khurshid *et al.* (2006) and Yusuf (2006), who concluded that tillage practices significantly affects crop yield and growth.

CONCLUSSION

It can be concluded that tillage method of moldboard plow followed by two passes of disk harrow was found to be more appropriate and profitable tillage treatment in improving grain yield of maize as compared to other tillage treatments.

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