

Effect of Different Tillage Methods on Grain Yield and Yield Components of Corn (*Zea mays*)

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Abstract: Field experiments were conducted to study the effects of seven tillage methods on grain yield and yield components of corn. 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. The statistical results of the study indicated that tillage method significantly ($P=0.05$) affected grain yield, number of plants per hectare and number of rows per ear, but there was no significant differences in other components such as number of ears per plant, number of grains per row, ear diameter and ear length. The maximum value of grain yield (4.15 t ha^{-1}), number of plants per hectare (39830) and number of ears per plant (0.92) was obtained in case of MDD treatment, while maximum value of number of rows per ear (14.9) and ear diameter (37.2 mm) was observed in case of MR treatment. Also, maximum value of number of grains per row (51) was obtained in case of R treatment, while maximum value of ear length (196.3 mm) was observed in case of NT treatment. Conversely, the minimum value of grain yield (2.32 t ha^{-1}) and number of plants per hectare (20390) was obtained in case of NT treatment, while minimum value of number of ears per plant (0.89) was observed in case of C treatment. Moreover, minimum value of number of rows per ear (13.4) was obtained in case of R treatment, while minimum value of number of grains per row (47), ear diameter (35.2 mm) and ear length (190.7 mm) was noted in case of MDD treatment. Hence, moldboard plow followed two passes of disk harrow was found to be more appropriate and profitable tillage method in improving grain yield of corn possibly due to reduced soil compaction, enhanced seed-soil contact, increased soil moisture and suppressing weed growth.

Key words: Tillage methods • corn • grain yield • yield components

INTRODUCTION

Corn (*Zea mays*) is one of the most important cereal crops and it ranks forth in cultivated area and production after wheat, barley and rice in Iran. Although the use of improved varieties and fertilizers has increased corn production to much extent, the full potential of crop production has not yet been achieved.

Corn has greater nutritional value as it contains about 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 17% ash. 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 [1].

Soil tillage is among the important factors affecting soil physical properties and crop yield. Among the crop production factors, tillage contributes up to 20% [2]. Tillage method affects the sustainable use of soil resources through its influence on soil properties [3]. The proper use of tillage can improve soil related constrains, while improper tillage may cause a range of undesirable processes, e.g. destruction of soil structure, accelerated erosion, depletion of organic matter and fertility and disruption in cycles of water, organic carbon and plant nutrient [4]. Use of excessive and unnecessary tillage operations is often harmful to soil. Therefore, currently there is a significance interest and emphasis on the shift to the conservation and no-tillage methods for the purpose of controlling erosion process [5].

Conventional tillage practices modify soil structure by changing its physical properties such as soil bulk density, soil penetration resistance and soil moisture content. Annual disturbance and pulverizing caused by conventional tillage produce a finer and loose soil structure as compared to conservation and no-tillage method which leaves the soil intact [6]. This difference results in a change of number, shape, continuity and size distribution of the pores network, which controls the ability of soil to store and transmit air, water and agricultural chemicals. This in turn controls erosion, runoff and crop performance [7].

On the other hand, conservation tillage methods often result in decreased pore space [8], increased soil strength [9] and stable aggregates [10]. The pore network in conservationally tilled soil is usually more continuous because of earthworms, root channels and vertical cracks [11]. Therefore, conservation tillage may reduce disruption of continuous pores. Whereas, conventional tillage decreases soil penetration resistance and soil bulk density [12]. This also improves porosity and water holding capacity of the soil. Continuity of pore network is also interrupted by conventional tillage, which increases the tortuosity of soil. This all leads to a favorable environment for crop growth and nutrient use [7]. However, the results of no-tillage are contradictory [5]. No-tillage methods in arid regions of Iran had an adverse effect on crop yields [13]; while Chaudhary *et al.* [14] comparing conventional tillage method to no-tillage method concluded that higher moisture preservation and 13% more income was obtained in case of no-tillage.

At this time, a wide range of tillage methods is being used in Iran without evaluating their effect on crop growth. Therefore, the present investigation was planned to determine the effect of different tillage methods on yield and yield components of corn in the arid lands of Iran.

MATERIALS AND METHODS

Two field experiments were conducted to evaluate the effect of different tillage methods on yield and yield components of forage corn during 2004 and 2005 growing seasons at the Agronomic Research Area, Varamin, Iran. The site is located 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 summer season is dry and hot while the winter is cool. The soil of the experimental site was a fine, mixed, thermic, Typic Haplacambids clay-loam soil. Details of soil physical and chemical characteristics are given in Table 1.

Table 1: Physical and chemical characteristics of soils of the experimental site

Soil characteristics	Values
Sand (%)	24.60
Silt (%)	38.00
Clay (%)	37.40
Texture	Clay-loam
Bulk density (mg kg ⁻¹)	1.15
Organic carbon (%)	0.60
SP (%)	45.00
pH	7.50
EC (dS m ⁻¹)	2.30
Available P (mg kg ⁻¹)	40.40
Available K (mg kg ⁻¹)	460.00
Available Fe (mg kg ⁻¹)	2.84
Available Mn (mg kg ⁻¹)	12.90
Available Zn (mg kg ⁻¹)	1.50
Available Cu (mg kg ⁻¹)	1.13

Table 2: 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

The experiments were laid out in a randomized complete block design (RCBD) 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 year (2004-2005) 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) as direct drilling method (Table 2).

In both growing season, corn variety 704 was planted at the rate of 12.5 kg ha⁻¹ on 20th April with the help of 4-rows corn planter by keeping row to row and plant to plant distance 75 cm and 30 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. Pest and weed controls were performed according to general local practices and

Table 3: Comparison of the means for grain yield and yield components of corn between different tillage treatments (mean of 2004 & 2005)

Treatments	Grain yield t ha ⁻¹	Number of plants per hectare	Number of ears per plant	Number of rows per ear	Number of grains per row	Ear diameter mm	Ear Length mm
MDD	4.15 a	39830 a	0.92 a	13.7 ab	47 a	35.2 a	190.7 a
MR	4.11 a	35625 b	0.90 a	14.9 a	48 a	37.2 a	194.1 a
DD	3.54 b	35580 b	0.90 a	14.1 ab	49 a	37.0 a	193.8 a
CD	3.53 b	32260 c	0.90 a	13.5 ab	48 a	36.1 a	192.2 a
R	3.21 c	30385 d	0.90 a	13.4 b	51 a	36.2 a	191.4 a
C	3.02 c	26965 e	0.89 a	14.5 ab	50 a	36.5 a	191.1 a
NT	2.32 d	20390 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

recommendations. All other necessary operations except those under study were kept normal and uniform for all the treatments.

Standard procedures were adopted for recording the data on various growth and yield parameters. Grain yield was determined by harvesting the two middle rows of each plot. Yield components, i.e. number of plants per hectare, number of ears per plant, number of rows per ear, number of grains per row, ear diameter and ear length, were determined from the 10 samples taken randomly from the remaining part of each plot. Data on grain yield and yield components were recorded by using standard procedures. The data collected were analyzed statistically using Completely Randomized Block Design (RCBD) as described by Steel and Torrie [15]. Duncan's Multiple Range test at 5% probability was performed to compare the means of different treatments by using the computer software SPSS 12.0 (Version, 2003).

RESULTS

Grain yield: Different tillage treatments significantly affected grain yield during both the years of study. The highest grain yield of 4.15 t ha⁻¹ was obtained for the MDD treatment and the lowest (2.32 t ha⁻¹) for the NT treatment (Table 3).

Number of plants per hectare: A significant effect of different tillage treatments on number of plants per hectare was also found during the study years. The highest number of plants per hectare of 39830 was obtained for the MDD treatment and the lowest (20390) for the NT treatment (Table 3).

Number of ears per plant: A non-significant effect of different tillage treatments on number of ears per plant was found during the years of study. However, the highest number of ears per plant of 0.92 was obtained for

the MDD treatment and the lowest (0.89) for the C treatment (Table 3).

Number of rows per ear: The effect of different tillage treatments on number of rows per ear was also found significant during both the years of study. The highest number of rows per ear of 14.9 was obtained for the MR treatment and the lowest (13.4) for the R treatment (Table 3).

Number of grains per row: The effect of different tillage treatments on number of grains per row was also found non-significant during the study years. However, the highest number of grains per row of 51 was obtained for the R treatment and the lowest (47) for the MDD treatment (Table 3).

Ear diameter: A non-significant effect of different tillage treatments on ear diameter was also found during the years of study. However, the highest ear diameter of 37.2 mm was obtained for the MR treatment and the lowest (35.2 mm) for the MDD treatment (Table 3).

Ear length: The effect of different tillage treatments on ear length was also found non-significant during both the years of study. However, the highest ear length of 196.3 mm was obtained for the NT treatment and the lowest (190.7 mm) for the MDD treatment (Table 3).

DISCUSSION

In this study, effect of different tillage methods on grain yield and yield components of corn was investigated. The salient components of grain yield such as number of plants per hectare, number of ears per plant, number of rows per ear, number of grains per row, ear diameter and ear length were studied to analyze the effect of different tillage methods on growth and yield of corn.

The statistical results of the study indicated that tillage method significantly ($P=0.05$) affected grain yield, number of plants per hectare and number of rows per ear, but there was no significant differences in other yield components such as number of ears per plant, number of grains per row, ear diameter and ear length. The maximum value of grain yield (4.15 t ha^{-1}), number of plants per hectare (39830) and number of ears per plant (0.92) was obtained in case of MDD treatment, while maximum value of number of rows per ear (14.9) and ear diameter (37.2 mm) was observed in case of MR treatment. Also, maximum value of number of grains per row (51) was obtained in case of R treatment, while maximum value of ear length (196.3 mm) was noted in case of NT treatment (Table 3). These results are in agreement with those of Rashidi and Keshavarzpour [6], who concluded that annual disturbance and pulverizing caused by tillage practices produce a finer and loose soil structure which in turn affect the seedling emergence, plant population density and consequently crop yield. These results are also in line with the results reported by Khan *et al.* [7] that tillage practices produce a favorable environment for crop growth and nutrient use.

Conversely, the minimum value of grain yield (2.32 t ha^{-1}) and number of plants per hectare (20390) was obtained in case of NT treatment, while minimum value of number of ears per plant (0.89) was observed in case of C treatment. Moreover, minimum value of number of rows per ear (13.4) was obtained in case of R treatment, while minimum value of number of grains per row (47), ear diameter (35.2 mm) and ear length (190.7 mm) was noted in case of MDD treatment (Table 3). These results are in agreement with those of Hemmat and Taki [13], who concluded that no-tillage method in arid regions had an adverse effect on crop yields. These results are also in line with the results reported by Iqbal *et al.* [5] that no-tillage method can not compensate the adverse effect of fine texture, very low organic matter and an overall initial weak structure of the soil.

The results of the study also indicate that number of plants per hectare is the major yield component explaining grain yield of corn under different tillage methods and grain yield differences among different tillage treatments occur owing to significant differences in number of plant per hectare. Besides, the highest number of plants per hectare obtained in the CT treatment might be due to reduced soil compaction, enhanced seed-soil contact, increased soil moisture storage and suppressing weed growth. Where, in case of NT treatment, the lowest number of plants per hectare obtained may be due to

significantly greater soil bulk density and soil penetration resistance, which adversely affect seed emergence, root growth and plant population density. These results are in agreement with those of Rashidi and Keshavarzpour [6], who concluded that tillage practices significantly affect soil physical properties as they increased soil moisture content while decreased soil bulk density and soil penetration resistance. These results are also in line with the results reported by Keshavarzpour and Rashidi [16] that soil of the conventional tillage treatment had higher moisture content and lower bulk density and penetration resistance than other treatments.

CONCLUSIONS

It can be concluded that moldboard plow followed by two passes of disk harrow was found to be more appropriate and profitable tillage treatment in improving grain yield of corn in the arid land of Iran.

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