

Effect of Different Tillage Methods on Grain Yield and Yield Components of Corn in the Arid Lands of Iran

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Abstract: Field experiments were conducted to study the effect of different tillage methods on grain yield and yield components of corn (*Zea mays* L.) in the arid lands of Iran. 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 (NPPH) and number of rows per ear (NRPE), but there was no significant difference in other components such as number of ears per plant (NEPP), number of grains per row (NGPR), ear diameter (ED) and ear length (EL). The maximum value of grain yield (4.15 t ha^{-1}), NPPH (39830) and NEPP (0.92) was obtained in case of MDD treatment, while maximum value of NRPE (14.9) and ED (37.2 mm) was observed in case of MR treatment. Also, maximum value of NGPR (51) was obtained in case of R treatment, while maximum value of EL (196.3 mm) was observed in case of NT treatment. Conversely, the minimum value of grain yield (2.32 t ha^{-1}) and NPPH (20390) was obtained in case of NT treatment, while minimum value of NEPP (0.89) was observed in case of C treatment. Moreover, minimum value of NRPE (13.4) was obtained in case of R treatment, while minimum value of NGPR (47), ED (35.2 mm) and EL (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: Corn • Grain yield • Yield components • Tillage method • Arid lands • Iran

INTRODUCTION

Corn 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 [1]. 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 [2].

Soil tillage is among the important factors affecting soil physical properties and crop yield. Among the crop production factors, tillage contributes up to 20% [3]. Tillage method affects the sustainable use of soil resources through its influence on soil properties [4]. 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 [5]. 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 [6]. 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 [7]. 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 [8].

On the other hand, conservation tillage methods often result in decreased pore space [9], increased soil strength [10] and stable aggregates [11]. The pore network in conservationally tilled soil is usually more continues because of earthworms, root channels and vertical cracks [12]. Therefore, conservation tillage may reduce disruption of continues pores. Whereas, conventional tillage decreases soil penetration resistance and soil bulk density [13]. 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 [8]. However, the results of no-tillage are contradictory [6]. No-tillage methods in arid regions of Iran had an adverse effect on crop yields [14]; while Chaudhary *et al.* [15] 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 study the response of grain yield and yield components of corn (*Zea mays* L.) to different methods in the arid lands of Iran.

MATERIALS AND METHODS

Research Site: This study was carried out at the Research Site of Varamin, Iran on a sand loam soil for two successive growing seasons (2014 and 2015). The research site is located at latitude: 35° 19' N,

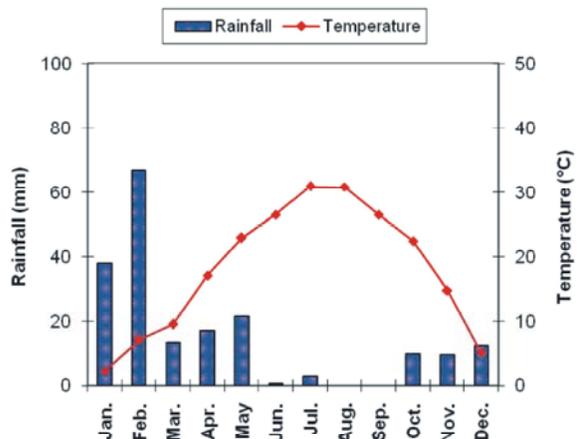


Fig. 1: Mean monthly rainfall and temperature (mean of 2014 and 2015)

Table 1: Soil physical and chemical properties of the research site (mean of 2014 and 2015)

Soil characteristics	Values
Texture	Clay loam
Sand (%)	24.6
Silt (%)	38.0
Clay (%)	37.0
Bulk density ($Mg\ m^{-3}$)	1.15
EC ($dS\ m^{-1}$)	2.30
pH	7.50
OC (%)	0.60
P (ppm)	40.4
K (ppm)	295
Fe (ppm)	2.84
Zn (ppm)	1.50
Cu (ppm)	1.13
Mn (ppm)	12.9

longitude: 51° 39' E and altitude: 1000 m in arid climate (150 mm rainfall annually) in the center of Iran. The soil of the research site is classified as an Aridisol (fine, mixed, active, thermic, typic haplocambids).

Weather Parameters: The mean monthly rainfall and temperature data of the research site during the years of study (2014 and 2015) are given in Fig. 1.

Soil Sampling and Analysis: To determine soil physical and chemical properties of the research site, a composite soil sample (from 21 points) was collected from 0-30 cm depth 30 days before during the study years. Soil sample was analyzed in the laboratory for P, K, Fe, Zn, Cu, Mn, EC, pH, organic carbon, particle size distribution and dry bulk density. Details of soil physical and chemical properties of the research site are given in Table 1.

Field Methods: 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 (2014 and 2015) 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. 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 recommendations. All other necessary operations except those under study were kept normal and uniform for all the treatments.

Observation and Data Collection: 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 (NPPH), number of ears per plant (NEPP), number of rows per ear (NRPE), number of grains per row (NGPR), ear diameter (ED) and ear length (EL) 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 [16]. 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 in case of MDD treatment and the lowest (2.32 t ha⁻¹) in case of NT treatment (Table 2).

Number of Plants per Hectare (NPPH): A significant effect of different tillage treatments on NPPH was also found during the study years. The highest NPPH of 79660 was obtained in case of MDD treatment and the lowest (40780) in case of NT treatment (Table 2).

Number of Ears per Plant (NEPP): A non-significant effect of different tillage treatments on NEPP was found during the years of study. However, the highest NEPP of 0.92 was obtained in case of MDD treatment and the lowest (0.89) in case of C treatment (Table 2).

Number of Rows per Ear (NRPE): The effect of different tillage treatments on NRPE was also found significant during both the years of study. The highest NRPE of 14.9 was obtained in case of MR treatment and the lowest (13.4) in case of R treatment (Table 2).

Number of Grains per Row (NGPR): The effect of different tillage treatments on NGPR was also found non-significant during the study years. However, the highest NGPR of 51 was obtained in case of R treatment and the lowest (47) in case of MDD treatment (Table 2).

Table 2: Means comparison for grain yield and yield components of corn between different tillage methods (mean of 2014 and 2015)

Treatment	Grain yield* (t ha ⁻¹)	NPPH*	NEPP ^{NS}	NRPE*	NGPR ^{NS}	ED ^{NS} (mm)	EL ^{NS} (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

NS = Non-significant

* = Significant at 0.05 probability level

Means in the same column with different letters differ significantly at 0.05 probability level according to DMRT.

(NPPH: number of plants per hectare; NEPP: number of ears per plant; NRPE: number of rows per ear; NGPR: number of grains per row; ED: ear diameter; EL: ear length)

Ear Diameter (ED): A non-significant effect of different tillage treatments on ED was also found during the years of study. However, the highest ED of 37.2 mm was obtained in case of MR treatment and the lowest (35.2 mm) in case of MDD treatment (Table 2).

Ear Length (EL): The effect of different tillage treatments on EL was also found non-significant during both the years of study. However, the highest EL of 196.3 mm was obtained in case of NT treatment and the lowest (190.7 mm) in case of MDD treatment (Table 2).

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 NPPH, NEPP, NRPE, NGPR, ED and EL 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 ($P \leq 0.05$) affected grain yield, NPPH and NRPE, but there was no significant differences in other yield components such as NEPP, NGPR, ED and EL. The maximum value of grain yield (4.15 t ha^{-1}), NPPH (39830) and NEPP (0.92) was obtained in case of MDD treatment, while maximum value of NRPE (14.9) and ED (37.2 mm) was observed in case of MR treatment. Also, maximum value of NGPR (51) was obtained in case of R treatment, while maximum value of EL (196.3 mm) was noted in case of NT treatment (Table 2). These results are in agreement with those of Rashidi and Keshavarzpour [7], 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.* [8] 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 NPPH (20390) was obtained in case of NT treatment, while minimum value of NEPP (0.89) was observed in case of C treatment. Moreover, minimum value of NRPE (13.4) was obtained in case of R treatment, while minimum value of NGPR (47), ED (35.2 mm) and EL (190.7 mm) was noted in case of MDD treatment (Table 2). These results are in agreement with those of Hemmat and Taki [14], 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.* [6] 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 NPPH 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 NPPH 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 NPPH 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 [7], 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 [17] that soil of the conventional tillage treatment had higher moisture content and lower bulk density and penetration resistance than other treatments.

CONCLUSION

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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