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Response of Yield and Yield Components of Forage Corn to Different Tillage Methods

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Abstract: Field experiments were conducted for two successive years to study the response of forage corn to different methods. Tillage treatments in the study were moldboard plow + two passes of disk harrow as conventional tillage (CT), two passes of disk harrow as reduced tillage (RT), one pass of disk harrow as minimum tillage (MT) and no-tillage (NT) as direct drilling method. The statistical results of the study indicated that tillage method significantly ($P \leq 0.05$) affected dry biological yield (DBY), dry grain yield (DGY) and number of plants per hectare (NPPH), but there was no significant difference in other yield components such as number of ears per plant (NEPP), number of rows per ear (NRPE), number of grains per row (NGPR), 1000 grain weight (1000GW), plant height (PLTH) and stem diameter (STMD). The maximum value of DBY (13.2 t ha^{-1}), DGY (4.15 t ha^{-1}), NPPH (39830) and NEPP (0.92) was obtained in case of CT treatment, while maximum value of NGPR (37.0), PLTH (178 cm) and STMD (2.0 cm) was observed in case of RT treatment. Also, maximum value of NRPE (14.7) and 1000GW (244 g) was noted in case of NT treatment. On the other hand, the minimum value of DBY (7.40 t ha^{-1}), DGY (2.39 t ha^{-1}) and NPPH (20390) was obtained in case of NT treatment, while minimum value of NEPP (0.89), PLTH (167 cm) and STMD (1.7 cm) was observed in case of MT treatment. Also, minimum value of NRPE (13.7), NGPR (35.2) and 1000GW (235 g) was noted in case of CT treatment. Accordingly, moldboard plow followed two passes of disk harrow was found to be more appropriate and profitable tillage method in improving growth and yield of forage corn in the arid lands.

Key words: Forage corn · Yield · Yield components · Tillage method · 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].

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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 tortuousity 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 forage corn 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 clay loam soil for two successive growing seasons (2013 and 2014). The research site is located at latitude: 35° 19' N, longitude: 51° 39' E and altitude: 1000 m in arid climate (150 mm rainfall annually) in the center of Iran.

Weather Parameters: The mean monthly rainfall and temperature data of the research site during the years of study (2013 and 2014) are given in Fig. 1.

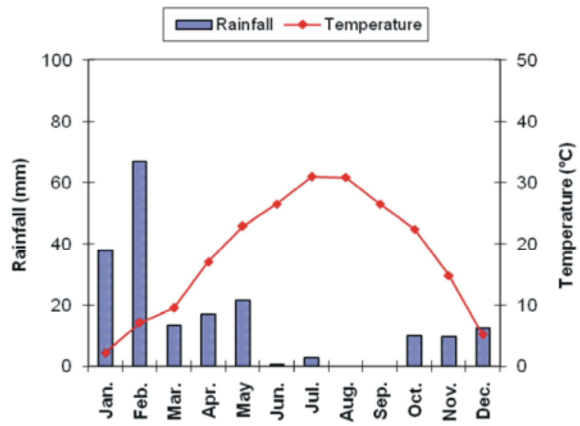

Fig. 1: Mean monthly rainfall and temperature (mean of 2013 and 2014)

Table 1: Soil physical and chemical properties of the research site (mean of 2013 and 2014)

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

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 (2013-2014) on farm study. Tillage treatments included one pass of moldboard plow followed two passes of disk harrow as conventional tillage (CT), two passes of disk harrow as reduced tillage (RT), one pass of disk harrow as minimum tillage (MT) and no-tillage (NT) as direct drilling method. In both growing season, one of the most common commercial variety of forage corn cv. 704 was planted at the rate of 12.5 kg ha^{-1} on 20th April with the help of 4-row 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. Dry biological yield (DBY), dry grain yield (DGY), number of plants per hectare (NPPH) and number of ears per plant (NEPP) were determined by harvesting the two middle rows of each plot. Other parameters, i.e. number of rows per ear (NRPE), number of grains per row (NGPR), 1000 grain weight (1000GW), plant height (PLTH) and stem diameter (STMD) were determined from the 10 samples taken randomly from each plot.

Statistical Analysis: The data collected were analyzed statistically using Randomized Complete Block Design (RCBD) as described by Steel and Torrie [16]. Duncan's Multiple Range Test (DMRT) at 5% probability was performed to compare the means of different treatments by using the computer software SPSS 12.0 (Version, 2003).

RESULTS

Dry Biological Yield (DBY): Different tillage treatments significantly affected DBY during both the years of study. The highest DBY of 13.2 t ha^{-1} was obtained in case of CT treatment and lowest (7.40 t ha^{-1}) in case of NT treatment (Table 2).

Dry Grain Yield (DGY): A significant effect of different tillage treatments on DGY was also found during the study years. The highest DGY of 4.15 t ha^{-1} was recorded in case of CT treatment and lowest (2.39 t ha^{-1}) in case of NT treatment (Table 2).

Number of Plants per Hectare (NPPH): The effect of different tillage treatments on NPPH was also found significant during the years of study. The highest NPPH of 39830 was obtained in case of CT treatment and lowest (20390) 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 both the years of study. However, the highest NEPP of 0.92 was recorded in case of CT treatment and lowest (0.89) in case of MT treatment (Table 2).

Number of Rows per Ear (NRPE): The effect of different tillage treatments on NRPE was also found non-significant during the study years. However, the highest NRPE of 14.7 was obtained in case of NT treatment and lowest (13.7) in case of CT treatment (Table 2).

Number of Grains per Row (NGPR): A non-significant effect of different tillage treatments on NGPR was also found during the years of study. However, the highest NGPR of 37.0 was recorded in case of RT treatment and lowest (35.2) in case of CT treatment (Table 2).

1000 Grain Weight (1000 GW): The effect of different tillage treatments on 1000 GW was also found non-significant during both the years of study. However, the highest 1000GW of 244 g was obtained in case of NT treatment and lowest (235 g) in case of CT treatment (Table 2).

Table 2: Means comparison for yield and yield components of forage corn between different tillage methods (mean of 2013 and 2014)

Treatment	DBY* (t ha^{-1})	DGY* (t ha^{-1})	NPPH*	$NEPP^{NS}$	$NRPE^{NS}$	$NGPR^{NS}$	$1000GW^{NS}$ (g)	$PLTH^{NS}$ (cm)	$STMD^{NS}$ (cm)
CT	13.2^{a}	4.15^{a}	39830^{a}	0.92^{a}	13.7^{a}	35.2^{a}	235^{a}	175^{a}	1.9^{a}
RT	11.3^{b}	4.02^{a}	35580^{b}	0.90^{a}	14.1^{a}	37.0^{a}	241^{a}	178^{a}	2.0^{a}
MT	9.63^{c}	3.07^{b}	26970^{c}	0.89^{a}	14.5^{a}	36.5^{a}	242^{a}	167^{a}	1.7^{a}
NT	7.40^{d}	2.39^{c}	20390^{d}	0.90^{a}	14.7^{a}	36.3^{a}	244^{a}	173^{a}	1.9^{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.

(DBY: dry biological yield; DGY: dry grain yield; NPPH: number of plants per hectare; NEPP: number of ears per plant; NRPE: number of rows per ear; NGPR: number of grains per row; 1000GW: 1000 grain weight; PLTH: plant height; STMD: stem diameter)

Plant Height (PLTH): A non-significant effect of different tillage treatments on PLTH was also found during the study years. However, the highest PLTH of 178 cm was recorded in case of RT treatment and lowest (167 cm) in case of MT treatment (Table 2).

Stem Diameter (STMD): The effect of different tillage treatments on STMD was also found non-significant during the years of study. However, the highest STMD 2.0 cm was obtained in case of RT treatment and lowest (1.7 cm) in case of MT treatment (Table 2).

DISCUSSION

In this study, response of forage corn to different tillage methods was investigated. The salient components of growth and yield of forage corn such as DBY, DGY, NPPH, NEPP, NRPE, NGPR, 1000GW, PLTH and STMD were studied to analyze the response of forage corn to different tillage methods.

The statistical results of the study indicated that tillage method significantly ($P = 0.05$) affected DBY, DGY and NPPH, but there was no significant difference in other yield components such as NEPP, NRPE, NGPR, 1000GW, PLTH and STMD among the different tillage treatments during the study years (Table 2). The maximum value of DBY (13.2 t ha^{-1}), DGY (4.15 t ha^{-1}), NPPH (39830) and NEPP (0.92) was obtained in case of CT treatment, while maximum value of NGPR (37.0), PLTH (178 cm) and STMD (2.0 cm) was observed in case of RT treatment. Also, maximum value of NRPE (14.7) and 1000GW (244 g) 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.

On the other hand, the minimum value of DBY (7.40 t ha^{-1}), DGY (2.39 t ha^{-1}) and NPPH (20390) was obtained in case of NT treatment, while minimum value of NEPP (0.89), PLTH (167 cm) and STMD (1.7 cm) was observed in case of MT treatment. Also, minimum value of NRPE (13.7), NGPR (35.2) and 1000GW (235 g) was noted in case of CT 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 DBY of forage corn under different tillage methods and DBY differences among different tillage treatments occur owing to significant differences in NPPH. 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

Among tillage treatments, moldboard plow followed two passes of disk harrow (CT) was found to be more appropriate and profitable tillage method in improving growth and yield of forage corn in the arid lands.

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