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Tillage and nitrogen fertilization impact on irrigated corn yields and soil chemical and physical properties under semi-arid climate

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ABSTRACT

Management practices are important to soil productivity for sustainable crop production. A field experiment based on randomized complete design with split plot combination was conducted with three tillage treatments, i.e. deep tillage (DT), minimum tillage (MT) and conventional tillage (CT) as main plots and three nitrogen levels: 0 (N_0), 200 (N_{200}) and 250 (N_{250}) kg ha^{-1} as subplots. A maize variety (DK-919) was sown during the month of July. The recommended dose of PK @ 150 and 120 kg ha^{-1}were applied, respectively. The following growth and physical parameters of plant and soil were recorded after harvesting the crop: plant height, cob length, number of grains per cob, yield, soil porosity, bulk density, soil strength, nitrate nitrogen, NPK in soil and in plants.The data obtained was analyzed statistically and differences among treatment's means will be compared by using least significant difference test at 5% level of significance. Results showed that DT×N_{250} were useful to increase agronomic parameters and also increased soil porosity and decreased soil bulk density.

Key words; nitrogen, maize, physical and chemical properties, tillage

INTRODUCTION

Amongst the extensively grown food crops in the world, maize (*Zea mays* L.) is one of utmost chief cereals and has extraordinary significance and used as human as well as animal feed. About 50-55 % of the entire world's maize production is used as food in world's developing countries [1]. It is most essential cereal crop of Pakistan and standing third position after wheat and rice which is grown as spring and autumn maize in Pakistan. In Pakistan area under maize in 2009-10 was 0.95 m. ha with 3.67 t ha^{-1} average yield and an annual production of 3.49 m. tons [2]. Average yield of maize in the Pakistan is very low as compared to the biological capacity of the current cultivars. Numerous aspects are responsible for low production of maize and diverse approaches desired to be established to increase maize yield [3]. Similarly in Pakistan there is a need to develop a site specific agro-technology to increase yield of maize by making improvement in some basic components of the prevailing maize production technology. Amongst different agro management practices, appropriate nutrient management and tillage practices are of primary significance to attain optimal potential of maize as this crop is importantly responsive to tillage, rate and timing of N application. The corn production principally depends on nutrient management especially nitrogen [1].

Nitrogen had a key role on nutritional and physiological status of plants and stimulates variations in mineral composition of plant [4]. Nitrogen is present in the chlorophyll molecule deficiency of N will result in a chlorotic condition of the plant. Nitrogen is also an important component of cell wall [5]. Nitrogen plays important roles in numerous biological processes in the plant. It elongates the effective leaf area duration and postponing senescence [6]. It aids to uphold functional kernels throughout grain filling prompting the number of developed kernels and kernel final size [7].

Nitrogen is one of most unstable nutrient in the soil and is affected by several reactions such as leaching, volatilization, immobilization and de-nitrification. The variety of reactions that effect N dynamics makes timing of N application a fundamental problem to balance N requirements for optimal maize growth and to lessen N losses to the environment [8]. Delayed application of nitrogen resulted to increase in N recovery by the crop as compared to sole application at sowing. Nitrogen applied at crop sowing may resulted to different N losses due to less use of nutrients at seedling stage and these losses may occur in different forms such as leaching, immobilization and de-nitrification [9]. Exhaustive agriculture has improved the productivity and efficacy of agricultural systems over past decades, but has also caused adverse effects on the environment e.g. soil degradation [10].

Tillage intended to destroy weeds, incorporate crop residues and amendments into soil, increase infiltration and reduce evaporation, prepare seedbed, break hard layers to facilitate root penetration and maintains crop yields [11]. Soil tillage is amongst the important factors affecting soil physical quality parameters and crop yield. Among the crop productivity factors, tillage adds up to twenty % [12].

Reduced tillage or NT systems accumulates OM and results in more aggregate stability, infiltration rate and water holding capacity of soil [13] and Deep tillage reduces density, enhances water movement in soil, increases root development and enhances crop yield [14]. Tillage practices influence the soil environment elements are important for crop growth and caused to improved crop production. Soil disturbance and tillage operations usually can cause rise in organic nitrogen mineralization and soil aeration which caused to more nitrogen accessibility for the use of plants [15]. Compaction of soil can be decreased by

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reducing soil bulk density or enhancing porosity of soil [16]. Sub soiling the soil up to 0.30 meter depth improved the air penetrability and saturated hydraulic conductivity of the soil by up to two orders of degree and increases soil porosity up to 27% of the total soil volume [17]. Repeated tillage operations caused to occurrence of soil hard pans in many agricultural sandy-loam soils due to tilling the soil at the same depth and with same implement, and must be removed by ploughing the soil at deeper depth to optimize crop yield. Disturbing the soil to a deeper soil layer increases water movement and also infiltration in the soil by breaking the hard soil layers and increases root development and its growth and leads to improved crop growth and income [14]. A compacted soil layer is removed by sub-soiling the soil and increases nutrient availability to crop plants and also improves the soil physical properties [18]. The present study was therefore, scheduled to achieve the following objectives:

- To evaluate the tillage and nitrogen impact on corn growth and yield
- To evaluate the tillage and nitrogen impact on total soil carbon, nitrogen and available nutrient concentration
- To evaluate the tillage and nitrogen impact on soil physical properties

MATERIALS AND METHODS

A field experiment laid-out following randomized complete design with split plot combination was conducted with three tillage treatments : Deep tillage (DT), conventional tillage (CT) and minimum tillage (MT) on main plots and three nitrogen levels: 0 (N_0), 200 (N_{200}) and 250 (N_{250}), kg ha^{-1} as subplots. A maize variety (DK-919) was sown during the month of July in soil having sandy clay loam in texture. The some other chemical properties of testing soil were as follows: ECe 1.16 dS m^{-1}; pH 7.7; organic matter contents 0.88%; and total N contents 0.05%.. The recommended dose of PK @ 150 and 120 kg ha^{-1} were applied, respectively. The following growth and physical parameters of plant and soil were recorded after harvesting the crop: plant height, cob length, number of grains per cob, yield, soil porosity, bulk density, soil strength, nitrate nitrogen, NPK in soil and in plants. Plant samples were dried and ground to determine NPK concentrations by method of Sulphuric acid digestion and distillation on Kjeldhal's apparatus, spectrophotometer and flamephotometer respectively [19].

Data was collected for various characteristics designed under randomized complete design with split plot combination and was analyzed statistically through Analysis of Variance Technique. The treatment means were compared by LSD [20].

RESULTS AND DISCUSSION

Agronomic Parameters

Data indicated that tillage methods and their interaction with nitrogen rates had significant effect on plant height (Table 1). As regard tillage, more plant height (231.17cm) was produced by DT, followed by (210.81 cm) CT and least (185.43 cm) was produced by MT. Regarding nitrogen rates, the maximum mean value of plant height 219.83 cm was recorded in N_{250}, followed by 219.33 cm in N_{200} while minimum 188.24 cm in N_{150}. As regard the interactive effect of tillage and nitrogen rates, the maximum mean value of plant height 248.68 cm was obtained in treatment combination CT × N_{250} followed by 230.50 cm in case of DT × N_{250}, followed by 228.0 cm in case of DT × N_{200}. Least plant height (164.63 cm) was observed in treatment combination MT × N_{150}. It was observed that CT × N_{250} with increase plant height by 51 % over control. Whereas, in case of DT × N_{250}, 40 % increase in plant height was observed over control. Increased plant height was might be due to better nutrient availability, good soil conditions and weed control in CT and DT. Same results were obtained by Gill and Auakh [21] (1996), who stated that the tallest maize plants were observed in case of deep tillage due to more proliferation of roots which resulted in increased nutrient uptake from the deeper soil layer and led to the greater plant height as compared to conventional tillage practices. Significant effect of tillage systems on plant height was also found by Evans et al. [22], who obtained statistically the highest plant height with deep tillage systems as compared to other tillage practices. The related results were obtained by the Amanullah et al. [23], who reported that significantly maximum plant height was found when maize grown with the application of 50 % higher nitrogen rate than recommended. Similarly Akmal et al. [24] also stated that the plant height in maize increased with increasing N rate and maximum plant height was recorded when maize was fertilized with N @ 150 kg ha^{-1}.

As regard tillage (Table 2) maximum cob length (7.14cm) was produced by DT, followed by (7.0 cm) in CT and minimum (5.88 cm) was produced by MT. Regarding nitrogen rates, the maximum mean value of cob length 7.25 cm was recorded in N_{250}, followed by 6.66 cm in N_{200} while minimum 6.11 cm in N_{150}. As regard the interactive effect of tillage and nitrogen rates, the maximum mean value of cob length 7.76 cm was observed in treatment combination DT × N_{250} followed by 7.66 cm in case of CT × N_{250}, followed by 7.0 cm in case of DT × N_{200} as well as CT × N_{200}. Minimum cob length (5.33 cm) was observed in treatment combination MT ×N_{150}. It was observed that DT × N_{250} increased cob length by 45.5 % over control. Whereas, in case of CT × N_{250}, 43.7 % increase in cob length was observed over control. Increased cob length was might be due to better nutrient availability, good soil conditions and weed control in CT and DT. Gokmen et al. [25] also reported a significant nitrogen effect on cob length. Statistically larger cobs of maize were obtained as the nitrogen level was increased.

As concern tillage, highest crop yield (8.97) (Table 3) was produced by DT, followed by (8.90) in CT and lowest (6.58) was produced by MT. Regarding nitrogen rates, the maximum mean value of crop yield 8.9 was measured in N_{250}, followed by 8.14 in N_{200} while minimum 7.41 in N_{150}. As regard the interactive effect of tillage and nitrogen rates, the maximum mean value of crop yield 9.63 was observed in treatment combination CT × N_{250} and DT × N_{200}, followed by 9.35 in case of DT × N_{250}. Lowest crop yield (5.67) was observed in treatment combination MT × N_{150}. It was observed that CT × N_{250} and DT × N_{200} increase crop yield by 69.8 % over control. Whereas, in case of DT × N_{250}, 64.9 % increase in crop yield was observed over control. Increased crop yield was might be due to better nutrient availability, good soil conditions and weed control in CT and DT. Increase in grain yield under chisel plough treatment was due to more grains weight per cob as well as 1000-grain weight.

About 9% more grain yield was obtained in deep tillage either using chisel plough or mould board plough as compared to no-tillage [26]. Deep tilled plots by disc plough and chisel plough gave 12.3% more sorghum grain yield as compared to shallow or zero-tilled plots. This increased yield in deep tillage treatments was due to absorption of more water and suppressing weed growth [27]. The results are in agreement with the results of Astier et al. [28], who got the highest yield of maize under chisel plough (used as conventional tillage) cultivated plots as compared to zero tillage. Marwat et al. [29] obtained higher maize grain yield in case of conventional tillage (CT) as compared to reduced tillage. The results are in association with the results of Khaliq et al. [30] who also found that grain yield improved by increasing nitrogen level upto 150 kg ha^{-1}. Enhance in grain yield by increasing N level was also reported by Ahmad et al. [31].

By way of regard tillage practices, maximum number of grains cob^{-1} (46) was produced by DT, followed by (44) in CT and minimum (39) were produced by MT (Table 4). Regarding nitrogen rates, the maximum average value of number of grains cob^{-1} 46 was produced in N_{250}, followed by 43 in N_{200} while minimum 39 in N_{150}. As regard the interactive effect of Tillage and nitrogen rates, the maximum mean value of crop yield 48 was observed in treatment combination DT × N_{250}, followed by 46 in case of CT × N_{250}, followed by 45 in DT × N_{200}. Minimum number of grains cob^{-1} 33 were observed in treatment combination MT × N_{150}. It was observed that DT × N_{250} increased number of grains cob^{-1} by 45 % over control. Whereas, in case of CT × N_{250}, 39 % increase in number of grains was observed over control. Increased number of grains was might be due to better nutrient availability, good soil conditions and weed control in CT and DT. Reduction in grains per cob in mould board plough may be attributed to high soil bulk density which reduced the soil depth explored by maize roots [32]. Application of N at higher rate delayed growth period of maize and may be resulted to more grains per cob [33]. Likewise, greater number of grains per cob by using higher dose of nitrogen was reported by Akmal et al. [24].

Table 1. Effect of tillage and nitrogen rates on plant height (cm)

	MT	**CT**	**DT**	
N_0	164.63 c	190.67 bc	201.00 abc	188.24 B
N_{200}	185. 77 bc	218.67 ab	228.00 ab	219.33 A
N_{250}	214.33 abc	248.68 a	230.50 ab	219.83 A
Means	185.43 B	210.81 A	231.17 A	209.14

MT: Minimum tillage, CT: Conventional tillage and DT: Deep tillage

N_0: Nitrogen @ 0 kg ha^{-1}, N_{200}: Nitrogen @ 200 kg ha^{-1} and N_{250}: Nitrogen @ 250 kg ha^{-1}

Table 2. Effect of tillage and nitrogen rates on cob length (cm)

	MT	**CT**	**DT**	

N_0	5.33 b	6.33 ab	6.66 ab	6.11 A
N_{200}	6.00 ab	7.00 ab	7.00 ab	6.66 A
N_{250}	6.33 ab	7.66 ab	7.76 ab	7.25 A
Mean	5.88 B	7.00 A	7.14 A	5.04

MT: Minimum tillage, CT: Conventional tillage and DT: Deep tillage

N_0: Nitrogen @ 0 kg ha^{-1}, N_{200}: Nitrogen @ 200 kg ha^{-1} and N_{250}: Nitrogen @ 250 kg ha^{-1}

Table 3 Effect of tillage and nitrogen rates on yield (Mg ha^{-1})

	MT	**CT**	**DT**	
N_0	5.6667 c	8.1667 ab	8.4000 a	7.4111 B
N_{200}	6.3667 bc	8.9000 a	9.6333 a	8.1444 AB
N_{250}	7.7000 ab	9.6333 a	9.3548 a	8.8960 A
Mean	6.5778 B	8.9000 A	8.9738 A	

MT: Minimum tillage, CT: Conventional tillage and DT: Deep tillage

N_0: Nitrogen @ 0 kg ha^{-1}, N_{200}: Nitrogen @ 200 kg ha^{-1} and N_{250}: Nitrogen @ 250 kg ha^{-1}.

Table 4 Effect of tillage and nitrogen rates on grain cob[1]

	MT	**CT**	**DT**	
N_0	33.33	39.33	44.333	39.000 B
N_{200}	40.333	43.66	45.33	43.111 A
N_{250}	42.66	47.75	48.262	46.226 A
Mean	38.778 A	43.583 A	45.976 A	

MT: Minimum tillage, CT: Conventional tillage and DT: Deep tillage

N_0: Nitrogen @ 0 kg ha^{-1}, N_{200}: Nitrogen @ 200 kg ha^{-1} and N_{250}: Nitrogen @ 250 kg ha^{-1}

As concern tillage, maximum soil porosity (0.48) (Table 5) was measured in DT, followed by (0.46) in CT and lowest (0.44) was measured in MT. Regarding nitrogen rates, the maximum mean value of soil porosity 0.46 was recorded in N_{200}, followed by 0.45 in both N_{250} and N_{150}. As regard the interactive effect of tillage and nitrogen rates, the maximum mean value of soil porosity 0.48 was observed in treatment combination DT × N_{200} and DT × N_{250}, followed by0.46 in case of CT × N_{200}. Minimum soil porosity (0.43) was observed in treatment combination MT × N_{250}. It was observed that DT × N_{200} soil porosity by 11.63 % over control. Whereas, in case of CT × N_{200}, 6.98 % increase in soil porosity was observed over control. Deep ploughing treatments (disc and chisel) increased the total soil porosity than other tillage practices (minimum and tillage) which resulted to lower total soil porosity [27]. Similarly Hamblin[34] also noted increase in total porosity by increasing the pore size

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distribution and pore spaces. Non-significant effect of different nitrogen rates on total porosity of soil was also reported by Hossain et al. [35].

As concern tillage, better bulk density (1.39) (Table 6) was measured in DT, followed by (1.44) in CT and maximum (1.49) was measured in MT. Regarding nitrogen rates, the best mean value of bulk density 1.44 was recorded in N_{200}, while both other N_{250} and N_{150} give same value of bulk density 1.45. As regard the interactive effect of tillage and nitrogen rates, the minimum value of bulk density 1.38 was observed in treatment combination DT × N_{200} followed by1.39 in case of DT × N_{250}, and followed by 1.43 in case of CT × N_{200}. Maximum bulk density (1.49) was observed in treatment combination MT × N_{150}. It was observed that DT × N $_{200}$ decreased bulk density by 7.38 % over control. Whereas, in case of DT × N_{250}, 6.71 % decreased in bulk density was observed over control.

Generally lesser the soil bulk density, deeper the root penetration. Tillage intensity plays a significant role in increasing or decreasing the soil bulk density. Generally the soil bulk density decreases by increasing tillage intensity. In present study lower soil bulk density in chisel ploughed plots was recorded which might be due to ploughing the soil at deeper depth which resulted to lower bulk density by breaking hard pan, as chisel plough disturbed the soil upto a 0.40 m depth by breaking the hard pan. Significantly lower soil bulk density was observed by loosening the compacted soil layer by deep-tillage compared with conventional-tillage [36]. Similarly Jabro et al. [37] investigated that shallow tillage upto a depth of 10 cm gave significantly higher soil bulk density of 1.57 Mg m^{-3} although deep tillage gave lesser value of soil bulk density 1.54 Mg m^{-3}.

As respect tillage, maximum infiltration (20.10) (Table 7) was measured in DT, followed by (17.11) in CT and lowest (13.30) was measured in MT. Regarding nitrogen rates, the maximum mean value of infiltration 17.13 was recorded in N250, followed by 16.91 in N_{200} and minimum 16.46in N_{150}. As regard the interactive effect of tillage and nitrogen rates, the maximum mean value of infiltration 2 0.4 3 was observed in treatment combination DT × $N_{200,}$ followed by20.13 in case of DT × N_{150}. Minimum infiltration (12.53) was observed in treatment combination MT × N_{150}. It was observed that DT × N_{200} increased infiltration by 63 % over Control. Whereas, in case of DT × N_{250}, 60 % increase in infiltration was observed over control. Data regarding increased in infiltration rate in the case of DT × N_{250} over control can be correlated with work of [38]. They described that DT × N_{250} improved infiltration rate over control.

As regard tillage, maximum soil organic carbon (0.49) (Table 8) was measured in MT, followed by (0.43) in CT and lowest (0.42) was measured in DT. Regarding nitrogen rates, the maximum average value of soil organic carbon 0.48 was recorded in N_{250}, followed by 0.44 in N_{200} and minimum 0.41in N_{150}. As regard the interactive effect of tillage and nitrogen rates, the maximum average value of soil organic carbon 0.54 was observed in treatment combination MT × N_{250}, followed by 0.48 in case of MT × N_{200}. Minimum soil organic carbon (0.40) was observed in treatment combination CT × N_{150}. It was observed that MT × N_{250} increased soil organic carbon by 35 % over CT × N_{150}. Whereas, in case of MT × N_{200}, 20 % enhance in soil organic carbon was observed over control. The non-significant effect of tillage systems on SOC may be due to no more difference in organic matter which resulted to non-significant effect on soil organic carbon. These results are in arrangement with Ishaq et al. [39] who also reported a non-significant effect of tillage systems on organic carbon.

Table 5 Effect of tillage and nitrogen rates on Porosity (0-10 cm) $m^3\ m^{-3}$

	MT	CT	DT	
N_0	0.4367 c	0.4533 bc	0.4733 ab	0.4544 A
N_{200}	0.4367 c	0.4600 ab	0.4767 a	0.4578 A
N_{250}	0.4333 c	0.4492 bc	0.4786 a	0.4537 A
Mean	0.4356 C	0.4542 B	0.4762 A	

MT: Minimum tillage, CT: Conventional tillage and DT: Deep tillage

N_0: Nitrogen @ 0 kg ha^{-1}, N_{200}: Nitrogen @ 200 kg ha^{-1} and N_{250}: Nitrogen @ 250 kg ha^{-1}

Table 6 Effect of tillage and nitrogen rates on Bulk density (g cm^{-3})

	MT	CT	DT	
N_0	1.4900 a	1.4467 b	1.4000 cd	1.4456 A
N_{200}	1.4867 a	1.4367 bc	1.3867 d	1.4367 A
N_{250}	1.4967 a	1.4567 ab	1.3940 d	1.4491 A
Mean	1.4911 A	1.4467 B	1.3936 C	

MT: Minimum tillage, CT: Conventional tillage and DT: Deep tillage

N_0: Nitrogen @ 0 kg ha^{-1}, N_{200}: Nitrogen @ 200 kg ha^{-1} and N_{250}: Nitrogen @ 250 kg ha^{-1}

Table 7 Effect of tillage and nitrogen rates on infiltration rate (cm hr^{-1})

	MT	CT	DT	
N_0	12.533 e	16.717 bcd	20.133 ab	16.461 A
N_{200}	13.300 de	16.997 abc	20.433 a	16.910 A
N_{250}	14.067 cde	17.617 abc	19.719 ab	17.134 A
Mean	13.300 C	17.110 B	20.095 A	

MT: Minimum tillage, CT: Conventional tillage and DT: Deep tillage

N_0: Nitrogen @ 0 kg ha^{-1}, N_{200}: Nitrogen @ 200 kg ha^{-1} and N_{250}: Nitrogen @ 250 kg ha^{-1}

Table 8 Effect of tillage and nitrogen rates on soil organic carbon (%).

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	MT	CT	DT	
N_0	0.4367 b	0.4067 b	0.3967 b	0.4133 B
N_{200}	0.4800 ab	0.4133 b	0.4600 ab	0.4378 B
N_{250}	0.5400 a	0.4200 b	0.4455 b	0.4818 A
Mean	0.4856 A	0.4267 B	0.4207 B	

MT: Minimum tillage, CT: Conventional tillage and DT: Deep tillage

N_0: Nitrogen @ 0 kg ha^{-1}, N_{200}: Nitrogen @ 200 kg ha^{-1} and N_{250}: Nitrogen @ 250 kg ha^{-1}

As regard tillage, maximum soil nitrogen (0.62) (Table 9) was measured in CT, followed by (0.61) in DT and lowest value for soil nitrogen (0.57) was measured in MT. Regarding nitrogen rates, the maximum mean value of soil nitrogen 0.63 was recorded in N_{250}, followed by 0.61 in N_{200} and minimum 0.56 in N_{150}. As regard the interactive effect of tillage and nitrogen rates, the maximum mean value of soil nitrogen 0.65 was observed in treatment combination CT × $N_{250,}$ followed by 0.62 in case of DT × N_{250}. Minimum value for soil nitrogen (0.50) was observed in treatment combination MT ×N_{150}. It was observed that CT × N_{250} increased soil nitrogen by 30 % over MT × N_{150}. Whereas, in case of DT × N_{250}, 24 % increase in soil nitrogen was observed over control. Data regarding increased in soil nitrogen in the case of DT × N_{250} over control can be correlated with work of Sadej and Przekwas[40] .They reported that DT × N_{250} increased soil nitrogen of maize over control.

As regard tillage, maximum soil P (17.6) (Table 10). was measured in DT, followed by (17.4) in CT and lowest value for soil P (16.5) was measured in MT. Regarding nitrogen rates, the maximum mean value of soil phosphorus 17.7 was recorded in N_{200}, followed by 17.5 in N_{250} and minimum 16.3 in N_{150}. As regard the interactive effect of tillage and nitrogen rates, the maximum mean value of soil phosphorus 18.20 was observed in treatment combination CT × $N_{200,}$ followed by 18.13 in case of DT × N_{200}. Minimum value for soil phosphorus 15.7 was observed in treatment combination NT × N_{150}. It was observed that CT × N_{200} increased soil phosphorus by 15.9 % over MT ×N_{150}. Whereas, in case of DT × N_{200}, 15.5 % increase in soil phosphorus was observed over control. Data regarding increased in soil P in the case of DT × N_{250} over control can be correlated with work of Carter et al. [41]. They reported that DT × N_{250} increased soil P over control.

As regard tillage, maximum maize K (207.69) (Table 11) was measured in DT, followed by (203.33) in CT and lowest value for maize potassium (155.56) was measured in MT. Regarding nitrogen rates, the maximum mean value of maize potassium 198.80 was recorded in N_{250}, followed by 183.89 in $N_{200}$and in N0. As regard the interactive effect of tillage and nitrogen rates, the maximum mean value of maize potash 230 was observed in treatment combination CT × $N_{250,}$ followed by 224.74 in case of DT × N_{250}. Minimum value for maize potash (141.67) was observed in treatment combination MT × N_{250}. It was observed that CT × N_{250} increased maize K by 62 % over MT × N_{250}. Whereas, in case of DT × N_{250}, 58 % increase in soil K was observed over control. Data regarding

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increased in plant height in the case of DT × N_{250} over control can be correlated with work of [42]. They reported that DT × N_{250} increased plant height of maize over control.

Table 9 Effect of tillage and nitrogen rates on soil nitrogen (g kg^{-1})

	MT	CT	DT	
N_0	0.5033 a	0.5800 a	0.5933 a	0.5589 A
N_{200}	0.5867 a	0.6200 a	0.6133 a	0.6067 A
N_{250}	0.6167 a	0.6450 a	0.6240 a	0.6286 A
Mean	0.5689 B	0.6150 A	0.6102 A	

MT: Minimum tillage, CT: Conventional tillage and DT: Deep tillage

N_0: Nitrogen @ 0 kg ha^{-1}, N_{200}: Nitrogen @ 200 kg ha^{-1} and N_{250}: Nitrogen @ 250 kg ha^{-1}

Table 10 Effect of tillage and nitrogen rates on soil P (mg kg^{-1})

	MT	CT	DT	
N_0	15.700 a	16.033 a	17.133 a	16.289 A
N_{200}	16.667 a	18.200 a	18.133 a	17.667 A
N_{250}	17.000 a	17.967 a	17.440 a	17.469 A
Mean	16.456 A	17.400 A	17.569 A	

MT: Minimum tillage, CT: Conventional tillage and DT: Deep tillage ;N_0: Nitrogen @ 0 kg ha^{-1}, N_{200}: Nitrogen @ 200 kg ha^{-1} and N_{250}: Nitrogen @ 250 kg ha^{-1}

Table 11 Effect of tillage and nitrogen rates on uptake of K by maize (mg kg^{-1})

	MT	CT	DT	
N_0	158.33 ab	200.00 ab	193.33 ab	183.89 A
N_{200}	166.67 ab	180.00 ab	205.00 ab	183.89 A
N_{250}	141.67 b	230.00 a	224.74 a	198.80 A
Mean	155.56 B	203.33 A	207.69 A	

MT: Minimum tillage, CT: Conventional tillage and DT: Deep tillage

N_0: Nitrogen @ 0 kg ha^{-1}, N_{200}: Nitrogen @ 200 kg ha^{-1} and N_{250}: Nitrogen @ 250 kg ha^{-1}

CONCLUSION

Main conclusions drawn from this study are summarized below:

- Tillage and nitrogen rates significantly influenced the most of growth and yield parameters of maize. A significant increase in plant height, number of grains cob^{-1}, cob length and grain yield of the maize was observed where DT×N_{250} were used.
- Tillage and nitrogen rates showed significant effect on plant growth and yield.
- Tillage and nitrogen rates showed significant effect on leaf area index.
- Tillage and nitrogen rates showed significant effect on maize NPK uptake.
- Tillage and nitrogen rates showed significant effect on soil NPK concentrations.
- Soil organic carbon upto 20 cm depth was significantly affected by Tillage and nitrogen rates, maximum SOC was observed with treatment combination ZT× N_{250}.
- DT significantly decreased BD and soil strength.
- DT significantly increased soil porosity and infiltration rate.

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