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EFFECT OF CONVENTIONAL AND NON- CONVENTIONAL TILLAGE PRACTICES ON MAIZE PRODUCTION

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ABSTRACT

Tillage is a potential crop production activity, which largely affects crop yield. A field study was conducted to compare the effect of Deep tillage (DT), Conventional tillage (CT) and Zero tillage (ZT) practices on maize production. Significant differences among tillage treatments were observed for seedling emergence, plant height, number of leaves per plant and grain and dry matter yields. Compared to other treatments, DT gave high seedling emergence percentage, tallest plants with many leaves and highest gain and dry matter yields, followed by the CT treatment. The ZT treatment tested in this study exhibited lower emergence, shortest plants, with fewer leaves and minimum grain and dry matter yields. Therefore, considering the soil and weather conditions of the experiment, the best tillage practice for maize production is DT, followed by CT and ZT treatments.

Keyword: Grain yield, maize growth, tillage practices, yield components.

INTRODUCTION

Tillage is a mechanical and manipulation action exerted on soil to modify soil conditions for nurturing crops. Tillage aims to provide suitable environment to radical and plumule development of germinating seeds. Tillage practice suppresses weeds, controls soil erosion and maintains adequate soil moisture (Koller, 2003). Tillage creates an ideal seedbed condition for seedling emergence, development and unimpeded root growth (Licht and Kaisi, 2005). Tillage practices are critical components of soil management system (Mosaddeghi *et al.*, 2009). Inappropriate tillage practices may reduce crop growth and yield. Whereas, selection of an appropriate tillage practice for crop production is very important for optimum growth and yield. A good, soil management program protects the soil from water and wind erosion, provides a good weed free seedbed for planting, breaks hardpans that may limit root

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development and allows maintenance and even an increase of organic matter (Wright *et al.*, 2008). Tillage management and chemical and manure applications are among the important factors affecting soil physical properties. Tillage is a practice which is performed to loosen the soil and to produce a good tilth. Among the crop production factors tillage contributes up to 20% (Ahmad *et al*., 1996; Mahajan, 1996). Tillage method affects the sustainable use of soil resources through its influence on soil properties (Hammel, 1989). Deep tillage breaks up high density soil layer, improves the water infiltration and movement in soil, enhances root growth, development and increases crop production potential (Bennie and Botha, 1986). Deep tillage up to 90 cm soil depth results in increased corn yield (Varsa *et al*., 1997). Zero tillage is also an appropriate method of sowing to have some less advantage in contrast to deep tillage and conventional tillage in the modern farming systems. The research is still needed to select an appropriate conventional and non-conventional tillage for better maize production in the rain-fed regions of Islamabad, Pakistan. In this study, effect of different tillage methods on maize growth, grain yield and yield components have been evaluated.

MATERIALS AND METHODS

The study was conducted at the experimental site of National Agriculture Research Center (NARC), Islamabad, Pakistan, during the spring season of 2009. The site is located at Latitude 33^0 40′ North and Longitude 73^0 08′ East. The experimental design was a randomized complete block design (RCBD) with three tillage treatments namely: Deep Tillage (DT = Sub-soiler + Mould board plow one pass), Conventional Tillage (CT = Cultivator + disc harrow one pass) and Zero Tillage (ZT = drill). All the implements were rated as standard size field tools and were operated according to RNAM (1995) by a diesel powered tractor MF-375. Four fertilizer treatments i.e. Control, 10000 kg ha^{-1} FM, 100-50-50 NPK kg ha^{-1} and 100-50-50 NPK kg ha^{-1} + 10,000 kg ha^{-1} FM were used. Each treatment was replicated three times in a plot measuring 7 m × 10 m. The maize seeds of Islamabad Gold variety, at a rate of 25 kg ha^{-1} were dibbled at 5 cm depth, with 20 cm seed to seed and 75 cm row spacing. Recommended rates of phosphorus, and potassium and ½ dose of the nitrogen were applied at the time of planting. The remaining ½ dose of nitrogen was applied in two splits. The farm manure used in the specified treatments was applied 30 days before sowing of maize seed. Thinning was done before first irrigation to maintain the desired seed to seed and row to row distance. Five plants were randomly selected and tagged from each treatment plot to collect data on various agronomic parameters. Soil samples were collected before planting and basic properties such as: texture, pH, $CaCO_3$, NO_3-N, P, I and organic matter contents were analyzed. The climatic data were also observed during the spring season (Table 1). All the data were subjected to analysis of variance (ANOVA), using the analysis of variance procedure adopted by Steel and Torri (1980). The means were compared using LSD test at 0.05 level of probability.

Table 1. Temperature, rainfall and relative humidity at the experimental site observed during the Spring 2009.

Month	Temperature (^{0}C)		Rainfall (mm)		Relative Humidity (%)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
March	8.0	30.7	0.1	47.0	47	81
April	11.2	35.0	0.1	46.4	40	95
May	14.8	40.8	0.1	11.0	31	85
June	18.0	44.0	0.1	11.0	28	67

Table 2. Some physico-chemical properties of the experimental soil.

Soil Property	Depth (cm)		
	0-15	15-30	30-45
Sand (%)	39	47	35
Silt (%)	41	35	40
Clay (%)	20	18	25
Textural class (USDA)	-	-	-
pH_5 (water)	7.85	7.80	7.82
Organic matter content (%)	1.211	0.621	0.569
$CaCO_3$ content (%)	5.0	5.5	5.6
NO_3-N content (mg kg^{-1} soil)	6.5	4.3	3.5
Available phosphorus (mg kg^{-1} soil)	3.12	2.28	0.513
Extractable potassium (mg kg^{-1} soil)	80	62	55

RESULTS AND DISCUSSION

Soil characteristics

The results on basic soil physical and chemical properties are given in the Table- 2. The soil was loamy in texture, its pH ranged between 7.8 and 7.85 (slightly alkaline in reaction). The organic matter content of the soil ranged between 0.569 and 1.211%, indicating that sufficient amount of organic matter was present in top soil layer. Lime ($CaCO_3$) content of the soil ranged from 5.0 and 5.6 %. This suggests that the soil was slightly calcareous in nature. While, nitrate-nitrogen (NO_3-N), available phosphorus and potassium contents ranged between 3.5 and 6.5 mg kg^{-1}, 0.513-3.12 mg kg^{-1} and 55-80 mg kg^{-1}, respectively. Over all the soil was deficient in NO_3-N and phosphorus contents. Furthermore, the average depth of sub-soiler (27.35 cm) indicates that it penetrated deeper in the soil than the other tillage implements i.e. mouldboard plow penetrated up to 21.33 cm depth, disc harrow up to 10.867 cm depth, cultivator reached up to 6.917 cm depth and ZT penetrated 4.738 cm only.

Effect of different tillage treatments on seedling emergence

Fig. 1 shows the percentage of maize seedlings emerged in different tillage and fertilizer treatment plots. There was significant ($p<0.05$) effect of tillage treatments on seedling emergence percentage. More seedlings were emerged in

the DT treatment plots. The effect of fertilizer treatments was also found significant ($p<0.05$) on seedlings emergence percentage. Seedling emergence was high with germination 80% under DT treatment with fertilizer applied @ 100-50-50 kg NPK ha^{-1} + 10,000 kg FM ha^{-1}; it was followed by CT and ZT treatments with fertilizer application and without fertilizer application. These results indicate that the addition of fertilizers and manures along with deep tillage operations improves the physical condition by manipulating and pulverization the soil, which not only provides suitable environment to the germinating seeds and emerging seedlings, but also supplies free oxygen and availability of soil moisture and essential nutrients to plants. These results are in consistence with that of the findings of Arora *et al.* (1991), who observed beneficial effect of deep tillage on maize production.

Effect of tillage treatments on the height of maize plants

The effect of tillage practices on the height of maize plants is presented in Fig. 2. There seems to be significant difference among the tillage treatments in plant height. The DT treatment produced tallest plants, followed by CT treatment, while the shortest plants were observed under ZT treatment. The comparison of each level of fertilizer indicated that the plants grown in control, FM and NPK alone were shorter in height. Application of NPK @ 100-50-50 kg ha^{-1} + 10,000 kg ha^{-1} FM produced tallest plants under DT treatment. Significantly, smaller plants were observed under ZT treatment. That was possibly due to availability of nitrogen both from urea as well as FM throughout growth period. These results are in greement with the findings by Mitchell and Tu (2005). The increase in plant height in response to higher levels of nitrogen was confirmed in some other studies (Akbar *et al.,* 2002; Rasheed *et al.,* 2004).

Effect of tillage treatments on the number of leaves per plant

Effect of different tillage treatments on the number of leaves per plant is presented in Fig. 3. There was significant difference between the tillage treatments for the number of leaves per plant. More leaves were observed on plants grown under DT treatment, followed by CT treatment, while the fewer leaves were observed on plants grown under ZT treatment. Comparison between fertilizer treatments reveals that fewer leaves were observed on the plants grown in almost all the tillage treatments where no fertilizer was applied. Plants receiving FM and NPK in all the tillage treatments had more leaves. Whereas, the plants receiving NPK fertilizer @ 100-50-50 kg ha^{-1} + 10,000 kg ha^{-1} FM produced additional leaves in DT treatment. Previous study conducted by Gungula *et al.* (2005) also supports the results of this study.

Effect of tillage treatments on grain production

The effect of different tillage treatments on the grain yield of maize is presented in Fig. 4. Significant differences between tillage treatments were observed. The plants grown under DT treatment gave the highest grain yield, followed by CT treatment, while the plants grown under ZT treatment gave the lowest grain yield.

The grain yield of plants grown under tillage treatment without application of NPK fertilizer was significantly lower. Whereas, the plants receiving NPK fertilizer @ 100-50-50 kg ha^{-1} + 10,000 kg ha^{-1} FM gave higher grain yield in almost all tillage treatments; particularly more yield (i.e. 5185 kg ha^{-1}) was obtained from the plants grown under DT treatment. In contrast, minimum grain yield (i.e. 4255 kg ha^{-1}) was obtained from the plants grown under ZT treatment. These results are in agreement with those reported by Shata *et al.* (2007); Sial *et al.* (2007); Adeniyan and Ojeniyi (2005) also harvested higher maize grain yield with the application of chemical fertilizers and organic manures. Improvement in the efficacy of fertilizers and manure under DT treatment plots was possibly due to the access of plant roots to nutrients.

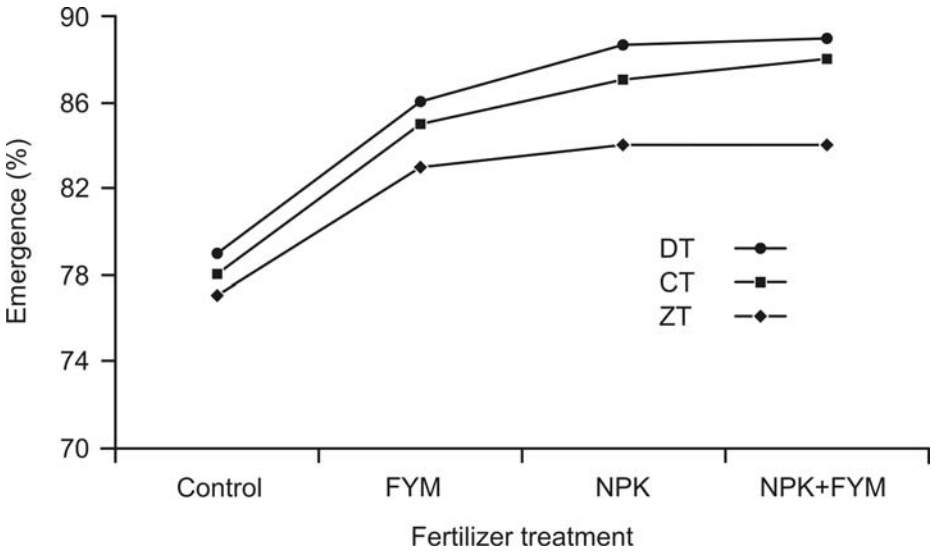

Figure 1. Effect of tillage practices and fertilizer/ manures on seedling emergence (%).

Effect of tillage treatments on the dry matter production

The effect of different tillage treatments on the dry matter yield of maize plants is presented in Figure 5. The variation among tillage treatments was significant ($p<0.05$) for dry matter production. Maximum dry matter yield was harvested from the plants gorwn under DT treatment, followed by the plants grown under CT treatment, while the plants grown in ZT treatment plots gave the lowest dry matter yield. The effect of application of NPK fertilizer on the dry matter yield of maize plants grown under different tillage treatment plots was significant ($p<0.05$). Compared to the other treatment plots, the plants treated with NPK fertilizer @ 100-50-50 kg ha^{-1} + 10,000 kg ha^{-1} FM under DT treatment gave the maximum dry matter yield. Minimum dry matter yield (i.e. 17558 kg ha^{-1}) was harvested from the plants grown under ZT treatment. Difference in dry matter yield of maize under different fertilizer treatments was ascribed to balanced

supply of nutrients from manure and chemical fertilizers over the growing period. Adequate biomass production, better nutrients uptake and improvement in yield parameters might have resulted in higher maize yield consequent to application of manure in combination with chemical fertilizer. These results are in agreement with the studies conducted by Farhat *et al.* (2009); Shata *et al.* (2007); and Chung *et al.* (2000) who estimated that organic manures added with chemical fertilizers gave higher dry matter yield of maize.

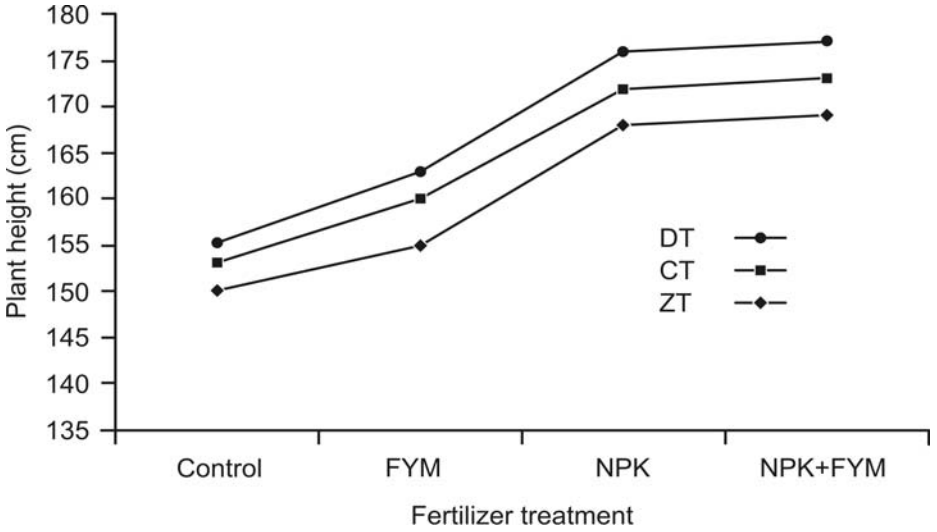

Figure 2. Effect of tillage practices and fertilizer/ manures on the height (cm) of maize plants.

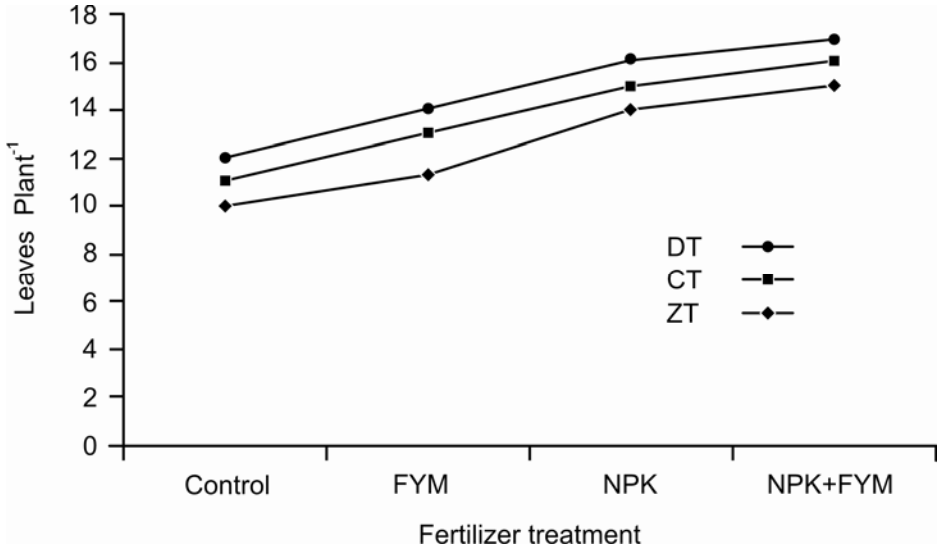

Figure 3. Effect of tillage practices and fertilizer/ manures on leaves plant^{-1}.

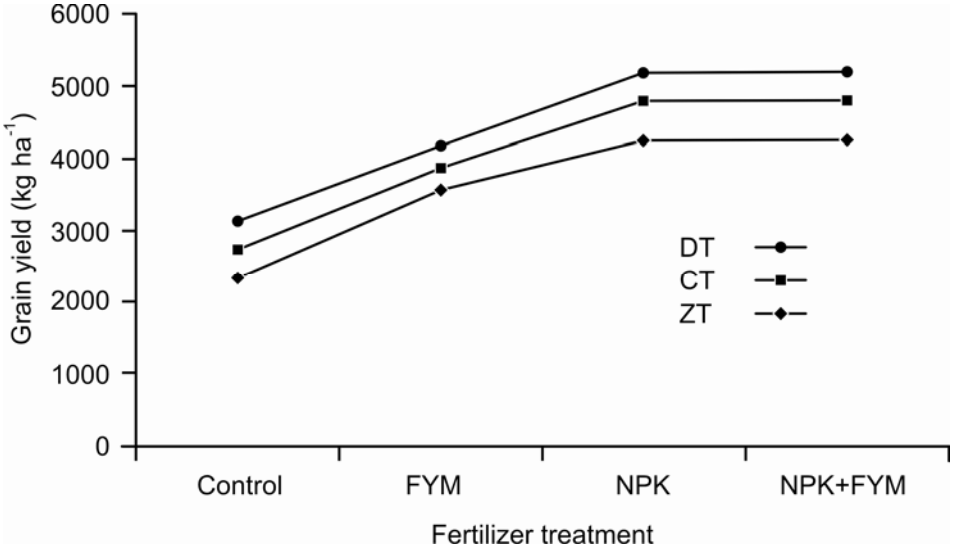

Figure 4. Effect of tillage practices FM and NPK fertilizer on maize grain yield (kg ha^{-1}).

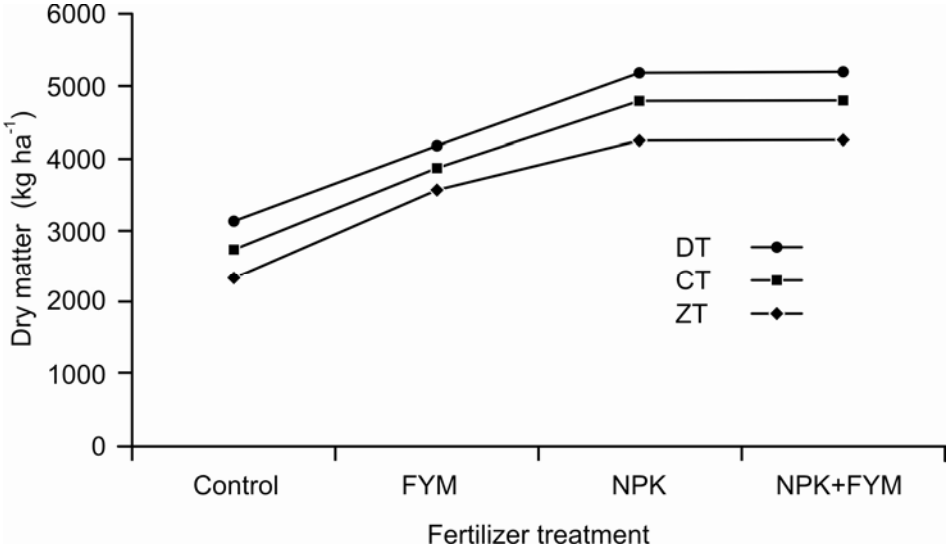

Figure 5. Effect of tillage practices, FM and NPK fertilizers on dry matter (kg ha^{-1}) yield of maize.

CONCLUSION

It can be concluded from the study that the DT with NPK @ 100-50-50 kg ha^{-1} + 10,000 kg ha^{-1} FM increased seedling emergence percentage, it produced tallest plants with many leaves gave higher grain and dry matter yield. The ZT treatment

had very mild effect on the growth and yield of maize plants. The results suggest that DT is the most effective treatment for maize production under the specific field conditions.

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