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EFFECTS OF DIFFERENT TILLAGE AND FERTILIZER TREATMENTS ON GROWTH AND YIELD COMPONENTS OF MAIZE

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ABSTRACT

Field experiment was conducted at the experimental site of National Agriculture Research Centre, Islamabad, Pakistan, during spring season of 2009. The experiment was laid out in a randomized complete block design with three replicates arranged in a split-plot configuration. Tillage method constituted the main-plots, which included: deep tillage (DT), conventional tillage (CT) and zero tillage (ZT). Whereas, four fertilizer treatments included; control, 10,000 kg ha^{-1} FYM, 200-100-100 NPK kg ha^{-1} and combination of 200-100-50 NPK kg ha^{-1} + 10,000 kg ha^{-1} FYM.

Significant differences in the plant height and yield components of maize i.e. grains cob^{-1}; 1000-grain weight, grain yield and dry matter yield were observed under three tillage methods. Deep tillage had the best results and produced taller plants, yielded more grains cob^{-1}, improved 1000-grain weight, that resulted in maximum (6118 kg ha^{-1}) grain yield and the highest (21732 kg ha^{-1}) dry matter yield, followed by conventional tillage. The zero tillage treatment produced the shortest plants with less grain cob^{-1}. The 1000-grain weight was the lowest (242 g) under this treatment that resulted in minimum (5145 kg ha^{-1}) grain yields; likewise, dry matter yield decreased significantly due to shortest (179 cm) plant heights. The NPK fertilizer application combined with FYM produced the tallest (191 cm) plants thus produced the highest dry matter yield as compared to discrete application of NPK and FYM treatment under deep tillage methods. Similar trends were observed in the grain yield and other components of maize under conventional and zero tillage. Results on application of organic and inorganic fertilizers further revealed that the increase in average per hectare yield can be obtained if soil fertility is maintained through their combined use.

Keyword: Farm yard manure**,** grain yield, inorganic fertilizer, tillage methods.

INTRODUCTION

In Pakistan, maize is third important cereal crop after wheat and rice. It is grown on about 1.11 million hectares. It is successfully grown in temperate and subtropical regions of the world (Ihsan *et al.,* 2005). Maize is used as staple food for rural population living in the mountain areas of the country (Khan *et al.,* 2003). Its total annual production is about 4.04 million tons with an average yield of 3.62 t ha^{-1} (GOP, 2008). In rain-fed areas of Pakistan grain yield of maize is 54% lower than in irrigated areas (GOP, 2008) where the average yield is about 1.86 tons ha^{-1}. About 99% of this crop is grown in Punjab and while in Khyber Pakhtoonkhwa wait is grown on about 0.492 million hectares (27% of the total cropped area) and produces about 0.782 million tons with an average yield of 1.590 tons ha^{-1} (Khan *et al.,* 2004; MINFAL, 2005-06).

Tillage is an operation that distracts the soil through various operations to place seeds and grow crops. However, almost all tillage operations are carried out to prepare a fine seed-bed for growing crops. Appropriate tillage operations are desired for better crop yields and as a result production increases.

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Proper operations improve soil physical properties while inappropriate, excessive, and unnecessary tillage operations may not provide the desirable results hence yield can significantly decrease (Khan, *et al.,* 1999; Khan, *et al.,* 2001; Iqbal, *et al.,* 2005). Most of these studies suggest that tillage tends to improve certain soil physical properties, which provide favorable soil conditions for plant growth, especially under the circumstances where the soil presents zones of high strength and compaction. Tillage also exerts adverse effects on soil when it is performed under inadequate moisture conditions, or when inadequate tillage implements are used. Several studies suggest that tillage is one of the most essential operations carried out to improve soil structure, increase infiltration capacity, expand pore volume and aeration (Lio, 2006) that in turn increases crop growth and yield consequently production boosts (Khurshid *et al*., 2006; Rashidi and Keshavarzpour, 2007; Keshavarzpour and Rashidi, 2008; Rashidi and Keshavarzpour, 2008, Rashidi, *et al.,* 2008; Rashidi, and Khabbaz, 2009), reported that plowing inverts the soil that reduces soil compaction. Campbell *et al.,* (1974) found chisel plow as a suitable implement that pulverized the high strength soils.

Many developing countries including Pakistan are striving to increase agriculture production to feed the ever increasing population. Focus is being given on cultivation of cereal crops to meet the food requirements. Maize is considered as one the most important cereal crops of the world. It is used for three main purposes as human food, feed for poultry and fodder for livestock. Maize, being one of the highest yielding cereal crops in the world, has significant importance in the countries like Pakistan, where rapidly increasing population has already outstripped the available food and feed supplies.

The conventional tillage methods have been used to grow major crops including maize since long but they are now considered as expensive operations in terms of work and fuel consumption. The researchers and farmers are looking to adopt alternative tillage methods due to environmental concerns and costs involved. Considerable attention has been diverted towards conservation tillage methods, i.e. reduced tillage, minimum tillage and no-tillage methods. Recently, a shift from conventional to conservation tillage methods has marked effects due to many reasons, which conserves soil and water, saves fuel energy and reduces soil erosion. The erosion control has always been a powerful argument for the acceptance of zero tillage (Torbet *et al.* 2001). Many researchers have found that the conventional tillage operations disturb more soil that generally increases soil aeration, residue decomposition, organic N mineralization, and the availability of N for plant use (Halvorson *et al*., 2001; Sainju and Singh, 2001; Dinnes *et al.*, 2002) but in contrast, under zero-tillage soil is not disturbed that increases the build-up of surface residue, which in turn increase nitrogen immobilization decreases its loss through leaching and results in denitrification (Gilliam and Hoyt, 1987).

As compared to conventional tillage, yield returns under zero tillage maize production are similar to or even exceed in some cases. Yet there are many management problems that limit the acceptance of conservation tillage. Increased diversity of weed species and population might have a harmful effect on crop yield but availability and extensive use of herbicides has solved some of the puzzling weed control problems under zero-tillage (Gangwar *et al.,* 2006).The conservation tillage methods can now be used for maize but they may reduce its growth and yield. In Pakistan, conventional tillage methods are mostly used for cultivation of crops without thoroughly studying their impacts on crop growth and yield. Hence there is limited information available on the effects of conservation tillage methods on growth, yield and quality of maize.

Beside appropriate selection of tillage operations, the improvement in average yield per hectare can be obtained if soil fertility is maintained through proper dose, application method and use of organic and inorganic fertilizers. In many countries in the world, balanced use of organic manure and inorganic fertilizers has been considered as one of the best and comprehensive soil fertility management strategies (Lombin *et al.*, 1991). In several studies, high and sustainable crop yields are only possible with combined use of inorganic fertilizers with organic manure (Raman *et al*, 1996; Singh *et al.,* 1999). Some other studies also have recommended judicious and balanced NPK fertilization combined with organic matter amendments for high and sustained crop yields (Makinde *et al*., 2001). The high yields are attributed to complementary application of organic and inorganic fertilizers as they increase nutrient accessibility and reduce losses by converting inorganic nitrogen into organic forms (Kramer *et al.,* 2002). The present study was undertaken to evaluate the effect of different tillage methods, NPK and manure application levels on maize growth, yield components and some selected quality characteristics of maize.

MATERIALS AND METHODS

Description of the study site

A field experiment was conducted at National Agriculture Research Centre, Islamabad, Pakistan, during spring season 2009. This experimental site is located at Latitude 33^0 40′ North and Longitude 73^0 08′ East. The soils at the site are loamy in texture, soil pH ranged between 7.8 and 7.9, indicating that the soil is slightly alkaline in reaction. The soil characteristics of the experimental area are presented in Table 1. Organic matter content ranged between 0.569 and 1.211 % indicating that enough amount of organic matter was present in upper layer. Lime content ($CaCO_3$) ranged between 5.0 and 5.6 % indicating that the soil was slightly calcareous. While, nitrate-nitrogen (NO_3-N), phosphorus and potassium content ranged between 3.5 and 6.5 mg kg^{-1}, 0.513 and 3.12 mg kg^{-1} and 55 and 80 mg kg^{-1}, respectively. The results indicated that the soil had lower NO_3-N and phosphorus concentration whereas potassium concentration was marginal. The climate data were taken during the spring season (Table 2). The minimum temperature ranged between 8 and 18^0C while the maximum temperature ranged between 30.7 and 44^0C during March and June.

Treatment details and experimental design

The effects of tillage methods, inorganic fertilizer and organic farmyard manure were evaluated on maize grown in spring. The experiment was laid out in a randomized complete block design with three replicates, arranged in a split-plot configuration. The experiment comprised of 36 plots, each measuring 10 x 7 m. Tillage method constituted the main-plot treatment, which included: deep tillage (sub soiler + Moldboard plow one pass), conventional tillage (cultivator + disc harrow one pass) and zero tillage. While, four fertilizer treatments included: control, 10,000 kg ha^{-1} FYM, 200-100-100 NPK kg ha^{-1} and 200-100-50 NPK kg ha^{-1} + 10,000 kg ha^{-1} FYM.

Seedbed preparation

Land was prepared and leveled properly for uniform distribution of seed, fertilizer and irrigation water. Twelve plots in each replicate under deep tillage (DT) treatment were plowed using a sub soiler and Moldboard plow. Similarly, twelve plots in each replicate under conventional tillage (CT) treatment were prepared by using a combination of cultivator and disc harrow. Whereas, twelve plots in each replicate under zero tillage (ZT) treatment did not receive any cultivation or seedbed preparation operation, the seeds were directly drilled using a seed driller. Sowing was done manually in deep tillage and conventional tillage on 10^{th}March, 2009, while seeds were drilled, on the same day, by using a seed driller in the plots with zero tillage treatment. First irrigation was applied after 15 days of sowing and subsequent irrigations were applied as per crop water requirement and the irrigation interval was fixed accordingly. A complete dose of P, K and half dose of N was applied at the time of final seedbed preparation whereas, the remaining dose of N was applied into three splits during 2^{nd}, 3^{rd} and 4^{th} irrigation. The FYM was applied and well mixed with soil during land preparation process before seed bed preparation. Weed management practices were done to remove unwanted weed plants crop through hand weeding.

Seeding method

Seeds of a maize variety Islamabad Gold were drilled at 5 cm depth, keeping row to row spacing at 75 cm and seed to seed spacing at 20 cm. Maize was sown at the rate of 25 kg $ha^{-1}$and the complete dose of PK and half dose of N was applied at the time of sowing. The remaining dose of N was applied in two splits; the farm yard manure was also applied before sowing of maize crop. Before first irrigation, thinning was done to maintain plant population and proper spacing. In each plot, five plants were randomly selected and tagged for measurements. Plant height (cm), number of seeds cob^{-1}, 1000-grain weight, grain yield and dry matter were recorded on the selected plants.

Table1. Selected soil physical and chemical properties at the experimental site.

Soil Property	Soil depth (cm)		
	0-15	15-30	30-45
Sand (%)	39	47	35
Silt (%)	41	35	40
Clay (%)	20	18	25
pH	7.8	7.8	7.8
Organic Matter (%)	1.21	0.62	0.57
$CaCO_3$ (%)	5.0	5.5	5.6
NO_3-N mg kg^{-1}	6.5	4.3	3.5
P mg kg^{-1}	3.12	2.28	0.51
K mg kg^{-1}	80	62	55

Table 2. Temperature, rainfall and relative humidity at the experimental site during 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

Data Analyses

All the data were subjected to analysis of variance (ANOVA) using the Analysis of Variance procedure developed by (Steel and Torroe, 1980). The treatment means were separated using least significant difference (LSD) for comparisons at $p<0.05$.

RESULTS AND DISCUSSION

Plant height

Plant height is an important parameter that determines the growth of maize plant. The results on plant height under different tillage treatments are shown in Figure 1. The results showed significant difference in maize plant height between the different tillage treatments. The tallest plants (191cm) were observed in the deep tillage, followed by (188 cm) conventional tillage treatment, while the shortest plants (179) were observed with zero tillage treatment. The comparison of various fertilizer treatments revealed that plant height increased significantly as compared to control. The application of NPK + FYM produced the tallest (191cm) plants under deep tillage followed by 185 cm under conventional tillage while poor results were recorded under zero tillage with separate application of either FYM or NPK. Increased plant height with application of combined fertilizer is attributed to more availability of nitrogen both from urea as well as manure throughout the growing season. These results are in agreement with the findings by Mitchell and Tu (2005). Almost similar results were reported in previous studies by Akbar *et al*., (2002) and Rasheed *et al*., (2004), they observed increased plant heights in response to higher levels of nitrogen.

Yield components

The tillage treatments were evaluated on the basis of total number of cobs produced $plant^{-1}$, number of grain cob^{-1}, 1000-grain weight. The results suggest that these components were affected by tillage and fertilizer treatments. Among different tillage treatments, the deep tillage followed by conventional tillage produced the more number of cobs $plant^{-1}$. Zero tillage treatment had the less number of cobs $plant^{-1}$ which ultimately resulted in the lowest number of grains with least 1000-grain weight. Such results are expected because deep tillage loosens more soil as compared to conventional and zero tillage which in turn provides more aeration and has higher water retention capacity, they both provide favorable environment for plant growth hence plants become much healthier. The present results are in agreement with those of Polthanee and Wannapat (2000) who reported that tilled plots produced higher number of seeds plant^{-1} than that of untilled plots. According to them tillage operation which improve soil aeration provide better results. In a study, Rashidi and Keshavrzpour (2007) evaluated seven tillage methods under clay-loam soil and observed higher maize grain yield and yield components under tillage treatments as compared to no till treatment. In contrast, Olaoye (2002) reported significantly higher number of pods plant^{-1} in no tillage plots as compared to plowing followed by harrowing under Ferrisols Ferruginous soils in the derived savannah agro-ecological zone of Nigeria while, Agbede *et al*. (2008) observed superior sorghum grain yield under no till treatment as compared to different tillage treatments. In a recent study, Aikins and Afuakwa (2010) observed that number of pods plant^{-1}, number of seeds pod^{-1} and 1000 seed-weight are generally influenced by the tillage treatments. According to them, tillage carried by plowing and followed by disc harrowing provided the highest number of pods plant^{-1}, the greatest number of seeds pod^{-1} and the highest 1000 seed-weight. While no tillage treatment produced the lowest number of pods plant^{-1}, number of seeds pod^{-1} and 1000 seed-weight. Such results were attributed to soil loosening by tillage treatments. Rashidi and Abbassi (2011) studied effects of different tillage methods on yield, yield components and quality of sugar beet (*Beta vulgaris*). No significant effects of different tillage treatments on root yield, root dry matter, root length, rim diameter were observed however, treatments significantly ($p = 0.05$) affected root number only. The results of their study however, indicated that tillage operations were useful in improving the yield and quality of sugar beet. In a recent study, Ahmad *et al.* (2010) reported that yield and yield components significantly improved up to 120 kg N ha^{-1} however, additional N up to 180 kg ha^{-1} failed to induce any increase. Split application significantly increased grains ear^{-1}, grain weight and grain yield as compared to sole application. According to the conventional tillage which was superior as all yield components were higher under this treatment as compared to zero-tillage.

Grains cob^{-1}

The data pertaining to the grain cob^{-1} under different tillage treatment are presented in Figure 2. Results showed significant difference in grains cob^{-1} between the different tillage methods, the maximum (382) grains cob^{-1} were found under the deep tillage, followed by (373) grains cob^{-1} under conventional tillage, while the minimum (360) grains cob^{-1} were found under zero tillage. The interaction between tillage methods and various organic and inorganic fertilizer treatments reveals that the number of grains cob^{-1} increased significantly with combined application of NPK + FYM as compared to separate application of FYM and NPK. However, no significant differences ($p = 0.05$) were observed between discrete application of NPK and combined application of NPK with FYM. Similarly no significant differences between deep and conventional tillage were observed under NPK treatment where 368 grains cob^{-1} in deep tillage as compared to 365 grains cob^{-1} in conventional and 346 grains cob^{-1} in no tillage treatments were observed. Under FYM treatment 274 grains cob^{-1} in deep tillage as compared to 264 grains cob^{-1} in conventional and 251 grains cob^{-1} in no tillage treatments were observed. Results further suggest that zero tillage produced minimum grains cob^{-1} for FYM, NPK and combined application of NPK + FYM as compared to deep and conventional tillage treatments. These results are in agreement with Rowe and Johnson (1995) who reported more grains spike^{-1} under high levels of applied nitrogen. Increase or decrease in grain cob^{-1} has been attributed to tillage operations (Halvorson *et al.,* 2006; Sainju and Singh, 2001; Dinnes *et al.,* 2002). As reported by Monneveux *et al.* (2006) zero tillage produced less number of grains ear^{-1} in maize as compared to conventional tillage. The higher number of grains ear^{-1} has been attributed to high levels of N and P (Maqsood *et al.,* 2001). They concluded that increased levels of N and P fertilizer increases the size of individual ears ultimately the number of grains ear^{-1} also is higher. Costa *et al.* (2002) reported that cob length and its diameter increases up to a certain level of N application but any further increase do not make any significant difference. They observed maximum cob diameter at 85 and 170 kg N ha^{-1} than any further N fertilization rates.

1000-grain weight

The data pertaining to 1000-grain weight are illustrated in Figure 3. Statistical analyses of the data reveal that the tillage and fertilizer treatments significantly affected 1000-grain weight of maize. The interactions among tillage and fertilizer treatments were also significant for grain weight. The results showed significant differences in 1000-grain weight between the different tillage treatments. Deep tillage produced heavier grains than conventional and no tillage at all fertilizer treatments. Similarly combined application of NPK + FYM had significant influence on grain weight and proved to be superior in terms of 1000-grain weight than NPK and FYM applied separately.

The maximum (257 g) 1000-grain weight was observed under deep tillage, followed by (250 g) conventional tillage, while the lowest (242 g) 1000-grain weight was observed at zero tillage. The comparison of various fertilizer treatments showed that the 1000-grain weight increased significantly with application of organic and inorganic fertilizers as compared to control. Significant interaction among tillage and fertilizer was obvious in 1000-grain weight. The combined application of NPK + FYM produced the maximum (257 g) 1000-grain weight under deep tillage followed by conventional tillage while, poor 1000-grain weights were recorded under zero tillage for all fertilizer treatments. The grain weights were higher under combined application of NPK + FYM as compared to separate practice of NPK and FYM for all tillage treatments. The results are in agreement with those by Ahmad *et al.,* (2010). According to them, significantly higher grain yields were produced under conventional tillage as compared to zero-tillage. Significant interaction among tillage and nitrogen was also observed for grains ear^{-1}, grain weight and grain yield. Conventional tillage produced higher grains ear^{-1} and heavier grains even with lower dose of 60 kg N ha^{-1}, while zero-tillage required 180 kg N ha^{-1} to produce the same results. Grain yield was highly responsive to increase in N fertilizer up to 120 kg N ha^{-1} under conventional tillage method. Further increase up to 180 kg N ha^{-1} merely induced any increase in grain yield under conventional tillage. In case of zero tillage grain yield decreased beyond 120 kg N ha^{-1}. Grain yield increased up to 120 kg N ha^{-1} but grains ear^{-1} and grain weight were higher at the highest dose of 180 kg N ha^{-1}. Split application of N significantly increased all parameters including yield and yield components as compared to full application of N in single dose. Higher 1000-grain weight has been attributed to increased application rate of nitrogen in studies from past (Maqsood *et al*. 2001). Alkain *et al.* (1993) also reported that increased levels of N (up to 112 kg ha^{-1}) increased 1000-grain weights.

Grain yield

The results on grain yield under various tillage and fertilizer treatments are depicted in Figure 4. Analysis of the data revealed that tillage and fertilizer treatments significantly affected grain yield of maize. The significant differences were recorded in maize grain yields between different tillage treatments. Deep tillage produced significantly higher grain yield as compared to conventional and no-tillage. Grain yields were affected by different fertilizer treatments and they had a positive linear relationship with fertilizer application. The tillage x fertilizer interaction showed that grain yield mostly increased under deep tillage as compared to conventional and no tillage irrespective of fertilizer application. The highest (6118 Kg ha^{-1}) grain yield was observed under deep tillage, followed by (5654 Kg ha^{-1}) conventional tillage whereas, the lowest (5145 Kg ha^{-1}) grain yield was observed with zero tillage treatment. Comparison between organic and inorganic fertilizer treatments showed that the minimum (3119 Kg ha^{-1}) grain yield was observed under control as compared to FYM, NPK and combined application of NPK + FYM treatments. Combination of NPK + FYM produced the maximum (6118 Kg ha^{-1}) grain yield under deep tillage followed by 5664 Kg ha^{-1} under conventional tillage while the minimum (5145 Kg ha^{-1}) grain yield was recorded under zero tillage. The lower grain yields under no tillage treatment are attributed to slow early crop growth as compared to deep and conventional tillage treatments which resulted shorter plant heights. Slow growth was witnessed under no tillage during this study and also from the past studies by Halvorson *et al.*, (2006). It has also been recognized by Simes *et al.* (1998) that pre-plant tillage is necessary to achieve higher grain yields under maize crop. They reported lower continuous corn yields with no tillage as compared to conventional tillage. However, Beyaert *et al.* (2002) did not find any significant effects of early corn growth on maize yields under different tillage systems.

Similar trends were observed under application of NPK alone which produced 6112, 5654, and 5139 Kg ha^{-1} grain yield under deep, conventional and zero tillage treatments, respectively. Application of FYM alone produced 4170, 3873 and 3576 Kg ha^{-1} grain yield under deep, conventional and zero tillage treatments, respectively. The results suggest that combined application of organic and inorganic fertilizers have significant effects on grain yields and produced maximum yields under all tillage treatments as compared to separate applications of organic or inorganic fertilizer. It is suggested that combined application of organic or inorganic fertilizers should be preferred over separate application of each. These results are in agreement with earlier studies by other researchers (Adeniyan and Ojeniyi, 2005) who reported that application of chemical and organic manure improved maize grain yield. Similarly, Ahmad *et al*., (2008) also reported better crop yield by the integrated use of organic and mineral fertilizers. Higher grain yields under conventional tillage methods have also been reported by many researchers (Halvorson *et al.,* 2006). Similarly, Pederson and Lauer, (2003) noted 5% lower corn yield under no tillage as compared to conventional tillage methods. In a more recent study Ahmad *et al*., (2010) observed a significant interaction among tillage and nitrogen fertilizer applications and observed grains ear^{-1}, grain weight and grain yield under conventional tillage as compared no till. They further observed that the number of grains ear^{-1} were produced with lower dose of 60 kg N ha^{-1} under conventional tillage, while no till required 180 kg N ha^{-1} to obtain the same results. However, maximum yield was obtained with 120 kg N ha^{-1} under conventional tillage, further increase up to 180 kg N ha^{-1} merely did produce any significant increase in grain yield. Under no tillage, grain yield even decreased with application beyond 120 kg N ha^{-1}. Conventional tillage proved superior in terms of grains ear^{-1}, grain weight and grain yield as compared to no till. Though the crop growth and yields under no tillage were relatively low as compared to deep and conventional tillage but it did not cause a serious reduction in yield hence it stands a great potential to be adopted. In spite of the yield differences, no-till remains an extremely important method that uses minimum energy and can reduce soil erosion.

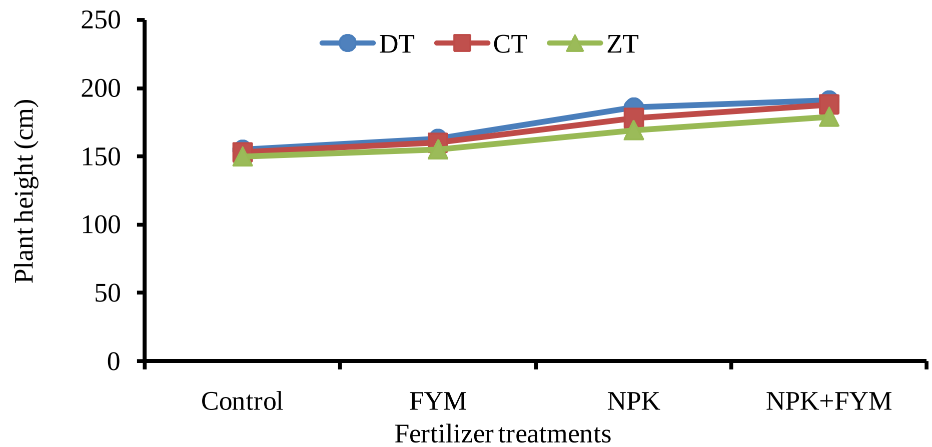

Figure 1. Effect of fertilizer levels on plant height (cm) under different tillage treatments.

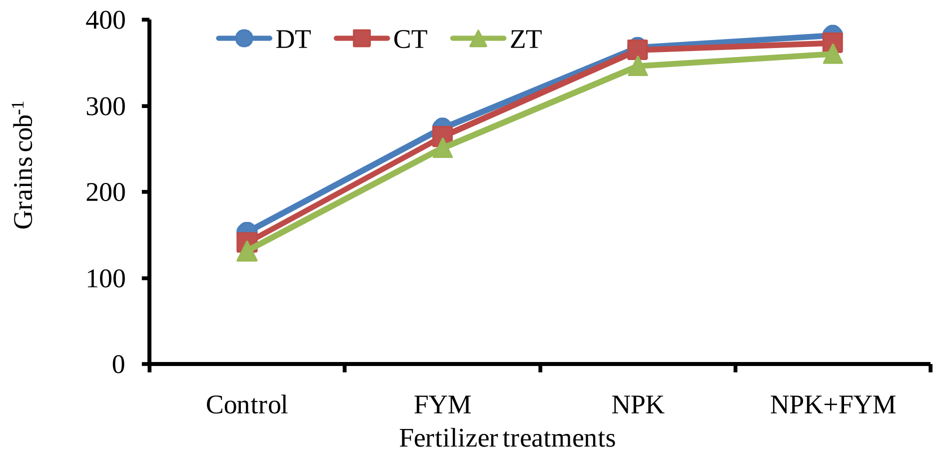

Figure 2. Effect of fertilizer levels on grains cob^{-1} under different tillage treatments.

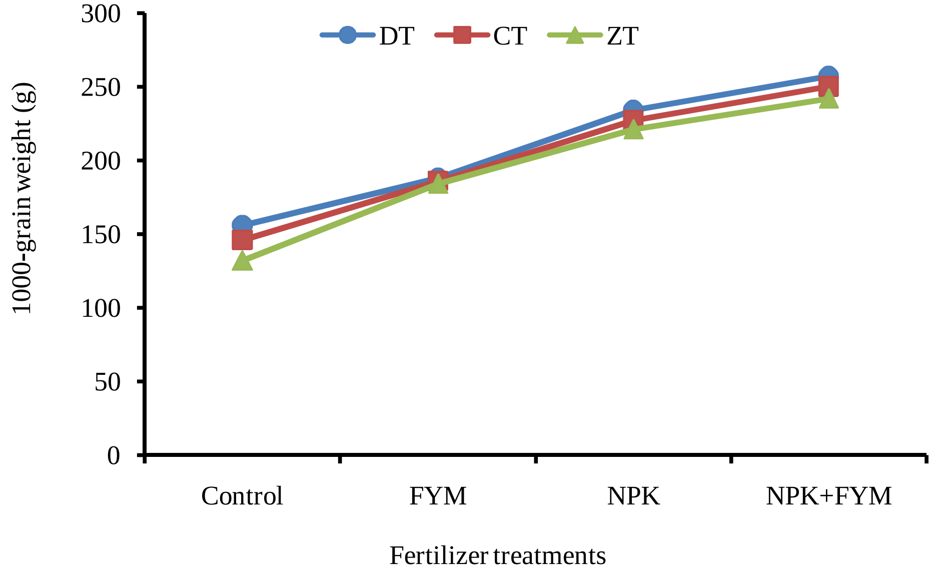

Figure 3. Effect of fertilizer levels on 1000-grain weight (g) under different tillage treatments.

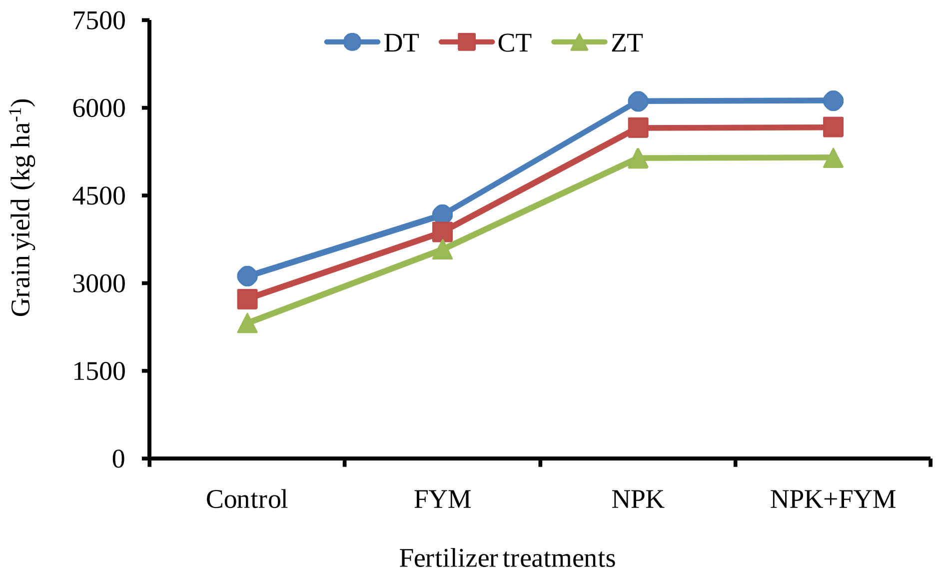

Figure 4. Effect of fertilizer levels on grain yield (kg ha^{-1}) under different tillage treatments.

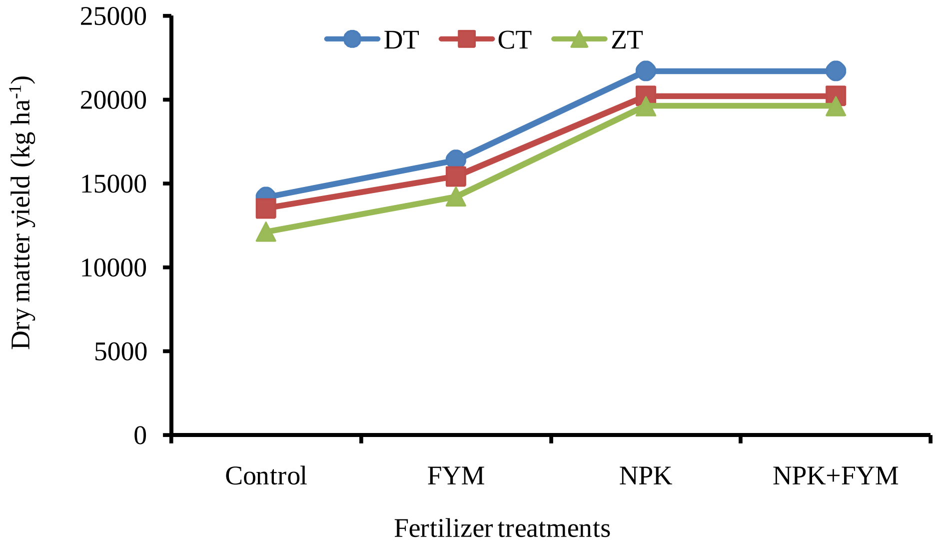

Figure 5. Effect of fertilizer levels on dry matter yield (kg ha^{-1}) under different tillage treatments.

Dry matter yield

The results on maize dry matter yield are illustrated in Fig. 5. Significant differences in dry matter yield between the different tillage treatments were observed. Maximum (21732 kg ha^{-1}) dry matter was observed under deep tillage treatment followed by (20235 kg ha^{-1}) conventional tillage treatment, while the minimum (19641 kg ha^{-1}) dry matter was observed with zero tillage treatment. Comparison between fertilizer treatments showed that the minimum (14214 kg ha^{-1}) dry matter was observed under control treatment as compared to discrete application of FYM & NPK and combination of NPK + FYM under deep tillage. While, combined application of NPK + FYM, NPK and FYM produced 21732, 21725 and 16434 kg ha^{-1} dry matter, respectively under deep tillage treatment. Similar trends were observed under conventional tillage where, maximum (20235 kg ha^{-1}) dry matter was produced with combined application of NPK + FYM followed by NPK, FYM and control they produced 20225, 15434, 13529 kg ha^{-1} dry matter yield, respectively. Similar, trends were observed under conventional tillage where maximum (20235 kg ha^{-1}) dry matter yields were observed. The minimum dry matter yield was recorded under zero tillage for all fertilizer treatments where 19641, 19631, 14251 and 12141 kg ha^{-1} dry matter was produced under NPK + FYM, NPK, FYM and control, respectively. Difference in dry matter yield under different fertilizer treatments was ascribed to balance supply of nutrient from manure and chemical fertilizers throughout the growing period. Adequate biomass production, better nutrient 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 show close agreement with the finding of other researchers (Farhat *et al*., 2009). Similarly, Chung *et al*., (2000) reported higher dry matter yields of corn when organic manure along with judicious amount of fertilizers was applied.

CONCLUSION

Different tillage treatments were evaluated on the basis of plant height and yield components of maize. Deep tillage followed by conventional tillage had the tallest plants and produced the highest number of cobs plant^{-1} with higher number of grains. Also 1000-grain weight and dry matter yields were higher under deep tillage. Zero tillage produced the lowest number of cobs plant^{-1} with small number of maize grains which ultimately resulted in the lowest yields under this treatment. The study further revealed that maize yield from control was significantly lower as compared fertilizer treatments. The combined application of organic and inorganic fertilizers provided the best results under deep tillage treatment followed by discrete application of NPK. Based on the results of this study, it is suggested that the combined application of NPK + FYM are more appropriate for better grain and dry matter yields of maize.

REFERENCES

Adeniyan, O. N. and S. O. Ojeniyi. 2005. Effect of poultry manure, NPK 15-15-15 and combination of their reduced levels on maize growth and soil chemical properties. Nig. J. Soil Sci., 15: 34-41.

Agbede, T. M., S. O. Ojeniyi and M. A. Awodun. 2008. Effect of tillage methods on growth, grain yield and nutrient content of sorghum (*Sorghum bicolor* L.) in forest Savanna transition zone of Nigeria. Int. J. Sustain. Crop Prod., 3 (5): 35-39.

Ahmad, R., M. Naveed, M. Aslam, Z. A. Zahir and M. Arshad. 2008. Economizing the use of nitrogen fertilizer in wheat production through enriched compost. Renewable Agric. Food Syst., 23: 243- 249.

Ahmad, I., M. T. Jan and M. Arif. 2010. Tillage and nitrogen management impact on maize. Sarhad J. Agric. 26 (2): 157-167.

Aikins, S. H. M. and J. J. Afuakwa. 2010. Effect of four different tillage practices on cowpea performance. World J. Agric. Sci., 6 (6): 644-651.

Akbar, H., Miftahullah Jan., M. T. Jan and Ihsanullah. 2002. Yield potential of sweet corn asinfluenced by different level of nitrogen and plant population. Asian J. Plant Sci., 6: 631- 633.

Alkain, A., B. Sade, A. Tamkoe and A. Topat. 1993. Effect of different plant densities and nitrogen fertilizer rates on grain yield and some morphological characters of maize. Doga turk Tarim Ve Ormoncilik Dergisi, 17: 281-294.

Beyaert, R. P., J. W. Schott and P. H. White. 2002. Tillage effects on corn production in a coarse-textured soil in suthern Ontario. Agron. J., 94: 767-774.

Campbell, R. B., B. E. Reicosky and E. W. Doty. 1974. Physical properties and tillage of Paleudilts in the eastern costal plains. J. Soil Conserv., 29: 220-224.

Chung, R. S. C. H. Wang, C.W. Wang and Y. P. Wang. 2000. Influence of organic matter andinorganic fertilizers on the growth and nitrogen accumulation of corn plants. J. Plant nutrition, 23 (3): 297-311.

Costa, C., L. M. Dwyer, D. W. Stewart, and D. L. Smith. 2002. Nitrogen effect on grain yield and yield components of leafy and nonleafy maize genotypes. Crop Sci. 42; 1556-1563.

Dinnes, D. L., D. L. Karlen, D. B. Jaynes, T. C. Kaspar, J. L. Hatifield, T. S. Colven and C. A. Cambardella. 2002. Nitrogen management strategies to reduce nitrate leaching in tile-drained Midwestern soils. Agron. J., 94: 153-171.

Farhat, W., M. F. Saleem, M. A. Cheema and H. M. Hammad. 2009. Effect of Poultry Manure Levels on the productivity of spring maize (*Zea mays* L.). J. Ani. Plant Sci., 19 (3): 122-125.

Gangwar, K. S., K. K. Singh, S. K. Sharma and O. K. Tomar. 2006. Alternative tillage and crop residue management in wheat after rice in sandy loam soils of Indo-Gangetic plains. Soil & Tillage Res., 88: 242-252.

GOP, 2008. Agricultural statistics of Pakistan. 2007-2008. Ministry of Food, Agriculture and Livestock (Economic Wing), Islamabad.

Halvorson, A. D., A. R. Mosier, C. A. Reule and W. C. Bousch. 2006. Nitrogen and tillage effects on irrigated continuous corns. Agron. J., 98: 63-71.

Halvorson, A. D., B. J. Weinhold and A. L. Black. 2001. Tillage and nitrogen fertilization influences on grain and soil nitrogen in a spring wheat-fallow system. Agron. J., 93: 1130-1135.

Ihsan, H., I. H. Khalil, H. Rahman and M. Iqbal. 2005. Genotypic variability for morphological and reproductive traits among exotic maize hybrids. Sarhad J. Agric., 21 (4): 599-602.

Iqbal, M., A. U. Hassan, A. Ali and M. Rizwanullah. 2005. Residual effect of tillage and farm manure on some soil physical properties and growth of wheat (*Triticum aestivum* L.). Int. J. Agri. Biol., 7: 54-57.
Keshavarzpour, F. and M. Rashidi. 2008. Effect of different tillage methods on soil physical properties and crop yield of watermelon (*Citrullus vulgaris*). World Appl. Sci. J., 3: 359-364.

Khan, K., M. Iqbal, Z. Shah, B. Ahmad, A. Azim and H. Sher. 2003. Grain and stover yield of corn with varying times of plant density reduction. Pak. J. Biol. Sci., 6 (19): 1614-1743.

Khan, K., F. Karim, M. Iqbal, H. Sher and B. Ahmad. 2004. Response of maize varieties to environments in two agro-ecological zones of NWFP: Effects on morphological traits. Sarhad J. Agric., 20 (3): 395-399.

Khan, F. U. H., A. R. Tahir and I. J. Yule. 1999. Impact of different tillage practices and temporal factor on soil moisture content and soil bulk density. Int. J. Agri. Biol., 1: 163-166.

Khan, F. U. H., A. R. Tahir and I. J. Yule, 2001. Intrinsic implication of different tillage practices on soil penetration resistance and crop growth. Int. J. Agri. Biol., 3: 23-26.

Khurshid, K., M. Iqbal, M. S. Arif and A. Nawaz. 2006. Effect of tillage and mulch on soil physical properties and growth of maize. Int. J. Agri. Biol., 8: 593-596.

Kramer, A. W., T. A. Doane, W. R. Horwath and C. V. Kessel. 2002. Combining fertilizer and organic inputs to synchronize N supply in alternative cropping systems in California. Agric. Eco. Envir., 91: 233-243.

Lio, F. S. 2006. The influence of tillage practices on the performance of cereals and root and tuber crops. Journal of Sustainable Agriculture and Environmental Studies, 3 (3): 101-105.

Lombin, L. G., J. A. Adepetu and K. A. Ayotade. 1991. Organic fertilizer in the Nigerian agriculture: present and future F.P.D.D. Abuja, pp. 146-162.

Makinde, E. A., A. A. Agboola and F. I. Oluwatoyinbo. 2001. The effects of organic and inorganic fertilizers on the growth and yield of maize in a maize/melon intercrop. Moor Journal of Agricultural Research, 2: 15-20.

Maqsood, M., A. A. Amanat, I. Iqbal and M. I. Hussain. 2001. Effect of variable rates of nitrogen and phosphorus on growth and yield of maize (Golden). Biol. Sci. 1 (1): 19-20.

MINFAL. 2005-06. Agricultural statistics of Pakistan. Ministry of Food, Agriculture and Livestock. Islamabad.

Monneveux, E. Quillerou, C. Sanchez and J. Lopez-Cesati. 2006. Effect of zero tillage and residue conservation on continuous maize cropping in a subtropical environment (Mexico). Plant & Soil. 279:95-105.

Olaoye, J. O. 2002. Influence of tillage on crop residue cover, soil properties and yield components of cowpea in derived savannah ectones of Nigeria. Soil and Tillage Research, 64 (3-4): 179-187.

Pederson, P. and J. G. Lauer. 2003. Corn and soybean response to rotation sequence, row spacing, and tillage system. Agron. J., 95:965-971.

Polthanee, A., and S. Wannapat. 2000. Tillage and mulching affect on growth and yield of cowpea grown following rice in the post-monsoon season of northeastern Thailand. Kasetsart J. (nat. Sci.), 34: 197-204.

Raman K. B., M. P. Singh, R.O. Singh and U.S.P. Singh. 1996. Long-term effects of inorganic and organic-inorganic nitrogen supply system on yield trends of rice-wheat cropping system. J. Appl. Bio., 6 (1, 2): 56-58.

Rasheed, M., T. Mahmood, M. S. Nazir, W. A. Bhutta and A. Ghaffar. 2004. Nutrient efficiencyand economics of hybrid maize under different planting methods and nutrient levels. International Journal of Agriculture and Biology, 6 (5): 922-925.

Rashidi, M., and S. Abbassi. 2011. Effect of different tillage methods on root yield, yield components and quality of sugar beet (*Beta vulgaris*). Libyan Agriculture Research Center Journal International, 2 (2): 51-56.

Rashidi, M., and F. Keshavrzpour. 2007. Effect of different tillage methods on grain yield and yield components of maize (*Zea mays* L.). Intl. J. Agric. Biol., 9 (2): 274-277.

Rashidi, M. and F. Keshavarzpour. 2008. Effect of different tillage methods on soil physical properties and crop yield of melon (*Cucumis melo*). American-Eurasian J. Agric. and Environ. Sci., 3: 31-36.

Rashidi, M., F. Keshavarzpour and M. Gholami. 2008. Effect of different tillage methods on yield and yield components of forage corn. American-Eurasian J. Agric. and Environ. Sci., 3: 347-351.

Rowe, B. A. and D. E. Johnson. 1995. Residual benefit of limestone and superphosphate on barley yield and soil water deficits on a kransnozem in north western Tasmania. Aust. J. Experiment Agri., 35 (5): 611-617.

Sainju, U. M. and B. P. Singh. 2001. Tillage, cover crop, and kill-planting date effects, on corn yield and soil nitrogen. Agron. J., 93: 878-868.

Simes, Al. L., J. S. Schepers, R. A. Olson and J. F. Power. 1998. Irrigated corn yield and nitrogen accumulation response in a comparison of no-till and conventional till: Tillage and surface-residue variables. Agron. J. 90: 630-637.

Singh, N. P., R. S. Sanchez, P. C. Pandey and R. S. Bishi. 1999. Effects of decade long fertilizer and manure application on soil fertility and productivity of rice-wheat system in a Mollisol. J. Ind. Soc. Soil Sci., 47 (1): 72-80.

Steel, R. G. and J. H. Torroe. 1980. Principles and procedures of statistic. 2nd Ed., New York: McGraw-Hill.

Torbert, H. A., K. N. Potter and J. E. Morrison, Jr. 2001. Tillage system, fertilizer nitrogen rate and timing effect on corn yield in the taxes black land prairie. Agron. J., 93: 1119-1124.

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