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PERFORMANCE OF MAIZE (Zea mays L.) YIELD ATTRIBUTES UNDER VARIOUS TILLAGE STRATEGIES

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Abstract

Tillage is one of the most important practices in agriculture which is done mainly to mix the soil with organic residues and fertilizers, to control weeds, loosen the upper layer of soil, and to create a suitable seedbed for germination and plant growth. The present study was conducted in 2011-2012 at research area of soil and environmental sciences, University of Agriculture, Faisalabad in randomized complete block design (RCBD) having three treatments of minimum tillage (MT), conventional tillage (CT) and deep tillage (DT) with three replicates to evaluate the performance of Maize *(Zea mays* L.) yield attributes and absorption of different nutrients under various tillage strategies. Maximum effect of tillage practices was observed in the CT and DT that gives the maximum number of leaves, plant height, plant biomass as well as straw yield. The effect of different tillage practices on the harvest index of maize crop was significant. The grain yield of maize was more in case of DT (7.24 ton ha^{-1}) as compared to CT (7.22 ton ha^{-1}) and MT (6.44 ton ha^{-1}). Deep tillage showed better results with reference to performance of maize crop as compared to conventional and minimum tillage.

Key words: Maize yield, biomass, tillage, nutrient uptake,

Introduction

Maize is the 3rd most important cereal crop after wheat and rice. Maize plays an important role in agriculture economy of the country. Nutritional value of maize is very important. Its seeds contain 72% starch, 10% protein, 4.8% oil, 8.5% fiber, and many other by-products like glucose, fatty acid, amino acid etc. (Ministry of Food and Agriculture (M.F.A), 2009-10).

Tillage is one of the most important practices in agriculture which is done mainly to mix the soil with organic residues and fertilizer, to control weeds, loosen the upper layer of soil, and to create a suitable seedbed for germination and plant growth (Rasmussen, 1999). Tillage practices have influences on soil physical and biological characteristics, which in turn leads to alter plant growth and yield (Wasaya *et al*., 2011. Rashidi and Keshavarzpour, 2007).

Aikins and Afuakwa (2010) find that the factors which affect nutrient movement in soil profile include soil physical properties (especially soil texture and structure), irrigation water, soil type, method and time of fertilizer application and the management practices and they reported after the experiment that the favorable soil conditions and the higher amount of nutrients availability to the plant can occur due to conventionally tilled soil may cause vigorous crop growth which is due to the rapid decomposition of organic source of N in soil deep layer.

Mehdi *et al*. (1999) and Sainju and Singh (2001) concluded that the application of tillage practices in crop production system is important for the plant growth and affect soil environmental components. It can also have its influence on the N availability and N pool status for maintaining proper nutrient levels in the soil environment system. For the crop production effect of tillage practices particularly on N, is therefore critical for the production of sustainable crops.

Soil tillage can also have adverse effects that can leads to the undesirable processes like enhanced erosion and deterioration soil properties (structure, pore spaces etc.) and also cause depletion of organic matter and fertility. The use of unnecessary and excessive tillage practices in soil often prove harmful to soil properties. People are now giving more emphasis to adopt no tillage and conservation tillage practices (Khattak *et al*., 2004).

Soil tillage is among the important factors affecting soil physical properties. Tillage method affects the sustainable use of soil resources through its influence on soil properties. The proper use of tillage can improve soil properties and its related constrains, while improper tillage may leads to a range of undesirable processes, e.g. accelerated erosion and destruction of soil properties (structure, pore spaces etc.), and also cause depletion of organic matter and fertility. Use of unnecessary and excessive tillage operations in soil often harmful to soil properties. Therefore, currently, different tillage techniques are being used without evaluating their effects on physical, chemical and mechanical properties of soil. So there is a significance interest and emphasis on the shift to the conservation and no-tillage methods. There is a need to adopt a suitable tillage practices like minimum tillage, conventional tillage and deep tillage to enhance the crop productivity as well as to minimize the nutrients leaching losses. Tillage practices present a significant challenge for sustainable crop production. Debatable opinions about the tillage strategies and availability of nutrients for crop productivity force to find the combination of suitable tillage practices and a variety for enhancing productivity. The present study was, therefore, commenced to estimate the response of maize (*Zea mays* L.) under minimum tillage, conventional tillage and deep tillage practices with reference to availability of nutrients in soil at different depths.

Materials and Methods

A field study was conducted at research farm of Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad (31.25°N, 73.09°E), Pakistan during the year 2011-12 to evaluate the effect of different tillage strategies (minimum, conventional and deep tillage) on nutrient availability in the soil profile, soil properties and crop growth with treatment plan (Table 1). The climate of Faisalabad is subtropical. The average precipitation was about 200 mm. The experiment was laid out in randomized complete block design (RCBD) having three replications with net plot size of 7.38 m × 8.53 m.

Table 1: Treatment Plan

Treatment	**Description**
Minimum Tillage (MT)	(2 ploughing + 2 planking)
Conventional Tillage (CT)	(1 disc + 2 planking + 2 ploughing)
Deep Tillage (DT)	(1 MBP + 2 planking + 2 ploughing)

The maize variety Pioneer 30Y87 was sown as a test crop with hand drill by keeping row to row (R×R) and plant to plant (P×P) distance of 30" and 9" respectively. The seed rate 25 kg ha^{-1} was used. Recommended doses of N, P and K (195, 140 and 105 kg ha^{-1}) were applied. Doses of nitrogen, phosphorous and potassium was applied through urea, di-ammonium phosphate and sulphate of potash (SOP) respectively. All the doses of phosphorous and potassium were applied at the time of sowing while nitrogen was applied in three splits. Six (6) irrigations of 4″ were applied to the maize crop. To avoid the competition by weeds and keep the crop free of insects, pests and diseases, plant protection measures were carried out uniformly.

Prior to experimentation soil samples were collected and analyzed using standard methods for soil properties (EC, pH, N, P and K contents) (Table 2). Data collected on all parameters was analyzed statistically by using fisher′s analysis of variance technique and least significant (LSD) test at 5% probability level was applied to compare the treatments' means (Steel *et al*., 1997).

Table 2: Physicochemical Properties of Experimental Site

Soil Physiochemical Analysis	
pH	7.83
EC (dSm^{-1})	1.73
Total Nitrogen (mg kg^{-1})	0.52
Available Phosphorus (mg kg^{-1})	9.46

Available Potassium	(mg kg^{-1})	114.08
Sand	(%)	46
Silt	(%)	30
Clay	(%)	25
Textural Class		Sandy clay loam

Agronomic Parameters: Plant height (cm), number of leaves per plant, cob's yield (ton ha^{-1}), total plant biomass (ton ha^{-1}), straw yield (ton ha^{-1}), total grain yield (ton ha^{-1}) and harvest index (HI) were measured at maturity. Plant samples were also collected from each plot according to standard procedure.

Harvest index (HI) is defined as ratio of grain weight to the total plant weight at harvest and was calculated (Sinclair, 1998) as:

$$HI = (GW / TPW) \times 100$$

Where;

GW = grain weight (kg)

TPW = total plant weight (kg).

Plant analysis

Digestion: Grain and straw/shoot samples were ground using a grinding mill after drying at 65^0C for 48 hours in an air circulating oven. The plant samples were digested by following method of Moore and Chapman (1986). For this purpose digestion mixture was prepared. Added 0.42 g Se and 14 g of $Li_2SO_4.H_2O$ to 350 mL of 100 % pure H2O2. Mixed well and added 420 mL of conc. H_2SO_4 with care. Cooled the mixture during addition of the acid. Weighed 0.4 g of dry ground sample into a suitable flask. Added 4.4 mL of digestion mixture. Digested at low heat until the initial reaction subsides avoiding loss of H_2SO_4 fumes. Continued the digestion until a clear and almost colorless solution was obtained. Then diluted sample five folds.

Nitrogen determination: After digestion, nitrogen was determined by Kjeldhal method. 5 mL of aliquot was taken in Kjeldhal distillation flask, added 10 mL of 40 % sodium hydroxide and the flask was immediately connected to the distillation apparatus. In 100 mL conical flask 5 mL of 2 % boric acid solution and few drops of mixed indicator (Bromocresol green + methyl red) were taken. When the distillate was approximately 40-50 mL, the conical flask was removed and distillation apparatus was turned off. The distillate was cooled for few minutes and titrated with 0.01 N standard sulphuric acid up to pink end point. Nitrogen was calculated by the following formula:

$$\% N = \frac{(V-B) \times N \times R \times 14.01 \times 100}{Wt \times 1000}$$

Where,

V = Volume of 0.01 N H_2SO_4 used for titration for the sample (mL)

B = Digested blank titration volume (mL), i.e. without soil

N = Normality of H_2SO_4 solution

14.01 = Atomic weight of nitrogen

R = Ratio between total volume of the digested and sample volume used for distillation.

Wt = Weight of air-dry soil (g)

Phosphorus determination: The extracted material (5 mL) was dissolved in 10 mL Barton reagent and volume was made up to 50 mL. The samples were kept for half an hour and phosphorus contents were determined with spectrophotometer at 880 nm wavelength after calibrating with P standards (Method 61, p.134).

Barton reagent

Solution A: 25 g ammonium heptamolybdate $(NH_4)_6MO_7O_{24}.4H_2O$ was dissolved in 400 mL of distilled water.

Solution B: Ammonium metavenadate (1.25 g) was dissolved in 300 mL of boiling water, cooled and 250 mL of conc. HNO_3 was added and again cooled at room temperature. Solution A and B were mixed and volume was made up to 1 L.

Standard curve: 4.3937 g potassium dihydrogen phosphate (KH_2PO_4) was dissolved in 1000 mL distilled water to have 1000-ppm phosphorus solution. A series of standards containing 0.5, 1.0, 1.5, 2.0 and 2.5 ppm phosphorus were prepared and calibration curve was prepared. Plant P was determined from this standard curve.

Potassium determination: Potassium was determined with Flame Photometer. A graded series of standards (ranging from 2 to 20 ppm) of K using KCl was prepared and standard curve was drawn. The values of soil K were determined from standard curve.

Statistical Analysis: The collected data were statistically analyzed by using ANOVA (analysis of variance) techniques according to RCBD. The means were compared by LSD (least significant difference) test at $p \leq 0.05$ (Steel *et al*., 1997). The software packages STATISTIX 8.1 (Stat Soft, Inc., 2001) and STATISTICA (version 8.1, www.statsoft.com, OK 74104, US) were used for statistical analysis.

Results and Discussion

Plant height (cm): Plant height (cm) in maize (*Zea mays* L.) was recorded at maturity, the highest plant height (232.67 cm) was measured from those plots where the conventional tillage was done followed by deep tillage and lowest plant height (227.41 cm) was recorded from minimum tillage practice. As regards conventional tillage, there is increase of 2.25% in plant height as compared to minimum tillage (Fig. No. 1).

Aikins *et al*. (2012) also studied the same results that there is no significant effect of tillage on the plant height. Basamba *et al*. (2007) studied that the tillage practices affected the soil properties those in turn can alter the soil environment ultimately they can affects the growth and the yield of the crop.

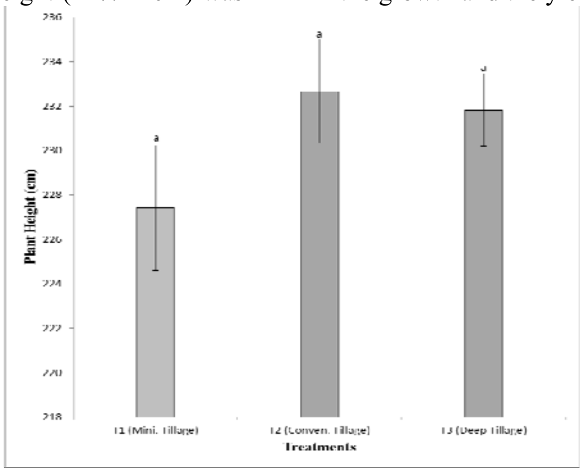

Fig. No. 1: Effect of different tillage strategies on plant height (cm) of maize (LSD value = 10.018)

Number of leaves per plant: At maturity stage of maize the number of leaves per plant was counted and highest number of leaves (14.40) was found from those plots where the conventional tillage was practiced followed by deep tillage (Fig. No. 2).

Gul *et al*. (2009) conducted a study and found similar results they studied that significantly highest biological yield was obtained by practicing of conventional tillage as compared to no tillage or reduced tillage.

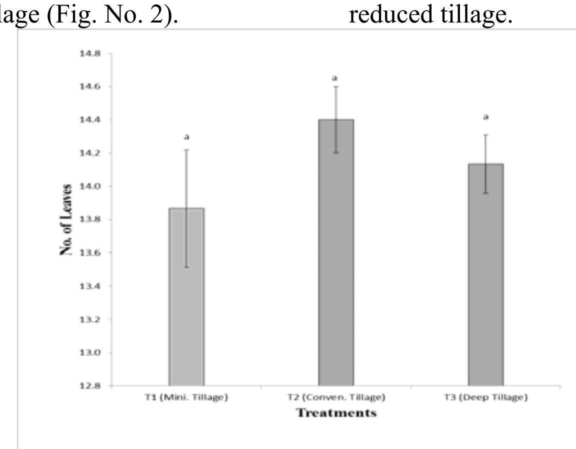

Fig. No. 2: Effect of different tillage strategies on no. of leaves of maize (LSD value = 0.6674)

Cob's yield (ton ha^{-1}): After the harvesting of maize crop cob's yield was recorded and maximum value for cob's yield (10.81 ton ha^{-1}) was obtained from those plots where the deep tillage was practiced followed by conventional tillage and minimum straw yield (9.60 ton ha^{-1}) was recorded from minimum tillage practiced plots. As regards deep tillage which shows 11.25% more value for the cob's yield than a minimum tillage practice (Fig. No. 3).

The results are in line with the results found by Habtegebrial *et al*. (2007) they also reported that the various tillage practices have significant influence on grain yield of maize. Higher yields can be achieved by conventional and deep tillage as compared to reduced tillage.

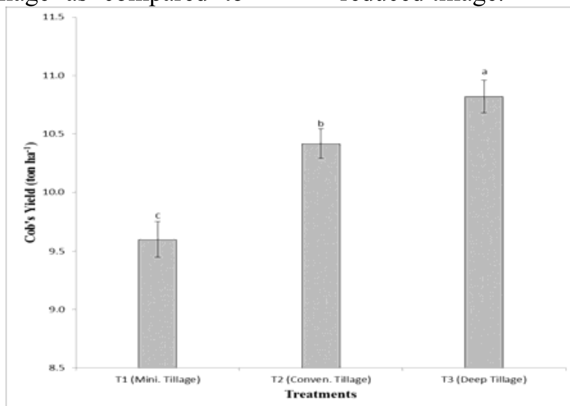

Fig. No. 3: Effect of different tillage strategies on cob's yield (ton ha^{-1}) of maize (LSD value = 0.2589)

Total plant biomass (ton ha^{-1}): After the harvesting of maize crop total plant biomass was recorded and maximum total plant biomass (39.82 ton ha^{-1}) was produced from those plots where deep tillage was practiced followed by conventional tillage and minimum total plant biomass (35.30 ton ha^{-1}) was recorded from minimum tillage practiced plots. As regards deep tillage which shows 11.35% more value for the total plant biomass then the minimum tillage practice (Fig. No. 4).

The results are in line with the findings of Gul *et al.* (2009) they conducted an experiment and their results are similar with the present study that significantly highest biological yield was obtained by practicing of conventional tillage as compared to no tillage or reduced tillage.

Memon *et al.* (2007) conducted an experiment and observed results of agronomic observations revealed that plant height, number of leaves per plant, number of cobs per plant, dry cob weight, seed index, root length and total grain yield ha^{-1} were superior in ridge sowing and second best was seed drilling while seed broadcasting was found to be less effective. Maize sown on ridges resulted in greater seed emergence (89%), plant height 155.1 cm, weight of hulled dry cob 177.67 g and de-hulled dry cob 127.53 g, which in turn caused greater grain yield 6.35 t ha^{-1}.

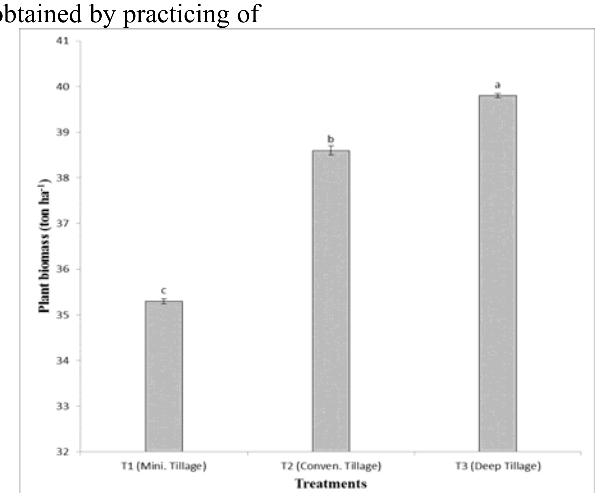

Fig. No. 4: Effect of different tillage strategies on plant biomass (ton ha^{-1}) of maize (LSD value = 0.1810)

Straw yield (ton ha^{-1}): After the harvest of maize crop straw yield was recorded and highest total straw yield (32.58 ton ha^{-1}) from those plots where deep tillage was done followed by conventional tillage and minimum straw yield (28.86 ton ha^{-1}) was recorded from minimum tillage practiced plots. As regards deep tillage, there is 11.43 % more value for the straw yield then minimum tillage practice (Fig. No. 5).

The results are similar to the findings of Gul *et al.* (2009) they conducted a study and resulted that significantly highest biological yield was obtained by practicing of conventional tillage as compared to no tillage or reduced tillage while these shows less biological and grain yield.

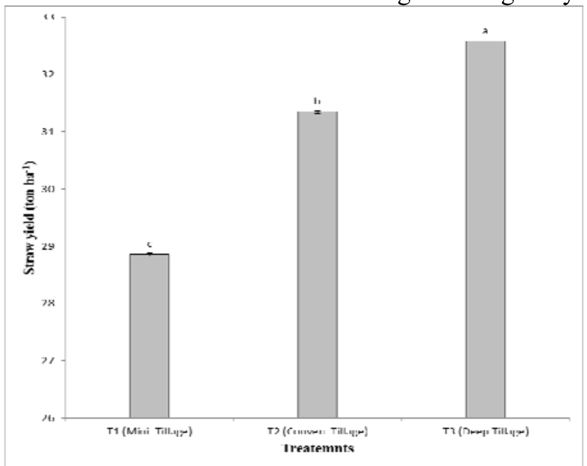

Fig. No. 5: Effect of different tillage strategies on straw yield (ton ha^{-1}) of maize (LSD value = 0.0997)

Total grain yield (ton ha^{-1}): After the harvest of maize crop total grain yield was recorded and highest total grain yield (7.25 ton ha^{-1}) was obtained from those plots where the deep tillage practiced followed by conventional tillage and lowest total grain yield (6.45 ton ha^{-1}) was obtained from minimum tillage practiced plots. However regards deep tillage which is 10.99% more value for the total grain yield then minimum tillage (Fig. No. 6).

Gomma *et al*. (2002) also found similar results they conducted a field experiments and study that the maize grain yield as influenced by different tillage systems and highest grain yield were obtain by the conventional tillage treatment.

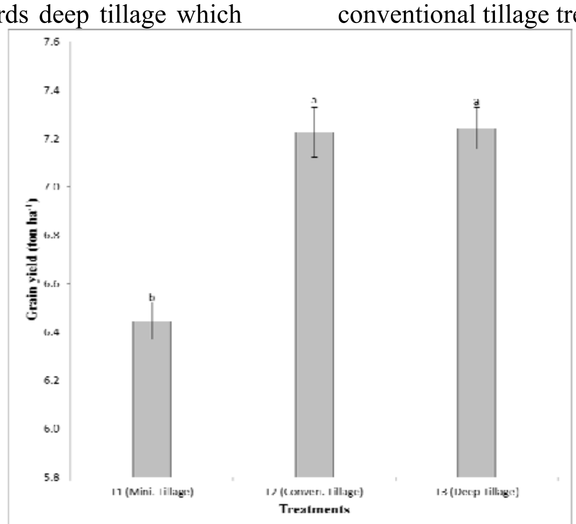

Fig. No. 6: Effect of different tillage strategies on grain yield (ton ha^{-1}) of maize (LSD value = 0.1647)

Harvest Index (%): In maize the highest harvest index (18.73) was recorded from those plots where the conventional tillage was practiced followed by minimum tillage and lowest harvest index (18.18) were recorded from deep tillage practiced plots. As regards conventional tillage which presented 2.93% more value for the harvest index than deep tillage (Fig. No. 7).

Habtegebrial *et al*. (2007) also found similar results they reported that the various tillage practices have significant influence on grain yield of maize. Higher yields can be achieved by conventional and deep tillage as compared to reduced tillage. Establishment of crop is better and conventional tillage might have contributed to higher grain yield and higher leaf area in these plots as compared to reduced tillage plots. It is also reported that tillage practices are also involving in retention of moisture in the soil and residues management on the soil surface which ultimately caused the increase in yield of maize.

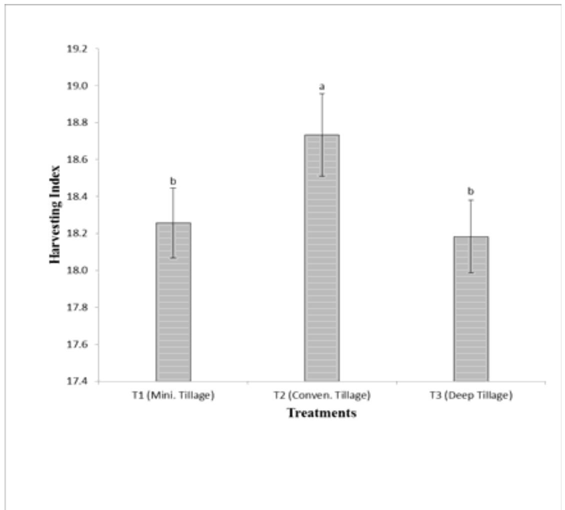

Fig. No. 7: Effect of different tillage strategies on harvesting index of maize (LSD value = 0.3497)

Total nitrogen accumulation by maize crop (kg ha^{-1}): In maize grain the maximum nitrogen accumulation (53.31 kg ha^{-1}) was recorded from those plots where conventional tillage was practices followed by deep tillage and lowest nitrogen (39.12 kg ha^{-1}) were recorded from minimum tillage practiced plots. As regards conventional which shows 26.63 % more value for the nitrogen accumulation than minimum tillage practice (Fig. No. 8).

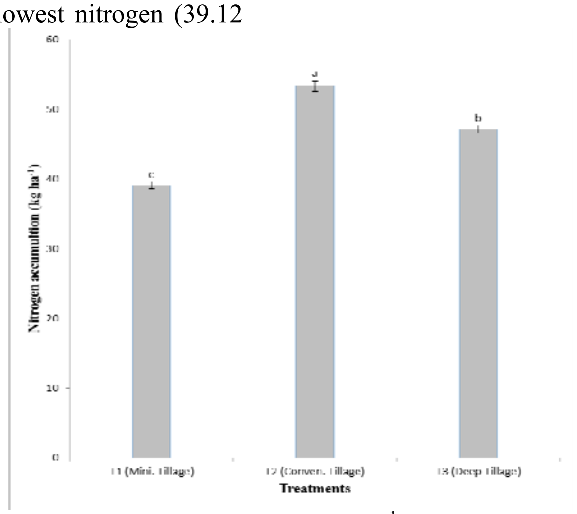

Fig. No. 8: Effect of different tillage strategies on nitrogen (kg ha^{-1}) accumulation in grain of maize (LSD value = 1.2028)

Total phosphorus accumulation by maize crop (kg ha^{-1}): In maize grain the highest phosphorous accumulation was (17.56 kg ha^{-1}) recorded from those plots where the conventional tillage was practiced followed by deep tillage and lowest phosphorous accumulation (12.50 kg ha^{-1}) was recorded from minimum tillage practiced plots. As regards conventional tillage which shows 28.80 % more value for the phosphorous accumulation then minimum tillage practice (Fig. No. 9).

Taki and Hemmat, (2001) also found similar results they studied that the practice of no-tillage strategies cause a negative impact on soil properties, root proliferation and ultimately on nutrient uptake from deeper depth.

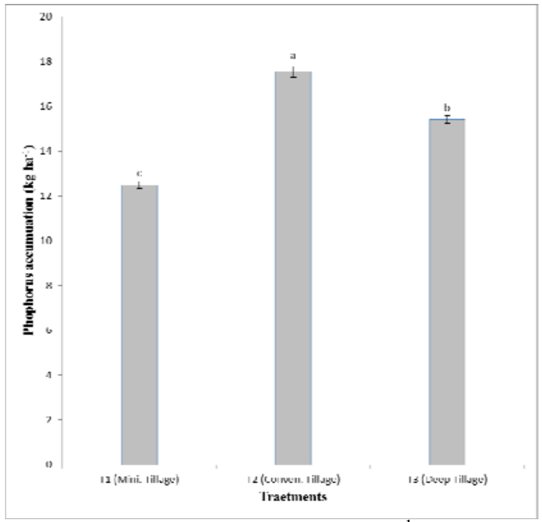

Fig. No. 9: Effect of different tillage strategies on phosphorous (kg ha^{-1}) accumulation in grain of maize (LSD value = 0.3961)

Total potassium accumulation by maize crop (kg ha^{-1}): In maize the highest potassium accumulation by grain (22.54 kg ha^{-1}) from those plots where conventional tillage was practiced followed by deep tillage and lowest potassium (17.21 kg ha^{-1}) were recorded from minimum tillage practiced plots. Therefore regards conventional tillage which had 23.66% more value for the potassium accumulation by the grain than minimum tillage practice (Fig. No. 10).

According to the Yuan *et al*. (2000) the method of irrigation application and the management practices also determine the movement of chemicals in the soil profile.

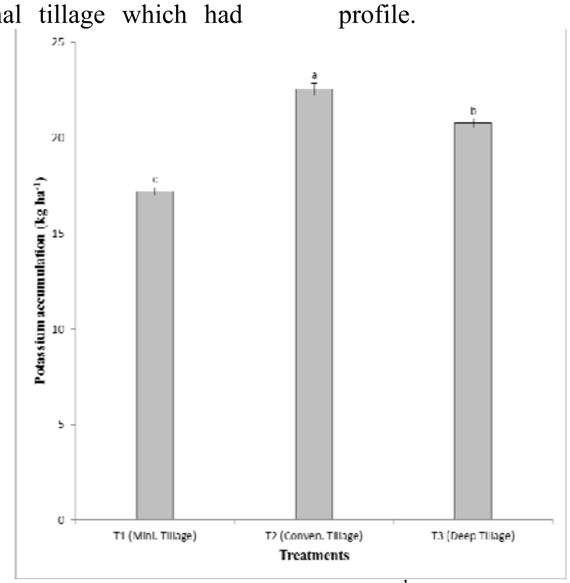

Fig. No.10: Effect of different tillage strategies on potassium (kg ha^{-1}) accumulation in grain of maize (LSD value = 0.5122)

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