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Effect of Mulch on Soil Physical Properties and N, P, K Concentration in Maize (*Zea mays*) Shoots under Two Tillage Systems

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ABSTRACT

Tillage is an ancient practice to alleviate soil related problems and mulch also have its definite role in conserving soil physical health. A field experiment was conducted on sandy clay loam soil to evaluate the effect of mulch on soil physical properties and N, P, K concentration in maize shoots under two tillage systems. Deep and conventional tillage were used along with three levels of wheat straw as mulch i.e., control (M_0), 7 (M_1) and 14 (M_2) Mg ha^{-1}. Recommended dose of N, P and K was applied. Mulch increased soil organic matter (1.32 g kg^{-1}) and soil moisture contents (17%), but decreased bulk density (1.35 Mg m^{-3}) and soil strength (464 kPa) compared to control. Greater plant height (2.59 m) and grain yield (10.6 Mg ha^{-1}) were obtained from M_2 and biological yield (20.7 Mg ha^{-1}) from M_1 in combination with deep tillage. Tillage and mulch significantly affected the N and P concentration in maize shoots, while its effect on K concentration was appreciable. Interactive effect of mulch and tillage was statistically significant in case of N (1.423 g kg $^{-1}$) and P (0.156 g kg^{-1}) concentration but non significant in case of K (1.767 g kg^{-1}) concentration. It is concluded that wheat straw as mulch in conjunction with deep tillage improves soil physical health and crop quality.

Key Words: Deep tillage; Wheat straw mulch; Soil physical properties; N, P, K concentration in maize

INTRODUCTION

World population is increasing day by day, which is likely serious thread to food security. This can be overcome by enhancing production of major crops. Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice with respect to area and productivity. In Pakistan, it was grown on area of 1017 thousand hectares with annual production of 3088 thousand tones (GOP, 2007-08). Developing countries like Pakistan, India, Iran are facing great challenges to meet input resources i.e., fertilizer, irrigation, good quality seed and energy crisis in order to sustain their production. There is need to adopt such practices and combination of organic and inorganic sources to decrease the cost of production.

The practice of spreading plant residue or any other material like straw on the soil surface to reduce water evaporation losses is called mulching. Appropriate tillage and mulch practices are used to conserve soil moisture and increase the yield of crops. Crop residues at the soil surface act as shade; serve as a vapor barrier against moisture losses from the soil, causing slow surface runoff. Rathore *et al.* (1998) reported that more water conserves in the soil profile during the early growth period with straw mulch than without it. Subsequent uptake of conserved soil moisture moderated plant water status, soil temperature and soil mechanical resistance, leading to better root growth and higher grain yields. Applications of crop residue mulches increase soil organic carbon contents (Havlin *et al.,* 1990; Paustin *et al.,* 1997; Duiker & Lal, 1999; Saroa & Lal, 2003).

Tillage systems are site-specific and depend on crop, soil type and the climate (Rasmussen, 1999). Tillage also affect nitrate-N concentration, water contents, aeration and available C (Rice & Smith, 1982; McKenny *et al*., 1993; Khurshid *et al*., 2006), which in turn, can impact N loss through denitrification and N_2O emissions (Rice & Smith, 1982; Fan *et al*., 1997). Conservation tillage methods are considered most effective under low rainfall conditions, typically 200-400 mm of annual rainfall (Unger *et al.,* 1991). No-tillage with standing stubble conserves soil organic matter and water, generally increases crop production (Zentner & Lindwall, 1978; Phillips *et al*., 1980). Tillage practices that maintain crop residue on the soil surface have shown higher maize yield in numerous studies (e.g., Lal, 1974, 1978 & 1995; Unger, 1986; Wicks *et al.,* 1994).

Keeping this in view, the present investigation was planned to determine the effect of different tillage systems in combination with mulch application on soil physical properties and N, P, K concentration in maize shoots.

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MATERIALS AND METHODS

An experiment was conducted on sandy clay loam soil from 15 July, 2005 to 15 October, 2005 at Research Area of Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan. Physical and chemical characteristics of original soil were determined (Table I). Maize was sown with dibbler, maintaining 30 cm plant-to-plant and 70 cm row-to-row distance. Deep tillage consisted of two ploughing with sub-soiler 0.45 m deep and two with narrow-tine cultivator followed by planking with wooden planker. Conventional tillage consists of three ploughs with narrow-tine cultivator followed by planking with wooden planker. Rigger was used to make ridges. Three mulch levels of wheat straw were applied at the rate of 0 (M_0), 7 (M_1) and 14 (M_2) Mg ha^{-1}.

Recommended levels of N (0.15 Mg ha^{-1}), P (0.15 Mg ha^{-1}) and K (0.05 Mg ha^{-1}) were applied by Urea, DAP and SOP respectively. Full dozes of P and K were applied at the time of sowing, while N was applied in splits. One third of recommended nitrogen was applied at seedbed preparation, after one month of germination and at tassling stage in three splits. Weedicides were used to control weeds.

A composite soil sample was taken (0-0.15 m depth) before sowing. Soil sample was air-dried, grounded, passed through 2 mm sieve and preserved in plastic bottles for analysis. Samples were analyzed for pH by pH meter (McLean, 1982), electrical conductivity of soil extract by Rhoades (1982) method, soil texture by Bouyoucos hydrometer method (Moodie *et al*., 2001), soil moisture by gravimetric method (Jalota *et al*., 1998), soil bulk density measured by core method (Blake & Hartge, 1986), soil strength by cone penetrometer, soil organic carbon by Walkley and Black (1934) method, Total N by Bremner and Mulvancy (1982) and Buresh *et al*. (1982), Available P by spectrophotometer (Olsen & Sommers, 1982), Available K by flame photometer (Richards, 1954).

Plant height was recorded at 45 and 70 days after sowing and at crop harvest. Biological yield (oven dried) and grain yield (at 15% moisture) were taken at harvesting manually. Total N was determined by Sulfuric-salicylic acid digestion method (Buresh *et al*., 1982), Total P by spectrophotomer (Chapman & Pratt, 1961) and Total K by flame photometer (Chapman & Pratt, 1961).

The data was analyzed by randomized complete block design with split plot arrangement and means were compared by least significant difference test (Steel & Torrie, 1980).

RESULTS AND DISCUSSION

Soil moisture contents. Soil mulching significantly affected soil moisture contents at harvest, while tillage affected non-significantly (Table II). Higher soil moisture contents were observed in case of deep tillage (16.1%) and minimum in conventional tillage (15.2%). These results are similar to Bonari *et al.* (1994) and Bhatt *et al*. (2004) that soil moisture contents are substantially higher with cheisel plowing than shallow, disk or deep plowing of maize field. Mulch levels also significantly affected the soil moisture contents, the maximum soil moisture contents were observed in M_2 (17.0%), followed by M_1 (15.8%) and minimum in M_o (14.0%) (Table II). The interactive effect of tillage and mulch was significant (Table III), the higher moisture contents were observed in conventional tillage with M_0 (17.8%) and minimum in deep tillage with M_2 (13.4%). Liu *et al*. (2002) and Khurshid *et al.* (2006) stated the same results that mulching improves the ecological environment of the soil and increases soil water contents.

Table I. Physical and Chemical Properties of Original Soil

Characteristics	Values
Sand (%)	58.6
Silt (%)	17
Clay (%)	24.4
Textural Class	Sandy Clay Loam
pH	8.0
Electrical Conductivity (dS m^{-1})	1.36
Bulk Density (Mg m^{-3})	1.45
Organic carbon contents (%)	0.117
Total N (%)	0.023
Available P (ppm)	6.029
Available K (ppm)	108

Soil bulk density. Tillage had significant effect on bulk density (BD) of soil (Table II). Higher BD was observed in case of conventional tillage (1.40 Mg m^{-3}) and minimum in deep tillage (1.37 Mg m^{-3}). Diaz-Zorita (2000) and Khurshid *et al.* (2006) reported that bulk density significantly decreased by enhancing tillage practices. Mulching also reduced soil BD (Table II). Higher BD was observed in M_0 (1.41 Mg m^{-3}), followed by M_1 (1.39 Mg m^{-3}) and minimum in M_2 (1.35 Mg m^{-3}). However, the interactive effect of mulch and tillage was non significant (Table III). Mulching increased soil moisture, organic matter contents leading to suitable environment for root penetration. Ghuman *et al*. (2001) and concluded that mulching decreases bulk density of the surface soil.

Soil strength. Tillage and mulch had significant effect on soil strength (Table II). Maximum soil strength was observed in conventional tillage (633 kPa) and minimum in deep tillage (539 kPa). Tillage caused manipulation of surface soil and increased soil pore-spaces leading to minimum soil strength. Lampurlanés *et al.* (2003) found larger soil strength in no-tillage than in sub-soiling and minimum-tillage. Akinci *et al*. (2004) described the same results that Sub-soiling has significant effect on the soil strength. Mulching significantly affected soil strength, the maximum soil strength was observed in M_0 (715 kPa), followed by M_1 (579 kPa) and minimum in M_2 (464 kPa). The interactive effect of tillage and mulch levels was significant (Table II), maximum soil strength was observed in conventional tillage with M_0 (831 kPa) and minimum in deep tillage with M_2 (450 kPa). Gajri *et al*. (1994) reported that both soil strength and bulk density decreased by increasing mulch levels.

Table II. Effect of Tillage and Mulch on Soil Physical Properties at Maize Harvest

	Treatments	Soil Moisture contents (%)	Soil bulk density (Mg m^{-3})	Soil Strength (kPa)	Soil Organic Matter Contents (g kg^{-1})	
					0-15 cm depth	15-30 cm depth
Tillage	Deep tillage	16.1NS	1. 37NS	539B	1.065A	0.626A
	Conventional tillage	15.2NS	1.40NS	633A	0.903B	0.545B
Mulch	Mulch @ 0 Mg ha^{-1} (M_o)	14.0C	1.41A	715A	0.650C	0.403C
	Mulch @ 7 Mg ha^{-1} (M_1)	15.8B	1.39AB	579B	0.980B	0.528B
	Mulch @ 14 Mg ha^{-1} (M_2)	17.0A	1.35B	464C	1.323A	0.825A

Means followed by different letters are significantly different at 1% and 5% level of probability

Table III. Effect of interaction of Tillage and Mulch on Soil Physical Properties at Maize Harvest

	Treatments	Soil Moisture contents (%)	Soil bulk density (Mg m^{-3})	Soil Strength (kPa)	Soil Organic Matter Contents (g kg^{-1})	
					0-15 cm depth	15-30 cm depth
Deep tillage	Mulch @ 0 Mg ha^{-1} (M_o)	14.7c	1.39NS	598b	0.7733e	0.408f
	Mulch @ 7 Mg ha^{-1} (M_1)	15.7b	1.37NS	569d	1.133c	0.542c
	Mulch @ 14 Mg ha^{-1} (M_2)	17.8a	1.35NS	450f	1.289b	0.929a
Conventional tillage	Mulch @ 0 Mg ha^{-1} (M_o)	13.4d	1.43NS	831a	0.526f	0.398e
	Mulch @ 7 Mg ha^{-1} (M_1)	15.9b	1.41NS	590c	0.826d	0.515d
	Mulch @ 14 Mg ha^{-1} (M_2)	16.3b	1.36NS	477e	1.356a	0.721b

Means followed by different letters are significantly different at 5% level of probability

Table IV. Effect of Tillage and Mulch at Growth Parameters of Maize

	Treatments	Plant Height (m)			Biological Yield (Mg ha^{-1})	Grain Yield (Mg ha^{-1})
		After 45 Days	After 70 Days	At Harvest		
Tillage	Deep tillage	1.846A	2.474A	2.494A	20.4A	9.9NS
	Conventional tillage	1.696B	2.444B	2.464B	17.5B	9.1NS
Mulch	Mulch @ 0 Mg ha^{-1} (M_o)	1.723NS	2.398B	2.418B	18.2B	8.6C
	Mulch @ 7 Mg ha^{-1} (M_1)	0.803NS	2.452B	2.472B	18.7AB	9.4B
	Mulch @ 14Mg ha^{-1} (M_2)	0.785NS	2.528A	2.548A	19.8A	10.5A

Means followed by different letters are significantly different at 1% and 5% level of probability

Table V. Effect of Interaction of Tillage and Mulch at Growth Parameters of Maize

	Treatments	Plant Height (m)			Biological Yield (Mg ha^{-1})	Grain Yield (Mg ha^{-1})
		After 45 Days	After 70 Days	At Harvest		
Deep tillage	Mulch @ 0 Mg ha^{-1} (M_o)	1.793NS	2.410NS	2.430NS	20.7a	9.7bc
	Mulch @ 7 Mg ha^{-1} (M_1)	0.903NS	2.440NS	2.460NS	20.7a	9.3c
	Mulch @ 14 Mg ha^{-1} (M_2)	0.840NS	2.573NS	2.593NS	19.6a	10.6a
Conventional tillage	Mulch @ 0 Mg ha^{-1} (M_o)	1.653NS	2.387NS	2.407NS	15.8b	7.5d
	Mulch @ 7 Mg ha^{-1} (M_1)	0.703NS	2.463NS	2.483NS	16.7b	9.6bc
	Mulch @ 14 Mg ha^{-1} (M_2)	0.730NS	2.483NS	2.503NS	20.1a	10.3ab

Means followed by different letters are significantly different at 1% and 5% level of probability

Soil organic matter contents. Tillage systems affected significantly at 0-15 cm and 15-30 cm depth. The mean maximum soil organic matter contents were observed in deep tillage (1.06 g kg^{-1}) and minimum in conventional tillage (0.9 g kg^{-1}) at 0-15 cm depth. Similarly, mean maximum soil organic matter contents were observed in deep tillage (0.63 g kg^{-1}) and minimum in conventional tillage (0.54 g kg^{-1}) at 15-30 cm depth. The deep tillage had 15.21 and 12.94% more SOM contents as compared to conventional tillage at 0-15 and 15-30 cm depths. Khurshid *et al.* (2006) found maximum organic matter contents in minimum tillage as compared to conventional tillage. The effects of mulch levels were also significant at both soil depths (Table II). Mean maximum value was observed in M_2 (1.32 g kg^{-1}), followed by M_1 (0.98 g kg^{-1}) and minimum in M_0 (0.65 g kg^{-1}) at 0-15 cm depth. Similarly, mean maximum value was observed in M_2 (0.82 g kg^{-1}), followed by M_1 (0.53 g kg^{-1}) and minimum in M_0 (0.40 g kg^{-1}) at 15-30 cm depth. The SOM increased due decomposition of applied mulch. Lal *et al.* (1980) and Khurshid *et al.* (2006) concluded that organic matter was significantly higher when more mulch was applied. The interactive effect of tillage and mulch was also significant (Table III), the mean maximum value of organic matter contents was observed in M_2 (1.36 g kg^{-1}) and minimum in M_0 (0.53 g kg^{-1}) in combination with conventional tillage at 0-15 cm depth. Similarly, maximum value of organic matter contents was observed in deep tillage with M_2 (0.93 g kg^{-1}) and minimum in conventional tillage with M_0 (0.40 g kg^{-1}) at 15-30 cm depth.

Plant height. Tillage system had significantly affected plant height (Table IV). Maximum plant height was observed in deep tillage (1.846 m) followed by conventional tillage (1.696 m) at 45 days after sowing. Similar trend regarding the plant height was found after 70 days and at harvest. Bonari *et al.* (1994), Albuquerque *et al.* (2001) and

Table VI. Effect of Tillage and Mulch on N, P, K Concentration at Maize Shoots

	Treatments	N (g kg^{-1})			P (g kg^{-1})			K (g kg^{-1})		
		After 45 Days	After 70 Days	At Harvest	After 45 Days	After 70 Days	At Harvest	After 45 Days	After 70 Days	At Harvest
Tillage	Deep tillage	1.124B	1.357B	1.149	0.197A	0.169A	0.117B	1.844B	1.789B	1.678A
	Conventional tillage	1.267A	1.440A	1.239	0.178B	0.159B	0.128A	1.978A	1.872A	1.603B
Mulch	Mulch @ 0 Mg ha^{-1} (M_o)	0.939B	1.185B	1.007B	0.1738B	0.1548A	0.0993C	1.842C	1.742C	1.530C
	Mulch @ 7 Mg ha^{-1} (M_1)	1.311A	1.507A	1.285A	0.2045A	0.1510B	0.1475A	2.008A	1.858B	1.717A
	Mulch @ 14 Mg ha^{-1} (M_2)	1.337A	1.503A	1.290A	0.1848B	0.1865B	0.1215B	1.883B	1.892A	1.675B

Means followed by different letters are significantly different at 5% level of probability

Table VII. Effect of interaction of Tillage and Mulch on N, P, K Concentration at Maize Shoots

	Treatments	N (g kg^{-1})			P (g kg^{-1})			K (g kg^{-1})		
		After 45 Days	After 70 Days	At Harvest	After 45 Days	After 70 Days	At Harvest	After 45 Days	After 70 Days	At Harvest
Deep tillage	Mulch @ 0 Mg ha^{-1} (M_o)	0.8633e	1.080d	0.970f	0.182bc	0.157b	0.086d	1.833NS	1.667NS	1.600NS
	Mulch @ 7 Mg ha^{-1} (M_1)	1.145c	1.403b	1.147d	0.226a	0.154b	0.139ab	1.867NS	1.883NS	1.667NS
	Mulch @ 14 Mg ha^{-1} (M_2)	1.363ab	1.587a	1.330b	0.184bc	0.196a	0.126bc	1.833NS	1.817NS	1.767NS
Conventional tillage	Mulch @ 0 Mg ha^{-1} (M_o)	1.014d	1.290c	1.043e	0.165c	0.152b	0.113 c	1.850NS	1.817NS	1.460NS
	Mulch @ 7 Mg ha^{-1} (M_1)	1.477a	1.610a	1.423a	0.183bc	0.148b	0.156 a	2.150NS	1.833NS	1.767NS
	Mulch @ 14 Mg ha^{-1} (M_2)	1.310b	1.420b	1.250c	0.186b	o.177a	0.1167c	1.933NS	1.967NS	1.583NS

Means followed by different letters are significantly different at 5% level of probability

Khurshid *et al.* (2006) observed the same results that plant height increases by increasing tillage intensity. This is due to deep tillage that develops suitable environment for root penetration. Mulch affected non-significantly plant height at 45 days, while significantly at 70 days after sowing, where as maximum plant height was obtained in M_2 (2.53 m), followed by M_1 (2.45 m) and minimum in M_0 (2.40 m), as shown in Table IV. Interactive effect of mulch and tillage was non significant (Table V). Similar trend in plant height was observed at harvest. Wicks *et al.* (1994) and Khurshid *et al.* (2006) pointed out that maize grew taller under greater mulch levels, because of availability of more soil moisture contents for plant growth.

Biological yield. Tillage increased biological yield significantly and maximum biological yield was observed in deep tillage (20.4 Mg ha^{-1}) and minimum in conventional tillage (17.5 Mg ha^{-1}) (Table IV). These results were similar to Diaz-Zorita (2000) that maize production increases with increasing tillage intensity. The biological yield was increased significantly by increasing mulch levels (Table IV), maximum biological yield was observed in M_2 (19.8 Mg ha^{-1}), followed by M_1 (18.7 Mg ha^{-1}) and minimum in M_0 (18.2 Mg ha^{-1}). The interactive effect of tillage and mulch on biological yield was significant (Table V). The maximum biological yield was observed in deep-tillage with M_1 (20.7 Mg ha^{-1}) and minimum in conventional tillage with M_0 (15.8 Mg ha^{-1}).

Grain yield. Tillage systems affected grain yield non-significantly while mulch effected significantly (Table IV). Although tillage effect was non-significant, higher grain production was observed in deep tillage (9.9 Mg ha^{-1}) and minimum in conventional tillage (9.1 Mg ha^{-1}). Bhatt *et al.* (2004) observed higher grain yield in minimum tilled plots as compared to conventionally tilled plots. Bonari *et al.* (1994) stated that grain yield is significantly higher with chisel plowing than shallow, disk or deep plowing.

Mulch significantly increased grain yield. Maximum grain yield was observed in M_2 (10.5 Mg ha^{-1}), followed by M_1 (9.4 Mg ha^{-1}) and minimum in M_0 (8.6 Mg ha^{-1}) (Table IV). The interactive effect of tillage and mulch was differed significantly (Table V). Maximum grain yield was observed in deep tillage with M_2 (10.65 Mg ha^{-1}). Tolk *et al.* (1999) and Liu *et al.* (2002) concluded that mulch increases soil moisture and nutrients availability to plant roots, in turn, leading to higher grain yield.

Nitrogen concentration in maize shoots. The data regarding the effect of tillage and mulch on nitrogen concentration (g kg^{-1}) in shoots at 45 and 70 days after sowing and at maturity indicated that tillage systems affected N significantly at 45 days and at 70 days after sowing. The mean maximum N conc. was observed in conventional tillage (1.26 g kg^{-1}) and minimum in deep tillage (1.124 g kg^{-1}) at 45 days. Similar trend in case of N concentration was observed at 70 days after sowing (Table VI). Mean maximum N concentration in maize shoots was observed in M_2 (1.337 g kg^{-1}), followed by M_1 (1.311 g kg^{-1}) and minimum in M_0 (0.911 g kg^{-1}) at 45 days after sowing. Similar trend was observed at harvest. But at 70 days after sowing, mean maximum N conc. in maize shoots was observed in M_1 (1.507 g kg^{-1}), followed by M_2 (1.503 g kg^{-1}) and minimum in M_0 (1.185 g kg^{-1}). Khera *et al.* (1976) observed green and dry forage yields. Similar to Acharya and Sharma (1994), these results showed that uptake of N and P significantly increased by mulching and each successive increment of nitrogen. The interactive effect of tillage and mulch was significant at all three stages of observation (Table VII). Maximum N concentration was observed after 45 days in conventional tillage (1.477 g kg^{-1}), after 70 days in conventional tillage (1.610 g kg^{-1}) and at harvesting in conventional tillage (1.432 g kg^{-1}). Similarly, minimum N concentration was observed in deep tillage with M_0 (0.863 g kg^{-1}) at 45 days, deep tillage with M_0 (1.08 g

kg^{-1}) at 70 days and deep tillage with M_0 (0.970 g kg^{-1}) at harvesting.

Phosphorous concentration in maize shoots. The data regarding the effect of tillage and mulch on phosphorous concentration (g kg^{-1}) in shoots revealed that tillage and mulch had statistically significant effect on phosphorous concentration in maize shoots (Table VI). Tillage systems affected non-significantly at 45 days and significantly at 70 days and at harvest. The maximum phosphorous concentration in shoots of maize was observed in deep tillage (0.169 g kg^{-1}) and minimum in conventional tillage (0.159 g kg^{-1}) at 70 days and at harvest. Maximum phosphorous concentration was observed in conventional tillage (0.128 g kg^{-1}) and minimum in deep tillage (0.117 g kg^{-1}). Mulch levels affected significantly at all three levels of observation. Maximum P concentration in shoot of maize was observed in M_1 (0.204 g kg^{-1}), followed by M_2 (0.185 g kg^{-1}) and minimum in M_0 (0.174 g kg^{-1}) at 45 days. The similar results were found at harvest. But at 70 days, mean maximum P concentration in shoot was observed in M_0 (0.155g kg^{-1}), followed by M_2 (0.187 g kg^{-1}) and minimum in M_1 (0.151 g kg^{-1}). These findings are in agreement with Acharya and Sharma (1994) that mulched treatments show significantly greater total uptake of nitrogen, phosphorus and potassium than corresponding unmulched ones. The interactive effect of tillage and mulch affected significantly at 45 days and at harvest (Table VII). Maximum P concentration was observed in deep tillage with M_1 (0.226 g Kg^{-1}) at 45 days, deep tillage with M_2 (0.196 g kg^{-1}) at 70 days and conventional tillage with M_1 (0.16 g kg^{-1}) at harvest. Similarly, minimum P concentration was observed in conventional tillage with Mo (0.165 g kg^{-1}) at 45 days, conventional tillage with M_1 (0.148 g kg^{-1}) at 70 days and deep tillage with M_o (0.09 g kg^{-1}) at harvest.

Potassium concentration in maize shoots. The data regarding the effect of tillage and mulch on potassium concentration (g kg^{-1}) in maize shoots at 45 and 70 days after sowing and at maturity are presented in Table VI. Tillage systems affected non-significantly at all three observations. Maximum K concentration was observed in conventional tillage (1.98 g kg^{-1}) at 45 and minimum in deep tillage (1.84g kg^{-1}) at 70 days after sowing. But at harvest, maximum K concentration was recorded in deep tillage (1.68 g kg^{-1}) and minimum in conventional tillage (1.60 g kg^{-1}). Iqbal *et al.* (2005) reported that tillage methods significantly increased K content in shoots only, while their effect on N and P content in shoot was non-significant. Mulch levels affected non-significantly, maximum K concentration in maize shoots was observed in M_1 (2.00 g kg^{-1}) and minimum in M_o (1.842 g kg^{-1}) at 45 days. The similar trend was observed at harvest. But at 70 day after sowing, maximum K concentration in maize shoots was observed in M_2 (1.89 g kg^{-1}) and minimum in M_o (1.74 g kg^{-1}). The interactive effect of mulch and tillage was found non-significant on K concentration in maize shoots (Table VII). Acharya and Sharma (1994) also reported that mulched showed significantly greater total uptake of nitrogen, phosphorus and potassium than un-mulched ones.

CONCLUSION

Mulch and tillage significantly affected the soil physical properties and growth of maize as it increased soil moisture contents, organic matter contents, plant height, grain yield and decreased bulk density and soil strength. Soil moisture and organic matter contents were maximum, while soil strength was minimum in deep tillage. Interaction between tillage and mulch levels significantly affect soil physical properties and growth of maize, while non significant for bulk density and plant height. Tillage significantly affected the N and P concentration in maize shoots, while effect on K concentration was non significant. Mulch significantly increased N and P concentration in maize shoots and its effect on K concentration was non significant. Interactive effect of mulch and tillage was statistically significant in case of N and P concentration but non significant in case of K concentration.

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