

SOIL PHYSICAL PROPERTIES AND GRAIN YIELD OF SPRING MAIZE (*ZEA MAYS* L.) AS INFLUENCE BY TILLAGE PRACTICES AND MULCH TREATMENTS

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ABSTRACT. Soil provides suitable media for plant growth and development during the whole crop life cycle. The agronomic management practices can improve the soil fertility and crop productivity on sustainable basis. To explore the effects of some agromanagement practices on the spring maize, an experiment was conducted at the Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan, during spring season 2010 and 2011, using randomized complete block design with split block design arrangements. The experiment comprised of four tillage treatments viz: zero tillage (T_1), minimum tillage (T_2), conventional tillage (T_3) and deep tillage (T_4) in the main plots, while the four mulch treatments i.e. control (M_1), black plastic mulch (M_2), wheat straw mulch 10 Mg ha^{-1} (M_3) and grass mulch 10 Mg ha^{-1} (M_4) in the sub plots. Irrigation was provided according to crop requirement and herbicides were applied to control the weeds. All the tillage practices significantly affected ($p < 0.05$) the different soil physical properties i.e. soil bulk density, soil total porosity, water infiltration rate and root penetration resistance. Deep tillage practice

and black plastic mulch significantly increased the grain yield (m^{-2}) of spring maize than the zero tillage, minimum tillage, conventional tillage, no mulch, wheat straw mulch and rice straw mulch in both years of study. The two years field results suggested that the mulches improved soil aeration and water infiltration rate, lower the soil bulk density and root penetration resistance than the control treatments.

Key words: Tillage; Nutrients; Tropical region; Grain yield; Spring maize.

INTRODUCTION

In Pakistan, maize is third important cereal crop after wheat and rice, contributing 4.8 % of the total cropped area and 3.5% of the value of agricultural output with an estimated area of 950 thousand hectares having an annual production of 3,487 thousand tones (GoP, 2010). Various soil properties i.e. structure, texture,

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geometry, water storage and transmission affected by the tillage practices (Azooz *et al.*, 1996). Soil disturbance and tillage operations usually can cause an increase in nitrogen mineralization and soil aeration which resulted in more nitrogen availability for the use of plant roots (Halvorson *et al.*, 2001; Dinnes *et al.*, 2002). Similarly, Khattak *et al.*, (2004) reported the 15% more grain yield in deep tilled plots (using mould board plough). Sub-soiler increased 24.5 % and 13.0% more seed yield compared to other treatments during both year experiments (Botta *et al.*, 2006).

Use of mulches is helpful to control pests, conserve soil moisture, modulate the soil temperature, suppress weed, increase crop yield and improve crop quality (Greer and Dole, 2003). However, synthetic plastic mulches promote plant growth and development in term of extensive root growth and nutrients absorptions by increasing the soil temperature and reflective radiation (Sharratt, 2002). Dry matter yield and grain yield of corn in wheat straw mulching plots were significantly higher (138% and 60.5% simultaneously) as compared to unmulched plots (Bhatt *et al.*, 2004).

This study is planned to observe the effect of different tillage practices and mulch treatments on the soil physical properties and yield of spring maize in the clay loam soil of Faisalabad, Punjab, Pakistan, under the tropical climate conditions.

MATERIALS AND METHODS

Two consecutive years research trials were conducted in the rice harvested field at the Agronomic Research Farm, University of Agriculture, Faisalabad, Punjab, Pakistan, situated at 30° E and 74° N having 184 m altitude during spring season 2010 and 2011. The experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement having three replications and plot size 10 m × 4.5 m with six rows in each plot. R×R 75 cm and P×P 20 cm was maintained to keep 300 plants plot⁻¹. During both years of study, the tillage practices were kept in the main plot while the mulch treatments were in the subplots. Four different tillage practices were used viz: zero tillage (T₁) [seed was sown with help of dibbling method without ploughing], minimum tillage (T₂) [one cultivation with normal cultivator + planking], conventional tillage (T₃) [2-3 cultivations with normal cultivator followed by planking], deep tillage (T₄) [two deep ploughing with chisel plough + one cultivation with normal cultivator followed by planking] and four mulch treatments were applied viz: control (M₁), black plastic mulch (M₂), wheat straw mulch 10 Mg ha⁻¹ (M₃) and grass mulch 10 Mg ha⁻¹ (M₄). Recommended rate of fertilizers (NPK) were applied using urea, Di-ammonium phosphate (DAP) and murate of potash as sources of nitrogen, phosphorous and potassium. Soil bulk density, soil total porosity, water infiltration rate and root penetration resistance (Table 1) using the standard procedures. Maize grain yield m⁻² was taken at crop harvesting using the quadratic. The data were statistically analyzed using the Statistica 10.1V software (StatSoft Inc., 2012) and the significant treatments means were separated using Tukey's test at 5 % probability level (StatSoft Inc., 2005).

Table 1 - Influence of different tillage practices and mulch treatments on the soil physical properties and grain yield of maize

Treatments	Bulk density (Mg m ⁻³)		Total porosity (m ³ m ⁻³)		Root penetration resistance (K pa)		Grain yield m ⁻² (g)		
	Year	2010	2011	2010	2011	2010	2011	2010	2011
A. Tillage practices									
T ₁	1.49a	1.47a	0.44c	0.45d	1768.8a	1762.7a	778.13c	898.66b	
T ₂	1.48a	1.42b	0.44c	0.47c	1758.3b	1752.1b	932.06b	1278.11a	
T ₃	1.45b	1.36c	0.46b	0.48b	1741.5c	1735.3c	945.91b	1284.09a	
T ₄	1.40c	1.32d	0.47a	0.50a	1727.0d	1720.7d	958.35a	1291.46a	
LSD	0.021	0.029	0.008	0.001	8.72	9.72	12.991	11.129	
B. Poultry manure treatments									
M ₁	1.49a	1.40	0.44c	0.47	1755.9a	1751.3a	701.01c	799.21c	
M ₂	1.43c	1.38	0.46a	0.48	1743.1b	1732.2c	945.73a	1256.09a	
M ₃	1.46b	1.39	0.45b	0.47	1747.3b	1742.8b	894.23b	1201.89b	
M ₄	1.45b	1.39	0.45b	0.47	1749.2ab	1744.4ab	881.09b	1191.11b	
LSD	0.019	NS	0.007	NS	8.40	8.06	13.319	11.094	
Interaction (T×M)	NS	NS	NS	NS	NS	NS	NS	NS	

RESULTS

Bulk density (Mg m⁻³)

Statistically higher soil bulk density (1.49 Mg m⁻³) was noted in the zero tillage treatment that was statistically similar with those of minimum tillage treatment (1.48 Mg m⁻³) followed by the conventional tillage treatment (1.45 Mg m⁻³). The minimum soil bulk density was observed in the deep tillage treatment (1.40 Mg m⁻³) in 2010. Almost similar data chemistry was noted in 2011 (*Table 1*).

The mulches significantly affected the soil bulk density during the first year of study and non-significant during the second year of study. The maximum soil bulk density

was recorded in the control treatment (1.49 Mg m⁻³) followed by the wheat straw mulch (1.46 Mg m⁻³) that was at par with those of grass mulch (1.45 Mg m⁻³). Significantly minimum soil bulk density was noted in the black plastic mulch in 2010 (1.43 Mg m⁻³).

Total porosity (m³m⁻³)

Statistically higher soil porosity was in the deep tillage treatment (0.47 m³ m⁻³) where chisel plough was used followed by the conventional tillage treatment (0.46 m³ m⁻³). The lower soil porosity was observed in the zero tillage treatment (0.44 m³ m⁻³) which was at par with those of minimum tillage treatment (0.44 m³ m⁻³) in 2010. During 2011, almost similar data trend was noted (*Table 1*).

The total soil porosity significantly affected by the mulches in 2010 while during the year 2011 that was non-significant. The higher total soil porosity was obtained in the black plastic mulch treatment ($0.46 \text{ m}^3 \text{ m}^{-3}$) followed by the wheat straw mulch treatment ($0.45 \text{ m}^3 \text{ m}^{-3}$) that was at par with those of grass mulch treatment ($0.45 \text{ m}^3 \text{ m}^{-3}$). The minimum total soil porosity was noted in the control treatment ($0.44 \text{ m}^3 \text{ m}^{-3}$).

Root penetration resistance (k pa)

Significantly higher root penetration resistance was recorded in the zero tillage treatment (1768.8 K pa) followed by the minimum tillage treatment (1758.3 K pa) and then followed by conventional tillage (1741.5 K pa) while the lower root penetration resistance was in the deep tillage treatment (1727.0 K pa) during 2010. The same data fashion was observed in 2011 (*Table 1*). As regards to mulch treatments, during 2010 the minimum root penetration resistance was observed in the black plastic mulch treatment (1743.1 k pa) that was at par with those of wheat straw mulch treatment (1747.3 k pa). Statistically, maximum root penetration resistance was recorded in the control treatment (1755.9 k pa) which did not significantly differ with those of grass mulch treatment (1749.2 k pa). During 2011, similar data trend was found (*Table 1*).

Grain yield (m^{-2}) [g]

Significantly higher grain yield was achieved in deep tillage sown

crop (958.35 g) followed by the conventional tillage sown crop (945.91 g) that was statistically at par with those of minimum tillage sown crop (932.06 g). The lower grain yield was recorded in zero tillage sown crop (778.13 g) during 2010. In 2011, almost similar data trend was recorded (*Table 1*). Significantly higher grain yield was obtained in the black plastic mulch sown maize crop (945.73 g) followed by the wheat straw mulch sown crop (894.23 g) which did not significantly differ from those of grass mulch sown crop (881.09 g). The control treatment gave the lower grain yield in 2010 (701.01 g). Similar findings were observed in 2011 (*Table 1*).

DISCUSSION

The interactive effect of tillage and mulch was found non-significant for all studied parameters during the both years of study which indicated that they performed individually. The higher soil bulk density in the zero tillage treatment might be due to the higher soil compactness and more soil moisture. The lower soil bulk density in deep tillage treatment might be due to cultivation of soil to deeper layers which may caused the breaking down of hard pane and ultimately lesser soil bulk density. These results are in line with those of Khan *et al.* (2010) who documented that higher soil bulk density was recorded in the zero tillage treatment as compared to conventional and minimum tillage treatments. As far as mulch treatments

concerned, the lower soil bulk density in the black plastic mulch sown crop might be due to less the surface crusting and proper soil moisture content in deeper soil profile which may resulted in lower soil bulk density. The results are in close agreement with the findings of Ghuman and Sur (2001) who concluded that mulching decreased bulk density of the soil than without mulch.

Higher soil total porosity in the deep tillage treatment might be due to more pore spaces in the soil due to deep and intensive cultivation. These results are in consonance with those of Hossain *et al.* (2004), who documented that higher soil porosity was recorded in the deep tillage treatment over control treatment (no tillage). As far as mulch treatments were concerned, these results are in line with those of Glab and Kulig (2008). They reported that with addition of the mulch of fodder radish which increased the soil porosity in range of 50-500 μm than the control plot in wheat crop.

The higher root penetration resistance in the zero tillage treatment might be due to undisturbed soil condition and less soil total porosity which resulted in higher soil bulk density and ultimately caused more root penetration resistance. These results are supported by those of Özpınar and Cay (2005), who noted the higher root penetration resistance was recorded in minimum tillage treatment over conventional and mould board plough treatment. As

regards to mulch treatments, the mulches may improved the ecological environment of the soil and increased soil water content which may resulted in less root penetration resistance (Khurshid *et al.*, 2006).

The higher grain yield in the deep tillage sown crop might be due to more number of grains per cob as well as 1000-grain weight. In addition, deep tillage broke the soil hard pan which may resulted to deeper root penetration for more nutrients uptake and ultimately higher grain yield was obtained. The lower grain yield in the zero tillage sown crop might be due to unfavorable soil conditions for crop growth under zero tillage treatment (Karunatilake *et al.*, 2000). Memon *et al.* (2011) resulted that higher grain yield was recorded in the deep tillage treatment as compared to conventional tillage and zero tillage treatments in maize crop. As far as mulches were concerned, the lower grain yield in the control treatment might be due to more weeds intensity and strong weeds plant competition which shared the plant nutrients. These results are in substantiated with those of Khurshid *et al.* (2006) who ascribed the positive yield response in maize to increased water contents in soils due to reduced evaporation in mulch treatments. Yang *et al.* (2006) noted that the straw mulch conserved more soil water but decreased grain yield probably due to low temperature that has slowed down the maize germination and growth.

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CONCLUSION

From the above two year experimental data, we concluded that under the agro-climatic conditions of Faisalabad, Pakistan, the deep tillage practice with chisel plough and black plastic mulch treatments have performed best for soil bulk density, total soil porosity, root penetration resistance and grain yield than the other tillage practices (zero tillage, minimum tillage and conventional tillage) and mulches treatments (no mulch, wheat straw mulch and rice straw mulch).

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