

Full Length Research Paper

# Improving Soil Physical Quality through Integrated Tillage and Farmyard Manure Management

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A field experiment was conducted at Research Area of Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad during year 2004 with the objective to determine the effect of tillage and Farm Yard Manure on soil tilth at sandy clay loam soil. The experiment was laid out in Randomized Complete Blocked Design with four replications having split plot arrangement. Three tillage aspects (Deep tillage (DP), Conventional tillage (CT) and Minimum tillage (MT) and three Farm Yard Manure levels (20 Mg ha<sup>-1</sup>, 40 Mg ha<sup>-1</sup> and control) were used as media of research. The tillage methods were kept in the main plots and FYM levels in subplots. The results revealed that tillage methods significantly increases the soil physical properties as increase in saturated hydraulic conductivity in deep tillage method and decrease in bulk density of soil was noted. The farm yard manure (FYM) also affected the physical properties as it increased saturated hydraulic conductivity. The maximum supply of nitrogen contents (0.079%) was recorded in case of application of FYM (40 Mg ha<sup>-1</sup>) during minimum tillage.

**Keywords:** Tillage, FYM, Physical properties, Soil

## INTRODUCTION

Soil is basic medium for seed germination, seed emergence, root growth and ultimately crop production. The aim of agriculture research is to raise crop productivity. In this context the importance of soil physical properties in optimizing production has been well recognized. Many management practices like tillage, mulching, fertilizer application and manuring are carried out to improve soil physical environment.

Tillage management and manure application are among the important factors effecting soil physical properties. Tillage and farm manure often have significant effect on soil bulk density, moisture and porosity. Tillage is a practice which is performed to loosen the soil and to produce a good tilth. Among the crop production factor tillage contributes up to 20% (Ahmad *et al.* 1996; Mahajan *et al.*, 1996). Tillage method affects the sustainable use of soil resources through its influence on soil properties (Hammel, 1989). Deep tillage break up

high density soil layer, improve the water infiltration and movement of in soil, enhance root growth, development and increase crop production potential (Bennie and Botha, 1986). Deep tillage of the soil resulted in increased corn yield up to the depth of 90cm (Varsa *et al.*, 1997). The use of minimum tillage management practices for maize production is increasing because it reduces planting time, fuel as well as labour requirements and also soil erosion on slopes.

Soil organic matter on the other hand is an important component of soil quality as it determines many soil characteristics such as nutrient mineralization, aggregate stability, aeration, favorable water uptake and retention properties. Organic matters not only increase the water holding capacity of the soil but also the portion of water available for plant growth and improve physical properties of soil (Epstien *et al.*, 1976; Pagliai *et al.*, 1981; Korentajer, 1991; Bolan *et al.*, 2004; Sial *et al.*, 2007). In addition it is major soil source of plant nutrients including phosphorus as well as sulphur and primary source of nitrogen for most plants (Brady and Weil, 1999). The

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water holding capacity of sandy soils are increased with heavy manure application, structure of fine textured soil is improved and reduces soil degradation. Farm manure increases the solubility of SSP from 32% to 40% (Sharif, 1985) and delays fixation.

The main sources of organic matter in Pakistan are; cattle dung, urine, litter, crop residues / waste like sugarcane trash, straw, poultry, sheep and goat dropping, waste from fruit and vegetables, press mud from sugar industries, rice husk and bran / dust from textile industries. These all organic matter can be used for building up and maintaining organic matter in soil to conserve the fertility and as well as soil physical condition (tilth) and to increase the fertilizer use efficiency. Application of FYM and incorporation of rice and wheat straw improved physical and chemical properties of soil (Sharma and Saxena, 1985)

Keeping in view, this investigation was conducted to determine the effect of tillage and FYM on soil physical properties under maize crop.

## MATERIALS AND METHODS

Faisalabad stands in the rolling flat plains of northeast Punjab, between longitude 73°74 east, latitude 30°31.5 North, with an elevation of 184 metres (604 ft) above sea level. The climate of the district can see extremes, with a summer maximum temperature 50 °C (122 °F) and a winter temperature of -1 °C (30.2 °F). The mean maximum and minimum temperature in summer are 39 °C (102 °F) and 27 °C (81 °F) respectively. In winter it peaks at around 21 °C (70 °F) and 6 °C (43 °F) respectively. The average yearly rainfall lies only at about 400 mm (16 in) and is highly seasonal with approximately half of the yearly rainfall in the two months July and August. A field experiment was conducted at Research Area of Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad during year 2004 with the objective to determine the effect of tillage and FYM on soil tilth. The experiment was laid out in Randomized Complete Blocked Design with four replications having split plot arrangement. Three tillage aspects; Deep tillage (DT), with chisel plow up to 30-40cm depth, Conventional tillage (CT), included three plowings and Minimum tillage (MT) included one plowing and farm yard manure (FYM) levels; Control (recommended levels of NPK), FYM (20 Mg ha<sup>-1</sup> and 40 Mg ha<sup>-1</sup>) were used as media of research keeping tillage methods in the main plots and FYM levels in subplots. The net plot size was kept 6m × 6m. Maize crop (FYH-399) was sown by dibbling method maintaining 20cm and 75cm plant to plant and row to row distance, respectively. Recommended rates of NPK (200- 125-60 Kg ha<sup>-1</sup>) were applied from the Urea, DAP and MOP, respectively. Whole of the Phosphorus and Potassium was added at the time of sowing while Nitrogen was applied in two splits i-e one half after germination and remaining half when the plants attained the height of 90 cm. Chisel plow was used for deep tillage while ordinary plow (tine cultivator) for all other treatments. Plant protection measures were done as and when required throughout the growth period. Composite soil sample was taken from the experimental area prior sowing of crop. The soil sample was air-dried, ground, well mixed and passed through a 2 mm sieve and analyzed for physical and chemical properties. Percentage of sand, silt and clay was determined by Bouyoucos hydrometer method using one percent sodium hexametaphosphate as a dispersing agent (Bouyoucos, 1962). Textural class was determined by using the international textural triangle

(Moodie *et al.*, 1959). Soil was analyzed for its various chemical properties by using the methods as described by Homer and Pratt (1961). The soil was analyzed for N, P and K. The soil was sandy clay loam containing 59 % sand, 19 % silt and 22 % clay (Table 2). Its chemical characteristics included saturation 35 %, pH 8.1, EC 1.46 dS m<sup>-1</sup>, organic matter 0.913 % (Page *et al.*, 1982), total nitrogen 0.061 % (Hussain and Jabbar, 1985), available phosphorous 9.0 mg kg<sup>-1</sup>, available K 147 mg kg<sup>-1</sup> (Workman, 1979), field saturated hydraulic conductivity (K<sub>fs</sub>) 3.24 X 10<sup>-4</sup> cm s<sup>-1</sup> and soil bulk density 1.38 Mg m<sup>-3</sup>. The field saturated hydraulic conductivity (cm s<sup>-1</sup>), bulk density (Mg m<sup>-2</sup>) and soil organic matters (%) were determined as parameters. The data collected for various variables was subjected to statistical analysis using the analysis of variance technique by using "MSTAT-C" (Anonymous, 1986) where as the means were compared through LSD test at 0.05 p (Steel *et al.*, 1997)

## RESULTS AND DISCUSSION:

### Effect of tillage and farm manure on soil bulk density

Data related to soil bulk density as mentioned in Table 1 depicted that tillage methods and farm yard manure have significantly affected the bulk density of soil. In case of tillage method, higher value of bulk density 1.397 Mg m<sup>-3</sup> was observed with minimum tillage while the minimum (1.323 Mg m<sup>-3</sup>) in case of deep tillage (Figure 1). The results showed significant decreasing trend in bulk density with the tillage. Mean decrease in bulk density was observed 5.1 % to 1.0% in case of deep tillage and conventional tillage, respectively as compare to minimum tillage. Diaz-Zorita (2000) reported that bulk density of soil in 3cm to 20cm layer was significantly increased when the intensity of tillage system was decreased. Farm yard manure (FYM) significantly decreases the bulk density of soil as compare to control. The higher mean value of 1.470 Mg m<sup>-3</sup> in case of control followed by 1.388 Mg m<sup>-3</sup> (5.57% decrease) and 1.24 Mg m<sup>-3</sup> (18.5% decrease) in case of application of farm yard manure (20 Mg ha<sup>-1</sup> and 40 Mg ha<sup>-1</sup>), respectively. The findings of Shirani *et al.* (2002) were in conformity of this finding who reported that manure application significantly decreases the bulk density.

### Effect of tillage and farm manure on soil saturated hydraulic conductivity

Data regarding soil saturated hydraulic conductivity after maize harvesting is presented in Table 1, which revealed that both tillage methods and FYM have significant effect on soil saturated hydraulic conductivity. As regards tillage, the maximum mean value of saturated hydraulic conductivity (4.897×10<sup>-4</sup> cm s<sup>-1</sup>) was observed with deep tillage followed by 4.393 × 10<sup>-4</sup> cm s<sup>-1</sup> noted in conventional tillage. Minimum value was observed in tillage method of zero tillage. While mean increase in field saturated hydraulic conductivity was observed as 25.9%

**Table 1.** effect of tillage and farm yard manure on physical properties of soil

Parameters	Soil Bulk Density (Mg m <sup>-3</sup> )	Saturated Hydraulic Conductivity (× 10 <sup>-4</sup> cm s <sup>-1</sup> )	Organic Matter (%)	Nitrogen Concentration (%)	Phosphorus Concentration (ppm)	Potassium Concentration (ppm)
<b>Tillage Methods (TM)</b>						
DT	1.32b	4.897a	0.993b	0.058b	15.16a	173.3ab
CT	1.38a	4.393b	1.026b	0.066b	13.56b	168.8b
MT	1.39a	3.889c	1.187a	0.079a	14.62ab	181.1a
<b>Farm yard manures (FYM)</b>						
Control	1.470a	3.313c	0.933c	0.051b	9.05c	157.9
FYM1	1.388b	4.490b	1.060b	0.071a	15.38b	175.8b
FYM2	1.240c	5.376a	1.212a	0.081a	19.36a	189.4a
<b>Interaction (TM x FYM)</b>						
DT x Control	1.40c	3.80e	0.95de	0.041e	9.57f	162.40ef
DT x FYM1	1.36c	4.91b	0.91de	0.062cd	16.32d	172.50cde
DT x FYM2	1.21d	5.98a	1.12c	0.07bc	20.93a	184.90bc
CT x Control	1.48ab	3.21f	0.87e	0.052de	8.64g	159.30ef
CT x FYM1	1.39c	4.43cd	1.01d	0.069bc	14.21e	168.60de
CT x FYM2	1.27d	5.54a	1.20bc	0.078b	17.82c	178.60bcd
MT x Control	1.553a	2.93f	0.98d	0.06cd	8.94fg	151.90f
MT x FYM1	1.41bc	4.13de	1.26ab	0.082ab	15.60d	186.40b
MT x FYM2	1.24d	4.61bc	1.32a	0.094a	19.33b	204.80a

and 12.9% in case of deep tillage and conventional tillage, respectively as compare to zero tillage, indicating that deep tillage increases the field saturation hydraulic conductivity. Karibba *et al.*, (2001) also found that field hydraulic conductivity values showed significant differences and observed that fallow soil tilled with chisel plow showed higher values than disc plow.

It is also depicted from the data that farm yard manure (FYM) significantly increased the field saturated hydraulic conductivity of soil as compare to treatments where recommended dose of NPK were applied. The higher mean value of field saturated hydraulic conductivity ( $5.376 \times 10^{-4}$  cm s<sup>-1</sup>) was observed with FYM (40 Mg ha<sup>-1</sup>) followed by  $4.49 \times 10^{-4}$  cm s<sup>-1</sup> with FYM applied with dose 20 Mg ha<sup>-1</sup> while the lowest mean value ( $3.13 \times 10^{-4}$  cm s<sup>-1</sup>) was recorded in case of recommended NPK treatment (control). Increasing levels of FYM had put significant effects on hydraulic conductivity as compare to with out FYM. Mean increase in hydraulic conductivity was observed 62.2% and 35.5% with FYM (40 and 20 Mg ha<sup>-1</sup>), respectively as compared to recommended NPK values (Figure 2). The findings are in conformity with those of Zachman (1987) and Shirani *et al.*, (2002) who reported that manures application improved hydraulic conductivity as the till and no till residue had higher infiltration then no residue treatment. The interactive effects of treatments showed that maximum value of field saturated hydraulic conductivity ( $2.98 \times 10^{-4}$  cm s<sup>-1</sup>) was recorded when the farm yard manure (FYM) was applied @ 40 Mg ha<sup>-1</sup> in deep tillage against the minimum value ( $2.93 \times 10^{-4}$  cm s<sup>-1</sup>) in case of application of recommended NPK in minimum tillage.

#### Effect of tillage and farm manure on organic matter (%) in soil

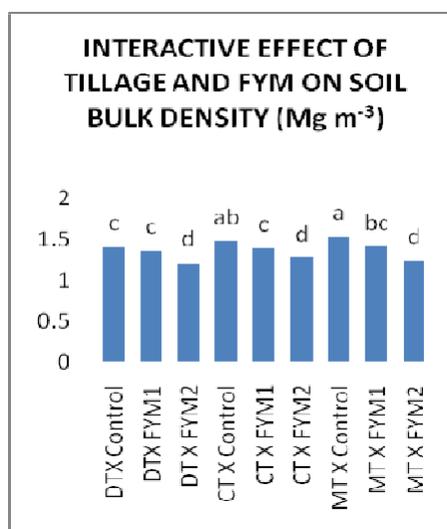
The data pertaining to organic matter concentration (%) in soil after harvest is listed in table 1, which showed that both the factor under study have significant effects on concentration of organic matter in soil. Farm yard manure (FYM) significantly influenced the soil organic matter concentration (%) in soil as compared to application of recommended NPK. The maximum mean value of organic matter (1.212%) was recorded with application of FYM @ 40 Mg ha<sup>-1</sup> followed by 1.06% in case of application of FYM @ 20 Mg ha<sup>-1</sup> against the minimum value of organic matter (0.93%) in recommended NPK. So the increase in organic matter (%) was observed 29.9% and 16.3% with FYM levels of 40 Mg ha<sup>-1</sup> and 20 Mg ha<sup>-1</sup>, respectively. Shirani *et al.*, (2002) concluded that FYM application level of 30 and 60 Mg ha<sup>-1</sup> increased organic matter contents on both row and inter row tracks significantly.

Tillage practices showed that minimum tillage had maximum organic matter (1.187%) followed by conventional tillage (1.026%) against the minimum mean value (0.993%) in case of deep tillage (Figure 3). The mean increase in organic matter was 13.6% and 16.3% in case of minimum tillage as compared to conventional and deep tillage. While Carter *et al.*, (2002) noted contradictory found that in soil samples significant differences were not evident among treatments for exchangeable ions and organic carbon in the plow layer depth.

The interactive effect of tillage methods with FYM on

**Table 2.** physical and chemical characteristics of original soil used for study

Sand	%	59
Silt	%	19
Clay	%	22
Textured Class		Sandy Clay Loam
Soil Bulk Density	Mg m <sup>-3</sup>	1.38
Field Saturated Conductivity	X 10 <sup>-4</sup> cm s <sup>-1</sup>	3.24
EC	dSm <sup>-1</sup>	1.46
PH		8.1
Soil Organic Matter	%	0.9313
Total Nitrogen	%	0.061
Available Phosphorus	mg Kg <sup>-1</sup>	9.00
Available Potassium	mg Kg <sup>-1</sup>	147



**Figure. 1**

organic matter concentration (%) was found statistically significant. Maximum organic matter (1.32) was observed when FYM was applied at 40 Mg ha<sup>-1</sup> in minimum tillage and minimum value of organic matter (0.87%) was observed in conventional tillage under recommended NPK.

#### **Effect of tillage and farm yard manure (FYM) on nitrogen in soil**

The data (Table 1) regarding effect of tillage and farm yard manure depicted significant effect on nitrogen concentration and revealed that maximum nitrogen concentration (0.079%) was observed in case of minimum tillage followed by conventional tillage (0.066%) against minimum nitrogen concentration (0.0577%) in condition of deep tillage (DT). Mean increase in nitrogen

concentration (%) was 36.4 % and 15.0 % in case of minimum tillage and conventional tillage, respectively as compare to deep tillage.

As regards farm yard manure (FYM), maximum nitrogen contents in soil at harvest (0.081%) was recorded with FYM (40 Mg ha<sup>-1</sup>) followed by 0.071% nitrogen in case of FYM (20 Mg ha<sup>-1</sup>) against the least value for nitrogen contents (0.051%) was observed in treatment where recommended NPK were applied. The increase in nitrogen contents (%) in soil was 58.2% and 39.2% from application of farm yard manure (40 Mg ha<sup>-1</sup> and 20 Mg ha<sup>-1</sup>), respectively as compare to recommended NPK. Halivin *et al.*, (1990) reported similar results that more liable organic matter results in short term influences on soil physical and chemical properties including aggregate stability and nutrients availability.

The interactive effects of both factors showed that

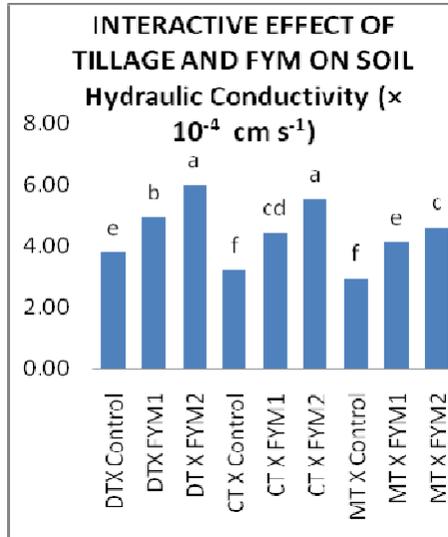


Figure. 2

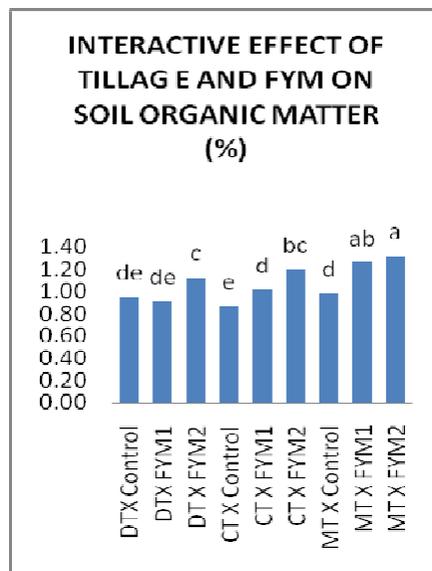


Figure. 3

maximum mean value of nitrogen contents (0.094%) was observed in case of application of FYM @ 40 Mg ha<sup>-1</sup> in minimum tillage against minimum value of 0.041% nitrogen contents in deep tillage and recommended NPK treatment. (Figure 4)

#### Effect of tillage and farm yard manure (FYM) on phosphorus concentration in soil.

The data (Table 1) related to the effect of tillage and farm yard manure on phosphorus concentration (ppm) showed

significant effect with respect to this parameter. The maximum mean value of phosphorus concentration (15.16 ppm) was observed with deep tillage followed by 14.62 ppm in case of minimum tillage against least value of 13.56 ppm in conventional tillage (Figure 5). The percentage increase in phosphorus contents (ppm) was 6.77 in deep tillage as compare to minimum tillage. Selles (1999) reported that phosphorus in soil was highly variable and was not affected by tillage and rotational treatments.

In case of application of farm yard manure (FYM) the more application (FYM @ 40 Mg ha<sup>-1</sup>) resulted in

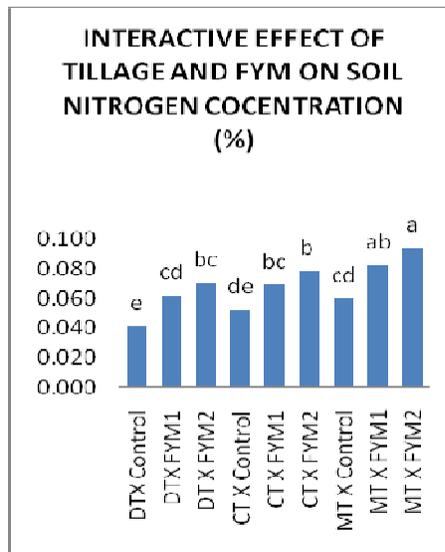


Figure. 4

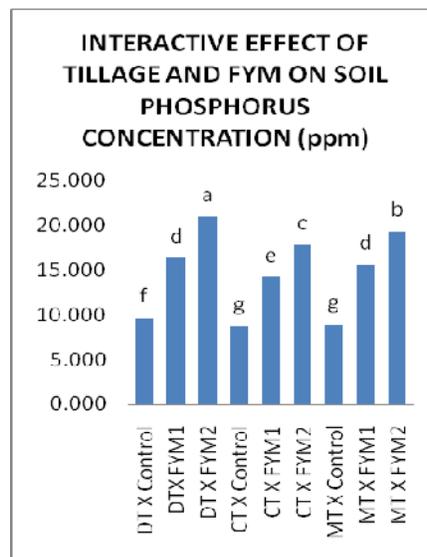


Figure.5

maximum phosphorus value (19.36 ppm) followed by 15.38 ppm in case of application of FYM @ 20 Mg ha<sup>-1</sup> and the least value (9.05 ppm) was observed in treatment where recommended NPK was applied. The increase in phosphorus concentration was observed as 113.9% and 69.9% in case of application of FYM @ 40 and 20 Mg ha<sup>-1</sup>, respectively. These results are conformity with the finding of Weil *et al.*, (1988) who reported that increase in available phosphorus (AP) due to organic matter accumulation at or near the surface, which decreased

phosphorus adsorption by inorganic colloids.

#### Effect of tillage and farm yard manure (FYM) on potassium concentration in soil

The data (Table 1) pertaining to the effect of tillage and farm yard manure (FYM) on potassium concentration (ppm) in soil revealed that tillage methods have statistically non significant effects with respect to this

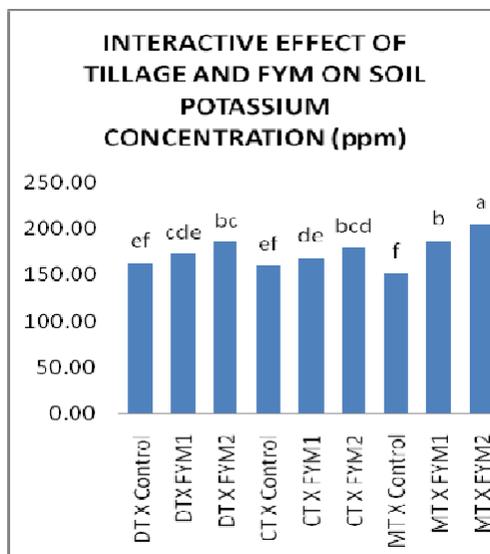


Figure.6

parameter. Carter *et al.*, (2002) noted non significant differences among the treatments. The effect of farm yard manure (FYM) on potassium concentration (ppm) was recorded significantly. Higher potassium concentration (189.4 ppm) was observed with application of FYM @ 40 Mg ha<sup>-1</sup> against the least (157.9 ppm) potassium concentration in application of recommended NPK (Figure 6). Mean increase in potassium contents was observed 19.9% and 11.3% in case of FYM @ 40 Mg ha<sup>-1</sup> and 20 Mg ha<sup>-1</sup>, respectively as compare to recommended NPK.

In conclusion, tillage methods and farm yard manure carries its impact on soil physical properties and health. Farm yard manure has positive role in maintaining physical properties of soil as it takes time to decompose completely. Farm yard manure significantly increased saturated hydraulic conductivity in deep tillage method and reduced bulk density of soil. The farm yard manure (FYM) also affected the physical properties as it increased hydraulic conductivity.

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