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SOIL PHYSICAL PROPERTIES AND WHEAT GROWTH AS AFFECTED BY TILLAGE AND FARM MANURE

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A field experiment was conducted to see the effects of three tillage systems, i.e. minimum, conventional and deep tillage and three farm manure (FM) levels (0, 20 and 40 Mg ha^{-1}) on soil physical properties and wheat growth. The maximum plant growth, yield, saturated hydraulic conductivity, soil nutrient status at harvest, nutrient uptake by plant and minimum bulk density were observed with treatment combination T_3M_2 (deep tillage + farm manure @ 40 Mg ha^{-1}). While organic matter was maximum in T_1 M_2 (minimum tillage + farm manure @ 40 Mg ha^{-1}). Regarding individual effects of tillage and farm manure, maximum plant growth, yield, saturated hydraulic conductivity, soil nutrient status at harvest, nutrient uptake by plant and minimum bulk density were seen with deep tillage and with farm manure level of 40 Mg ha^{-1}.
Key words: Soil physical properties, wheat plant growth, tillage methods, and farm manure.

INTRODUCTION

Wheat *(Triticum aestivum* L.) is a staple food of Pakistan. It is cultivated over an area of 8.216 million hectares with annual production of 19.5 million tons with an average yield of 2.373 tons ha^{-1} (Anonymous, 2004). This average yield is far less than the potential of cultivars and soils, which is due to many factors. Among these soil tillage and organic matter are important factors affecting soil physical properties and crop yield.

Soil is a medium for plant growth. Different soil properties have different effects on plant growth. Physical properties are caused by forces and operations of physics and affect the germination and emergence of seedlings and root penetration and growth into soil. In Pakistan there are many problems associated with soil.

In recent years, there has been increased interest in the use of conservation tillage (no-tillage, reduced tillage) systems for cereal production. Conservation tillage maintains or even increases soil organic carbon when coupled with more extensive cropping (Reeves, 1997). Reduced and no-till systems conserve more water early in the follow period than conventional systems (Farahani *et al.*, 1998). Deep tillage decreases bulk density; compaction effects and increases nutrient uptake, saturation percentage and saturated hydraulic conductivity resulting in improved yields. Deep tillage destroys plough pan layer and improves productivity of light coloured soils when combined with manure application. (Higashida & Yamagami, 2003). Deep tillage breaks, inverts and pulverizes sub-surface and decreases soil penetration resistance (Khattak *et al.* 2004).

Organic matter (O.M) has multiple functions in soil. The primary role of O.M is in reducing soil erodibilty by stabilizing the surface aggregates through reduced crust formation and surface sealing, which increases infiltration (Le Bissonais, 1990). The application of farm manure ameliorates the soil permeability, which is destroyed due to application of high RSC water for irrigation (Bhatti *et al.,* 1977). Soil organic matter can decrease soil compaction (Angers and Simard, 1986; Avnimelech and Cohen, 1988). Keeping all these factors in view, the present investigation is planned to determine the effects of tillage and farm manure on soil physical properties and growth of wheat under field conditions.

MATERIALS AND METHODS

The experiment was carried out under field conditions, in the research area, Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad during 2004-2005 to study wheat plant growth and soil physical properties as affected by tillage and farm manure. Soil was sandy clay loam, low in organic matter, nitrogen and available phosphorus, alkaline in reaction but adequate in potassium (Table 1).

Three tillage methods used were, i.e. minimum tillage (T_1), conventional tillage (T_2) and deep tillage (T_3) and three farm manure levels.(0, 20 & 40 Mg ha^{-1}). Tillage was placed in main plot, while farm manure levels in sub-plot. Thus there were total 27 treatment combinations. The system of layout was Randomized Complete Block Design with split plot arrangement having net plot size of 5.6m x 9m. The treatment combinations are given as under:

Wheat cultivar Watan was sown with automatic Rabi drill maintaining row to row distance of 22 cm. Chisels

plough was used for deep ploughing, while ordinary plough (tine cultivator) was used for all other treatments.

Canal water was applied as and when required. Plant protection practices were carried out and when needed throughout the growing period. Crop was harvested at maturity and the following crop and soil parameters such as Plant height (cm), Number of tillers (m^{-2}), Number of spike lets spike^{-}1, 1000-grain weight (g), Total biomass (Mg ha^{-1}), Straw yield (Mg ha^{-1}), Grain yield (Mg ha^{-1}), Hydraulic conductivity (cm s^{-1}), Soil bulk density (Mg m^{-3}) (Blake and Hartage, 1986) and Soil organic matter (%) (Ryan *et al.* 2001) were recorded.

After harvest of the crop both soil and plant samples were analyzed for N, P and K contents (Jackson, 1962. method 16-p.134. method 58a: p. 132). The data noted was subjected to statistical analysis, using appropriate method (Steel and Torrie, 1980).

Table 1. Physico-chemical properties of soil under study

Determinants	Units	Value
Sand	%	58
Silt	%	18
Clay	%	24
Textural Class	Sandy clay loam	
Bulk density	Mg m^{-3}	1.58
Saturated hydraulic conductivity	X 10^{-4} cm S^{-1}	2.59
Organic matter	%	0.86
EC_e	dS m^{-1}	2.48
pH_s		7.8
Saturation percentage	%	35
Na^+	$mmol_c$ L^{-1}	3.60
K^+	$mmol_c$ L^{-1}	0.55
$Ca^{2+} + Mg^{2+}$	$mmol_c$ L^{-1}	10.9
CO_3^{2-}	$mmol_c$ L^{-1}	-
HCO_3^-	$mmol_c$ L^{-1}	5.50
Cl^-	$mmol_c$ L^{-1}	6.50
SO_4^{2-}	$mmol_c$ L^{-1}	3.05
Total nitrogen	%	0.04
Available phosphorous	mg kg^{-1}	8.80
Extratable potassium	mg kg^{-1}	200

RESULTS AND DISCUSSION

Growth parameters

Results presented in table-2 showed that interactive effect of tillage methods and farm manure levels was statistically significant.

The maximum plant height (91.3 cm), number of tillers (280.7 m^{-2}), number of spike lets $spike^{-1}$ (21.0), total biomass (14.5 Mg ha^{-1}), straw yield (9.0 Mg ha^{-1}), grain yield (5.5 Mg ha^{-1}), and 1000 grain weight (45.2 g) was noted in treatment combination T_3M_2 (deep tillage +FM @ 40 Mg ha^{-1}). The minimum values of theses parameters were noted with treatment combination T_1M_0 (minimum tillage + no OM). This revealed that in T_1M_0 due to minimum tillage and no farm manure application less nutrients were available for plant's growth and soil physical condition was also poor so plants showed poor growth and gave lowest yield. Regarding individual effects of tillage, the Maximum plant height (88.6cm), number of tillers (258m^{-2}), number of spikelets per spike (18.2), 1000 grain weight (44.8g), total biomass (11.7 Mg ha^{-1}), straw yield (7 Mg ha^{-1}) and grain yield (4.7 Mg ha^{-1}) was noted with deep tillage. Regarding individual effects of farm manure, the maximum values of all growth and yield components were observed with farm manure level of 40 Mg ha^{-1}. These results are in agreement with those of Shirani *et al.* (2002) who concluded that increasing levels of manure increased dry biomass yield and plant growth because manure application provides nutrients to the plant. Other scientist Higashida and Yamagami (2003) also noted that growth of winter wheat was promoted by deep tillage.

Soil Physical Properties

Maximum improvement in saturated hydraulic conductivity 9.9 x 10^{-4}cm S^{-1}, bulk density 1.4 Mg m^{-3} (Table-2) was seen in treatment combination T_3M_2 (deep tillage + farm manure @ 40 Mg ha^{-1}). While in T_1M_0 (minimum tillage + farm manure @ 0 Mg ha^{-1}) the poor soil physical properties were observed. This can be related to the fact that minimum tillage without FYM increased bulk density (1.67 Mg m^{-3}) and decreased saturated hydraulic conductivity (6.2 x 10^{-4}cm S^{-1}). Regarding individual effects of tillage and farm manure, minimum bulk density of 1.48 Mg m^{-3} and maximum saturated hydraulic conductivity of 9.1x10^{-4}cm S^{-1}) were seen with deep tillage. Similarly minimum bulk density 1.48 Mg m^{-3} and maximum saturated hydraulic conductivity 8.7x10^{-4} cm S^{-1} were noted with manure level of 40 Mg ha^{-1}. These results are in agreement with those of Khattak *et al.* (2004) who showed that tillage treatments significantly affected bulk density at various depths. Celik *et al.* (2004) proved that organic fertilizers significantly affected soil physical properties.

Mineral Concentration in Soil and Plant

Data given in table-3 shows that maximum Nitrogen, Phosphorus and Potassium concentration are 0.39%,

Table 2. Interactive and individual effect of tillage and farm manure on growth parameters of wheat and soil properties.

Treatments	Plant height (cm)	No. of tillers (m^{-2})	No. of Spikelets per spike (No)	1000-grain weight (g)	Total biomass (Mg ha^{1})	Straw yield (Mg ha^{-1})	Grain yield (Mg ha^{-1})	Bulk density (Mg m^{-3})	Saturated hydraulic conductivity x10^{-4}cm s^{-1}
T_1M_0	81.33	133.33i	15.00	34.17f	5.5d	3.5d	2.0g	1.67a	6.2h
T_1M_1	82.00	186.33h	16.33	35.10e	8.3c	4.7c	3.6e	1.56c	7.0g
T_1M_2	89.67	275.67b	17.33	39.20d	11.3b	7.1b	4.2d	1.54d	7.5f
T_2M_0	84.67	228.67g	15.00	34.97f	11.3b	6.9b	4.3d	1.52e	7.0g
T_2M_1	88.33	232.33f	17.33	42.10c	11.8b	7.0b	4.8c	1.52e	8.4d
T_2M_2	90.33	268.00c	19.67	42.50c	12.0b	7.0b	5.1b	1.48f	8.7c
T_3M_0	85.67	236.67e	16.67	44.13b	9.1c	5.9b	3.1f	1.58b	8.1e
T_3M_1	89.00	257.33d	17.00	45.23a	11.0b	6.9b	4.0d	1.44g	9.4b
T_3M_2	91.33	280.67a	21.00	45.27a	14.5a	9.0a	5.5a	1.42h	9.9a
Tillage and farm manure levels means.									
T_1	84.33b	198.44c	16.22b	36.16c	9.4c	5.7b	3.7b	1.59a	6.9c
T_2	87.78a	243.00b	17.33a	39.86b	10.5b	6.7a	3.8b	1.51b	8.0b
T_3	88.67a	258.22a	18.22a	44.88a	11.7a	7.0a	4.7a	1.48c	9.1a
M_0	83.89b	199.56c	15.56c	38.12c	8.6c	5.5c	3.1c	1.59a	7.1c
M_1	86.44b	225.33b	16.89b	40.96b	10.4b	6.2b	4.1b	1.51b	8.3b
M_2	90.44a	274.78a	19.33a	41.81a	12.6a	7.7a	4.9a	1.48c	8.7a

Means with same letters (S) are statistically non significant at 5% level.

Table 3. Interactive and individual effect of tillage and farm manure on N, P and K concentration in soil and shoot.

Treatments	Shoot			Soil			
	N (%)	P (%)	K (%)	N (%)	P (ppm)	K (ppm)	O.M (%)
T_1M_0	0.25	0.039	2.15f	0.03	7.0e	140c	0.78
T_1M_1	0.29	0.040	2.35d	0.04	7.5e	160b	0.87
T_1M_2	0.31	0.040	2.45c	0.04	12.0c	160b	0.99
T_2M_0	0.28	0.040	2.25e	0.04	9.5d	140c	0.76
T_2M_1	0.31	0.041	2.45c	0.05	12.5c	160b	0.85
T_2M_2	0.34	0.041	2.65b	0.06	14.5ab	200a	0.97
T_3M_0	0.32	0.042	2.35d	0.05	14.0b	200a	0.73
T_3M_1	0.36	0.043	2.45c	0.06	14.0b	200a	0.83
T_3M_2	0.39	0.044	2.95a	0.07	15.0a	200a	0.94
Tillage and farm manure levels means.							
T_1	0.28c	0.040c	2.32c	0.04c	8.83c	166b	0.88a
T_2	0.31b	0.041b	2.42b	0.05b	12.17b	166b	0.86b
T_3	0.36a	0.043a	2.45a	0.06a	14.33a	200a	0.83c
M_0	0.28c	0.041	2.25c	0.04b	10.17c	160c	0.76c
M_1	0.32b	0.041	2.42b	0.05a	11.33a	173b	0.85b
M_2	0.35a	0.042	2.52a	0.06a	13.83a	200a	0.97a

Means with same letters (S) are statistically non significant at 5% level.

0.04% and 2.95 % respectively in plants and 0.07%, 15 ppm, and 200 ppm Nitrogen, Phosphorus and Potassium in soil respectively after harvest of crops noted in T_3M_2. This might be due to deep tillage, which made nutrients available for plants and also improved soil nutrients status. Similar results were obtained by Sanchez et al. (2003), Matsi et al. (2003) and Motavalli et al. (2003) The minimum N, P and K uptake by plant was 0.25, 0.04 and 2.15 %, respectively in T_1M_0. These results reveal the fact that less tillage, less mixing of soil and low release of nutrients for crops.

The maximum organic matter (0.99%) was seen in T_1M_0 (minimum tillage + farm manure @ 40 Mg ha^{-1}) while minimum organic matter (0.73%) was noted in T_3M_0 (deep tillage + farm manure @ 0 Mg ha^{-1}). This might be related to the fact that farm manure increases organic matter and minimum tillage decreases organic matter decomposition while deep tillage increases organic matter decomposition by exposing it to environment. As regard tillage, the maximum uptake of N(0.36%), P(0.043%) and K(2.45%) by plant was seen with deep tillage. Maximum value of N(0.06%), P(14.33ppm) and extractable potassium K(200ppm) in soil at harvest was also observed with deep tillage. While maximum soil organic matter (0.88%) was noted with minimum tillage. Regarding farm manure levels, the maximum uptake of N(0.35%), P(0.042%), K(2.52%) by plant and maximum value of N(0.06%), P(13.83ppm), extractable potassium K(200ppm) in soil at harvest was seen with farm level of 40 Mg ha^{-1}. While maximum organic matter (0.97%) was also noted with 40 Mg ha^{-1} level of manure. Liue *et al.* (2003) reported that soil organic matter declined rapidly at early years of cultivation and manure application resulted in a substantial increase in soil organic matter content.

LITERATURE CITED

Angers, D.A. and R.R. Simmered. 1986. Relationship between organic matter content and soil bulk density. Canadian J. Soil Sci. 66:743-746.

Anonymous. 2004. Economic Survey of Pakistan.

Avnimelech, Y. and A. Cohen. 1988. On use of organic manures for amendment of compacted clay soils: Effects of aerobic and anaerobic conditions. Biological Wastes 29:331-339.

Bhatti, H.M., B. Ahmad, R. Ahmad and M. Ahmad. 1977. Brackish water irrigation and soil productivity. Proc. Water Management for Agriculture. Seminar EXXON Chemical Pak. Ltd. 15-17 November, 1977. Vol. 1. p. 306-316.

Blake, G.R. and K.H. Hartge. 1986. Bulk density. P.363-375. In: A. klute (ed.) Methods of soil analysis part 1. Physical and Mineralogical Methods. Agronomy Monograph No. 9, 2nd Ed., Madison, WI, USA.

Celik, I., I. Ortas and S. Kilic. 2004. Effects of compost, mycorrhiza, manure and fertilizer on some physical properties of a chromoxerert. Soil Tillage Res. 78:59-67.

Farahani, H.J., G.A. Peterson and D.G. Westfall. 1998. Dryland cropping intensification: A fundamental solution to efficient use of precipitation. Adv. Agron. 64:197-223.

Higashida, S. and M.Y amagami. 2003. Effects of deep ploughing with concomitant application of farm manure on the productivity of arable crops. Bulletin of Hokkaido-Prefectural Agricultural Experiment Stations. No. 84:55-64.

Jakson, M.L. 1962. Soil chemical analysis. Constable and Co. Ltd., London. p.496.

Khattak, M.K, A.Q. Mughal, M.J. Khan, S.B. Bukhari and G.D. Khan. 2004. Effect of various tillage practices on selected physical properties in clay loam soil under wheat-maize rotation. Sarhad J. Agri. 20:233-241.

Le Bissonnais, Y. 1990. Experimental study and modeling of soil surface crusting processes. In Soil erosion: Experiments and models. p.13-28. Ed. R.B. Bryan. Catena Verlag: Cremlingen-Destedt, USA.

Liu, X.B., X.Z. Han, C.Y. Song, S.J. Herbert and B.S. Hing. 2003. Soil organic carbon dynamics in black soils of China under different Agricultural management systems. Commun. Soil Sci. Plant Anal. 34(7-8): 973-984.

Matsi, T., A.S. Lithourgidis and A.A. Gagianas. 2003. Effects of injected liquid cattle manure on growth and yield of winter wheat and soil characteristics. Agron. J. 95(3): 592-596.

Motavalli, P.P., W.E. Stevens and G. Hartwig. 2003. Remediation of subsoil compaction and compaction effects on corn N availability by deep tillage and application of poultry manure in a sandy texture soil. Soil Tillage Res. 71(2): 121-131.

Reeves, D.W. 1997. The role of soil organic matter in maintaining soil quality in continuous cropping systems. Soil Tillage Res. 43: 131-167.

Ryan, J., G. Estefan and A. Rashid. 2001. Soil and plant analysis. Laboratory Manual 2nd Ed. International Center for Agricultural Research in the Dry Areas (ICARDA), Alleppo, Syria. p.46-48.

Shirani, H., M.A. Hajabbasi, M. Afyuni and A. Hemmat. 2002. Effects of farm yard manure and tillage systems on soil physical properties and corn yield in Iran. Soil tillage Res. 68(2): 101-108.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedure of statistics. 2nd Ed. McGraw-Hill Book Co., NY, USA.