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Residual Effect of Tillage and Farm Manure on Some Soil Physical Properties and Growth of Wheat (*Triticum aestivum* L.)

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ABSTRACT

This study was conducted to investigate the residual effect of tillage and farm manure on soil physical properties and growth of wheat crop. Four tillage methods (Zero, Minimum, Deep and Conventional tillage) and three farm manure levels (control, FM @ 10 and 20 Mg ha^{-1}) were used. Tillage methods significantly affected soil physical properties as they increased field saturated hydraulic conductivity while decreased bulk density of soil. Farm manure significantly affected the soil physical properties and growth of wheat as it increased field saturated hydraulic conductivity, 1000- grain weight, straw and grain yields of wheat and decreased bulk density of soil.

Key Words: Tillage; Farm manure; Wheat; Hydraulic Conductivity; Bulk density

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of Pakistan and is well adapted to its soil and climatic conditions. Although the use of improved varieties and fertilizers has increased wheat production to much extent, the full potential of crop production has not yet been achieved. Soil tillage and manure application are among the important factors affecting soil physical properties and crop yield. Among the crop production factors, tillage contributes up to 20% (Ahmad *et al*., 1996). Tillage method affects the sustainable use of soil resources through its influence on soil properties (Hammel, 1989). The proper use of tillage can alleviate soil related constraints, while improper tillage may cause a range of degradative processes, e.g. destruction of soil structure, accelerated erosion, depletion of organic matter, fertility and disruption in cycles of water, organic carbon and plant nutrients (Lal, 1993). Use of excessive and unnecessary tillage operations is often harmful to soil. Therefore, currently there is a significant interest and emphasis on the shift to the minimum and no-tillage for the purpose of controlling erosion process, increasing water use efficiency of summer crops and improving crop productivity (Buschiazzo *et al*., 1998). But no-tillage systems could not compensate the adverse effects of fine texture, very low organic matter (0.1-0.5%) and an overall initial weak structure of the soil. However, the results of no-tillage are contradictory. No-tillage systems in arid regions of Iran had an adverse effect on crop yields (Hemmat & Taki, 2001), while Chaudhary *et al*. (1992) comparing conventional tillage system to zero tillage, concluded that higher moisture retention and 13% more income was obtained in case of zero tillage. Farmers use implements that are available without considering its suitability under specific conditions (Razzaq *et al*., 1993). In Pakistan, tillage is practiced mainly with a tractor drawn cultivator. This cultivator works the soil to about 0.08-0.15 m depths and continual cultivation to same depth has created a hard pan below 0.15 m, which hinders the movement of water, air and the growth of plant roots (Hassan & Gregory, 1999). Deep tillage breaks up high-density soil layers, improves water infiltration and movement in soil and increase crop production (Bennie & Botha, 1986). Conservation tillage has potential to bring soil quality to a high stage and reduce soil loss by providing protective crop residue on soil surface and improving water conservation by decreasing evaporation losses (Carter, 1991).

Soil organic matter is an important component of soil quality as it determines many soil characteristics such as nutrient mineralization, aggregate stability, aeration and favorable water uptake and retention properties. Recent concern over world wide climatic changes also increased interest in soil organic matter and its role in the global carbon budget through sequestration of atmospheric carbon in soil. A wide range of tillage methods (Moldboard ploughing, disking, harrowing, chiseling, ridge till and their combinations) is being used in Pakistan without evaluating their residual effect on soil properties and crop growth. Therefore, the overall objective of this study was to compare the residual effect of tillage methods and farm manure on soil physical properties and wheat growth under irrigated field conditions.

MATERIALS AND METHODS

This study was conducted on medium textured soil of the Research Area of Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad (Pakistan) to evaluate the residual effect of tillage system and Farm manure on physical properties of soils and yield of wheat. Physical and ionic composition of original soil is given in Table I. Four tillage systems used were Zero, Conventional, Reduced and Deep tillage. Conventional tillage (CT) comprised of one Disk plowing, four Cultivation and two Planking. Weeds were controlled by hoeing along with weedicides throughout growing season. Deep tillage (DT)

comprised of two chiseling with 0.3- 0.4 deep with three shovels spacing 0.45 m apart followed by narrow tine cultivation and planking with wooden planker. Weed control same as in case of conventional tillage. Minimum tillage (MT) comprised two plowing, planking and weed controls same as in case of conventional tillage. The field was not tilled in Zero tillage and herbicides were used to control weeds. Each tillage system comprised of three organic matter levels, i.e. Control, Farm manure @ 10 and 20 Mg ha^{-1}. In CT, DT and MT Farm manure was incorporated in the soil; while in NT it was applied on the surface. Recommended levels of N, P and K were maintained in all plots by adding chemical fertilizers by taking in account nutrient present in Farm Manure. Whole P and K was incorporated at sowing time. Experiment was laid out following Randomized Complete Block design with split plots. Tillage methods were kept in main plots, while treatment combinations in sub plot. Then wheat was sown after maize without addition of FM and any tillage practice because this crop was grown to study the residual effect of FM and tillage methods on soil physical properties and growth of wheat. Wheat was harvested at maturity and straw, total dry matter, 1000-grain weight and grain yields were recorded. Field saturated hydraulic conductivity and soil bulk density were determined at harvest of crop by using Guleph permeameter and core method (Blake & Hartge, 1986), respectively. The data collected were analyzed statistically following methods described by Steel and Torrie (1980). The experiment was conducted without deep tillage and farm manure to evaluate its residual effect.

RESULTS AND DISCUSSION

Residual effect of tillage and farm manure on grain yield of wheat (kg ha^{-1}). Farm manure significantly increased the grain yield of wheat as compared to control (Table II). The maximum mean value of grain yield (3034.4 kg ha^{-1}) was recorded in FM @ 20 Mg ha^{-1} treatment followed by 2683.1 kg ha^{-1} in case of FM @ 10 Mg ha^{-1} and the minimum mean value of grain yield (1015.83 kg ha^{-1}) was recorded in case of control. Mean increase in grain yield observed was 198.71 and 164.12% in farm manure levels @ 20 and 10 Mg ha^{-1}, respectively as compared to control. These findings are in agreement with those of Shirani *et al.* (2002) who reported that manure application improves soil physical properties and provide necessary plant nutrients and thus increase yield. Addition of manure to the soils low in organic matter (<1 %) and with poor soil properties, significantly affects plant yield. As regard tillage methods, the maximum mean value (2376.2 kg ha^{-1}) of grain yield was found in minimum tillage and 2335.0 kg ha^{-1} in case of conventional tillage followed by 2182.9 kg ha^{-1} for deep tillage, while the minimum (2083.7 kg ha^{-1}) grain yield was found in the zero tillage. Mean increase in grain yield observed was 14.0, 12.0 and 4.76% in conventional, minimum and deep tillage, respectively compared to zero tillage, but these differences was statistically non-significant. These results are in corroboration with those of Pikul and Aase (1999) who reported no differences in wheat yields due to sub-soiling and other treatments, average grain yield was 1820 kg ha^{-1} on annual wheat plots and 2380 kg ha^{-1} on wheat fallow plots.

Table I. Physical and ionic composition of original soil used for study

Physical		
Sand	%	58.5
Silt	%	17.5
Clay	%	23.01
Textural class		Sandy clay loam
Soluble anions and cations		
Total Nitrogen	%	0.105
Available Phosphorus	mg kg^{-1}	8.4
Extractable Potassium	mg kg^{-1}	147.7

Table II. Residual effect of tillage and farm manure on grain yield of wheat (kg ha^{-1})

Tillage methods	Control	FM @ 10 Mg ha^{-1}	FM @ 20 Mg ha^{-1}	Mean
Zero tillage	996	2580	2675	2083.67
Minimum tillage	1222	2717	3190	2376.22
Conventional tillage	918	2759	3322	2335.0
Deep tillage	923	2677	2950	2182.89
Mean	1016 C	2683 B	3034 A	

Mean sharing same letter(s) are statistically non-significant at 5% probability

Residual effect of tillage and farm manure on straw yield of wheat (kg ha^{-1}). Regarding tillage methods, statistically there was no effect on straw yield as in case of no-tilled plots (ZT), straw yield was 6497.8 kg ha^{-1} compared to minimum (6914.4 kg ha^{-1}), conventional (6234.4 kg ha^{-1}) and deep (6836.7 kg ha^{-1}) tillage treatments (Table III). Mean increase in straw yield observed was 6.4 and 5.2% in minimum tillage and deep tillage, respectively while there was a decrease of 3.6% in conventional tillage compared to zero tillage, but these differences were statistically non-significant. These results are in corroboration with those of Carter *et al.* (2002) who reported that corn silage yields (straw yields) and nutrient contents were same in both no-till and conventional till because yield variation was associated with variation in plant population rather than tillage or rotational differences. Farm manure, significantly increased the straw yield of wheat compared to control. The maximum straw yield (8784.2) and (8293.3) were recorded in FM @ 20 and 10 Mg ha^{-1} as compared to control (2785.0). Mean increase in straw yield observed was 215.4 and 197.4% in case of FM @ 20 and 10 Mg ha^{-1}, respectively as compared to control. Among the levels of FM both the treatments have (statistically) same effect on straw yield of wheat. These findings are in agreement with those of Shirani *et al.* (2002) who concluded that manure application rates of 30 and 60 Mg ha^{-1} increased dry biomass (straw) yield because manure

application improves soil physical properties and provides the necessary plant nutrients.

Residual effect of tillage and farm manure on1000-grain weight of wheat (g). Data pertaining to 1000-grain weight of wheat is given in Table IV, which revealed that both the tillage methods and farm manure have significant effect on 1000-grain weight of wheat. As regard tillage methods, the maximum mean value of 1000-grain weight (30.5 g) was observed in the deep tillage followed by conventional (28.6 g) and minimum (27.5 g) tillage methods, with the minimum mean value of 26.8g in case of zero tillage. Mean increase in 1000-grain weight observed was 2.8, 6.8 and 14.1% in the minimum, conventional and deep tillage treatments, respectively as compared to zero tillage. These results are in contradiction with those of Gill and Aulakh (1990) who reported that grain yield was influenced by tillage induced compaction but 1000-grain weight and plant height was not affected by tillage. As regard farm manure, it significantly increased the 1000-grain weight of wheat as compared to control. The maximum mean value of 1000-grain weight (29.7 g) was observed in case of FM @ 20 Mg ha^{-1} followed by (28.4 g) in FM @ 10 Mg ha^{-1} and the minimum mean value of 26.8 g was recorded in the control treatment. Mean increase in 1000-grain weight observed was 10.0 and 5.4% in FM @ 20 and 10 Mg ha^{-1}, respectively compared to control. These findings are in agreement with those of Shirani *et al.* (2002) who concluded that manure application rates of 30 and 60 Mg ha^{-1} increased dry biomass (1000-grain weight) yield because manure application improves soil physical properties and provides the necessary plant nutrients.

Residual effect of tillage and farm manure on soil saturated hydraulic conductivity (10^{-4} cm s^{-1}). Soil saturated hydraulic conductivity after wheat harvesting is listed in Table V, which revealed that both the tillage methods and farm manure have significant effect on saturated hydraulic conductivity of soil. As regard tillage methods, the maximum mean value of saturated hydraulic conductivity ($5.9x10^{-4}$ cm s^{-1}) was observed in case of deep tillage while the mean values for the other three tillage methods were 4.4, 4.6 and $4.8x10^{-4}$ cm s^{-1} for the zero, minimum and deep tillage, respectively which were statistically similar. Mean increase in saturated hydraulic conductivity observed was 4.5, 9.1 and 34.1% in the minimum, conventional and deep tillage treatments, respectively compared to zero tillage, indicating that deep tillage increases the saturated hydraulic conductivity when compared to other tillage methods. These results are in corroboration with those of Kribba *et al.* (2001) who reported that hydraulic conductivity values were significantly different between treatments, fallow soil tilled with chisel showed higher values than disc ploughed fallow, and both treatments yielded higher values than untilled fallow. As regard farm manure, it significantly increased the saturated hydraulic conductivity of soil as compared to control. The higher mean value of saturated hydraulic conductivity (5.7×10^{-4} cm s^{-1}) was observed in FM @ 20 Mg ha^{-1} followed by 5.6×10^{-4} cm s^{-1} in FM @ 10 Mg ha^{-1} while the lowest mean value (3.6×10^{-4} cm s^{-1}) was recorded in the control. The FM levels were statistically significant when compared to control but similar when compared among themselves. Mean increase in saturated hydraulic conductivity observed was 58.3 and 55.6% in FM @ 20 and 10 Mg ha^{-1}, respectively compared to control. These findings are in agreement with those of Zachman (1987) and Shirani *et al.* (2002) who reported that manure application improved hydraulic conductivity as the till and no-till residue had higher infiltration than the corresponding no residue treatments.

Residual effect of tillage and farm manure on bulk density of soil (Mg m^{-3}). Analysis of variance clearly indicated that both the tillage methods and farm manure had a significant effect on bulk density of soil, whereas their interactive effect was statistically non-significant (Table VI). As regard tillage methods, higher mean value for bulk

Table III. Residual effect of tillage and farm manure on straw yield of wheat (kg ha^{-1})

Tillage methods	Control	FM @ 10 Mg ha^{-1}	FM @ 20 Mg ha^{-1}	Mean
Zero tillage	2693	8307	8493	6497.67
Minimum tillage	3293	8423	9027	6914.33
Conventional tillage	2507	7860	8337	6234.67
Deep tillage	2646	8583	9280	6836.33
Mean	2785 B	8293 A	8784 A	

Mean sharing same letter(s) are statistically non-significant at 5% probability

Table IV. Residual effect of tillage and farm manure on 1000-grain weight of wheat (g)

Tillage methods	Control	FM @ 10 Mg ha^{-1}	FM @ 20 Mg ha^{-1}	Mean
Zero tillage	25.38	26.44	28.53	26.78 C
Minimum tillage	26.75	28.12	31.58	27.54 BC
Conventional tillage	27.27	28.65	29.86	28.59 B
Deep tillage	28.52	30.60	32.52	30.55 A
Mean	26.98 C	28.45 B	30.62 A	

Mean sharing same letter(s) are statistically non-significant at 5% probability

Table V. Residual effect of tillage and farm manure on soil saturated hydraulic conductivity (10^{-4} cm s^{-1})

Tillage methods	Control	FM @ 10 Mg ha^{-1}	FM @ 20 Mg ha^{-1}	Mean
Zero tillage	2.9	5.0	5.3	4.4 B
Minimum tillage	3.1	5.3	5.3	4.6 B
Conventional tillage	3.4	5.5	5.6	4.8 B
Deep tillage	4.9	6.4	6.5	5.9 A
Mean	3.6 B	5.6 A	5.7 A	

Mean sharing same letter(s) are statistically non-significant at 5% probability

density (1.51 Mg m^{-3}) was observed in case of zero followed by minimum (1.49 Mg m^{-3}) and conventional (1.46 Mg m^{-3}) tillage methods, whereas the lowest mean value for bulk density (1.42 Mg m^{-3}) was observed in case of deep tillage. The results show that there was a significant decrease in bulk density with increase in the depth of tillage. Mean decrease in bulk density observed was 1.3, 3.4 and 6.3% in case of minimum, conventional and deep tillage, respectively compared to zero tillage, indicating that deep tillage decreases the bulk density compared to other tillage methods. These results are in corroboration with those of Diaz-Zorita (2000) who reported that the bulk density in the 3-20 cm layer of the soils was significantly increased when the intensity of the tillage system decreased. The deep tillage treatment significantly decreased the bulk density in the no-tilled soils but not in the tilled soils probably because of breaking hard layers of soils and increasing pore-size distribution. As regard farm manure, it significantly decreased the bulk density of soil as compared to control. The higher mean value for bulk density (1.50 Mg m^{-3}) was observed in the control (without FM) followed by 1.46 Mg m^{-3} and 1.44 Mg m^{-3} in case of FM @ 10 and 20 Mg ha^{-1}, but both the farm manure levels had statistically similar value of soil bulk density. These findings are in agreement with those of Shirani *et al.* (2002) who reported that manure applications significantly decreased bulk density on the row due to the effect of manure accumulation and root density because root activity can increase porosity and decrease bulk density.

Table VI. Residual effect of tillage and farm manure on bulk density of soil (Mg m^{-3})

Tillage methods	Control	FM @ 10 Mg ha^{-1}	FM @ 20 Mg ha^{-1}	Mean
Zero tillage	1.55	1.50	1.47	1.51 A
Minimum tillage	1.53	1.48	1.45	1.49 AB
Conventional tillage	1.49	1.46	1.43	1.46 B
Deep tillage	1.44	1.42	1.40	1.42 C
Mean	1.50 A	1.46 B	1.44 B	

Mean sharing same letter(s) are statistically non-significant at 5% probability

CONCLUSION

Farm manure and tillage carries its impact on soil physical properties and nutrient status of soils. Farm manure has its positive role in maintaining physical health of soils conducive to crop growth as farm manure takes time to decompose completely. It is having its residual effect on succeeding crop. Farm manure significantly increased field saturated hydraulic conductivity, grain and wheat straw production. It also reduces soil bulk density. Tillage also significant increased field hydraulic conductivity and decreased soil bulk density.

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