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Nutrient (N, P and K) Content in Soil and Plant as Affected by the Residual Effect of Tillage and Farm Manure

MUHAMMAD IQBAL, ANWAR-UL-HASSAN, M. RIZWANULLAH AND AMANAT ALI
Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad–38040, Pakistan

ABSTRACT

Farm manure and tillage management are among the important factors affecting soil physical properties and crop yield. A field study was conducted to investigate the residual effect of tillage and farm manure on N, P and K content in soil and plant shoot in wheat. The experiment was laid out in randomized complete block design with split plots. Four tillage methods (zero, minimum, deep and conventional tillage) and three farm manure levels (control, FM @ 10 and 20 Mg ha^{-1}) were used in the previous crop/year. Wheat was grown up to maturity and levels of N, P and K in soil and plant were determined. Tillage methods significantly increased K content in wheat shoots only, while their effect on K in soil and N and P content both in shoot and soil was non-significant. Farm manure significantly increased N content in wheat shoots, P content in soil and K content both in wheat shoots and soil, while its effect on P content in wheat shoots and N content in soil was non-significant.

Key Words: Tillage; Farm manure; Wheat; Residual effect; N, P, K content

INTRODUCTION

Sustainable agriculture in Pakistan is not only the management and conservation of soil and water but also a steady and substantial increase in crop yields (Ahmad *et al*., 1996). Average yields of major crops are lower at farmer's level than other countries (FAO, 1993; Economic Survey, 1997-1998). Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of Pakistan and is well adapted to its soil and climatic conditions. Average yield of 2262 kg ha^{-1} of wheat in Pakistan is for less than the potential of cultivars and soils (Anonymous, 2002). Although the use of improved varieties and fertilizers application enhanced the production, full potential of crop production has not been achieved (Anonymous, 1994). Among the crop production factors tillage contributes up to 20% (Ahmad *et al*., 1996). The proper tillage practices can alleviate soil related constraints while improper tillage may cause a range of derogative processes. Tillage has been a principal tool for weed control, loosening crusted and compacted soil surface and preparing a loose and friable seedbed. Reduced and no tillage management for production of crops to decrease soil erosion and loss of organic matter, reduce fuel and labor cost and conserve soil water as compared with conventional tillage management. 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 change also increased interest in soil organic matter and its role in the global carbon budget. Moreover, residual effect of organic matter on soil properties and crop growth is rarely studied under our conditions. More recent developments in herbicide technology have provided opportunities to use chemical weed control using little or no tillage. The soil itself is more stable since it has not been broken loose by tillage and also natural channels left in soil by decaying plant roots and soil organisms allow the water to penetrate more easily (Blevins, 1981). Tillage operation carried out with heavy machinery tends to compact the soil as bulk density of soil have increased (Soane *et al*., 1981). In Pakistan most of the farmers are using shovel type cultivator for primary and secondary tillage operations having maximum depth from 8 cm (Rafiq, 1990) to 15 cm (Razzaq *et al*., 1993), while in developed countries mould board and chisel plough (>0.25m depth) are being used for primary tillage (Unger & Mc Calla, 1980). However, the physics of tillage has not made as much progress as that, for example made by the chemistry of nutrient requirement. Wide ranges of tillage methods are being used in Pakistan without the benefits of experimental data on their comparative effects on soil porosity, crop growth and nutrient composition of plants. Thus, it is important to study residual effects of tillage and farm manure on N, P and K concentrations under local field conditions.

MATERIALS AND METHODS

This study was conducted on sandy clay loam soil (Table I) to evaluate the residual effect of tillage system and farm manure on nutrients concentration in soil and plant. Four tillage systems were used, i.e. Zero tillage, Conventional tillage, Minimum tillage and Deep tillage. Physical methods, i.e. hoeing along with weedicides were used for controlling weeds throughout growing season. In Minimum tillage (MT) the field operation comprised two plowing and two planking, and weeds were controlled by same methods as in case of conventional tillage. In case of

zero tillage (NT) soil was not tilled and herbicides were used whenever needed to control weeds. Each tillage system was comprised following three organic matter levels: control, farm manure @ 10 and 20 Mg ha^{-1} in case of previous maize crop. In CT, DT and MT Farm yard manure was incorporated in the soil while in NT it was applied on the surface. It showed comparative effectiveness of incorporation of farm manure into the soil. Recommended levels of N, P and K were maintained in all plots by adding chemical fertilizers. Whole P and K were incorporated at sowing time. Wheat variety Inqulab-91 was used and seed rate of 50 kg per acre was used. Experiment was laid out following randomized complete block design with split plots. Tillage methods were kept in main plots, while farm manure levels in sub plot. For determination of N, P and K both from soil and plant samples recommended methods (Ryan *et al.*, 2001) were followed. Soil samples were collected from 0-0.15m at harvest of wheat and were analyzed for N, P and K concentrations. The data collected were analyzed statistically following methods described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Residual effect of tillage and farm manure on total-N content in shoot of wheat at maturity. The data regarding the effect of tillage and farm manure on total-N content in soil is presented in Table II, which revealed that the tillage methods have statistically non-significant effect with respect to this parameter as in the no-tilled plots, N contents were 0.39% compared to minimum (0.35%), conventional (0.39%) and deep (0.33%) tillage methods. These results are in line with those of Moshler and Marteus (1974) who reported that the concentrations of N, P and K in maize were not affected by no-till and conventional tillage methods on a silt loam soil. As regard farm manure, it significantly increased the N contents of wheat shoots as the higher mean value for N contents (0.44%) was observed in FM @ 20 Mg ha^{-1} followed by 0.43% for FM @ 10 Mg ha^{-1} treatments which were statistically similar to each other. Least mean value for N contents of wheat shoots (0.23%) was observed in case of control. Mean increase in N observed was 81.55% and 87.98% in case of FM @ 10 and 20 Mg ha^{-1}, respectively as compared to control. These results are in agreement with those of Acharya and Sharma (1994) who reported that the mulched treatments favourably moderated the hydrothermal regime resulting in greater root growth, nutrient uptake and grain yields of maize and wheat. The interactive effect of tillage methods with farm manure on total-N content was found statistically non-significant.

Residual effect of tillage and farm manure on total-P in shoot of wheat at maturity. The data regarding the effect of tillage and farm manure on total-P is listed in Table III, which revealed that the tillage methods and manure applications had statistically no effect with respect to this parameter. As regard tillage methods, it was revealed that

Table I. Physical and chemical characteristics of original soil used for study

Characteristics	Values
Sand (%)	58.5
Silt (%)	17.5
Clay (%)	23.01
Textural class (%)	Sandy clay loam
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 total-N content (%) in shoot of wheat at maturity

Tillage methods	Control	FM @ 10 Mg ha^{-1}	FM @ 20 Mg ha^{-1}	Mean
Zero tillage	0.233	0.47	0.47	0.39
Minimum tillage	0.233	0.41	0.41	0.35
Conventional tillage	0.233	0.47	0.47	0.39
Deep tillage	0.233	0.35	0.41	0.33
Mean	0.233 B	0.423 A	0.438 A	

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

Table III. Residual effect of tillage and farm manure on total-P (%) in shoot of wheat at maturity

Tillage methods	Control	FM @ 10 Mg ha^{-1}	FM @ 20 Mg ha^{-1}	Mean
Zero tillage	0.075	0.100	0.110	0.095
Minimum tillage	0.080	0.120	0.129	0.111
Conventional tillage	0.079	0.118	0.127	0.108
Deep tillage	0.083	0.130	0.140	0.118
Mean	0.079	0.117	0.126	

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

total-P in shoot of wheat at maturity was statistically similar in all the tillage methods as in the zero tillage plots, it was 0.10% compared to minimum (0.11%), conventional (0.118%) and deep (0.12%) tillage methods. These results are in line with those of Moshler and Marteus (1974) who reported that the concentrations of N, P and K in maize were not affected by no-till and conventional tillage on a silt loam soil. As regard farm manure, higher mean value for P was observed in FM @ 20 Mg ha^{-1} treatment which was 0.126% followed by 0.12% in case of FM @ 10 Mg ha^{-1} with the lowest P, i.e. 0.08% observed in case of control. Mean increase in P concentration was 23.2% and 32% in case of FM @ 10 and 20 Mg ha^{-1} respectively, as compared to control. However, these differences were statistically non-significant. These results contradict those of Acharya and Sharma (1994) who reported that the mulched treatments favourably moderated the hydrothermal regime resulting in greater root growth, nutrient uptake and grain yields of maize and wheat. The interaction of tillage methods with farm manure on total-P was non-significant.

Residual effect of tillage and farm manure on K content in shoot of wheat at maturity. Data pertaining to the K content in wheat shoot at maturity is given in Table IV, which revealed that both tillage methods and manure applications had statistically significant effect with respect

to this parameter. As regard tillage methods, maximum mean value 2.2% was found in deep tillage, which indicated that nutrient availability, is increased due to loosening of soil by deep tillage. This value was followed by conventional (2.20%) and minimum (2.18%) tillage treatments, which were statistically at par with each other and also similar with deep tillage treatment. Least mean value was found in zero tillage method, i.e. 1.98%. This showed that compaction due to no-tillage reduced soil macroporosity, which in turn decreased mobility of nutrients. These results are in conformity with those of Daniel *et al.* (1988) who reported that increased soil strength reduced root penetration and nutrient uptake by plants. As regard farm manure, higher mean value for K (2.46%) was observed in FM @ 20 Mg ha^{-1} treatment followed by 2.41% in case of FM @ 10 Mg ha^{-1} which were similar with each other. Least mean value (0.08%) was observed in the control treatment. Mean increase in K observed was 31.9% and 58.2% in case of FM @ 10 and 20 Mg ha^{-1}, respectively compared to control. These results are in agreement with those of Acharya and Sharma (1994) who reported that the mulched treatments favourably moderated the hydrothermal regime resulting in greater root growth, nutrient uptake and grain yields of maize and wheat. The interactive effect of tillage methods with farm manure on K content was non-significant.

Residual effect of tillage and farm manure on total-N content in soil at harvest of wheat. The data regarding the effect of tillage and farm manure on total-N contents in soil at harvest of wheat are presented in Table V, which revealed that the tillage methods and manure applications had statistically no effect with respect to this parameter. As regard tillage methods, data pertaining to nitrogen percentage revealed that total-P in shoot of wheat at maturity was statistically similar in all the tillage methods as in no-tilled plots, it was 0.07% compared to minimum (0.078%), conventional (0.072%) and deep (0.0702%) tillage methods. These results are in agreement with those of Carter *et al.* (2002) who noted that in the soil samples significant differences were not evident among treatments for extractable ions and organic carbon in the plough layer depth. As regard farm manure, higher mean value for N contents in soil at harvest (0.08%) was observed in FM @ 20 Mg ha^{-1} treatment followed by 0.73% in case of FM @ 10 Mg ha^{-1} and the least value for N contents in soil (0.06%) was observed in the control. These results are in contrast to those of Halvin *et al.* (1990) who reported that more labile organic matter results in short-term influences on soil physical and chemical properties including aggregate stability and nutrient availability. The interactive effect of tillage methods with farm manure on total-N content in soil at harvest of wheat was non-significant.

Residual effect of tillage and farm manure on total-P in soil at harvest of wheat. The data regarding the effect of tillage and farm manure on total-P in soil are presented in Table VI, which revealed that the tillage methods have statistically non-significant effect with respect to this parameter as in the no-tilled plots, P contents were 12.1 ppm as compared to minimum (14.9 ppm), conventional (13.0 ppm) and deep (14.8 ppm) tillage methods. These results are in line with those of Selles (1999) who reported that the Olsen P in soil was highly variable and was not affected by tillage and rotational treatments. As regard farm manure, higher mean value for P contents (16.7 ppm) was observed in case of FM @ 20 Mg ha^{-1} followed by 13.9 ppm in case of FM @ 10 Mg ha^{-1} and the least value (10.5 ppm) was observed in the control where no manure was added. Mean increases in P observed were 23.2% and 32% in case of FM @ 10 and 20 Mg ha^{-1}, respectively as compared to control.

Table IV. Residual effect of tillage and farm manure on K content (%) in shoot of wheat at maturity

Tillage methods	Control	FM @ 10 Mg ha^{-1}	FM @ 20 Mg ha^{-1}	Mean
Zero tillage	1.45	2.19	2.312	1.983 B
Minimum tillage	1.66	2.42	2.47	2.184 A
Conventional tillage	1.564	2.51	2.53	2.198 A
Deep tillage	1.640	2.53	2.55	2.240 A
Mean	1.578 B	2.412 A	2.464 A	

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

Table V. Residual effect of tillage and farm manure on total-N content (%) in soil at harvest of wheat

Tillage methods	Control	FM @ 10 Mg ha^{-1}	FM @ 20 Mg ha^{-1}	Mean
Zero tillage	0.064	0.0700	0.076	0.0703
Minimum tillage	0.065	0.0760	0.094	0.0780
Conventional tillage	0.059	0.0760	0.082	0.0720
Deep tillage	0.064	0.0700	0.076	0.0702
Mean	0.063	0.0732	0.082	

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

Table VI. Residual effect of tillage and farm manure on total-P (ppm) in soil at harvest of wheat

Tillage methods	Control	FM @ 10 Mg ha^{-1}	FM @ 20 Mg ha^{-1}	Mean
Zero tillage	8.67	12.17	15.50	12.11
Minimum tillage	12.33	15.08	17.33	14.92
Conventional tillage	9.42	13.83	15.67	12.97
Deep tillage	11.75	14.50	18.17	14.81
Mean	10.54 C	13.90 B	16.67 A	

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

Table VII. Residual effect of tillage and farm manure on K content (ppm) in soil at harvest of wheat

Tillage methods	Control	FM @ 10 Mg ha^{-1}	FM @ 20 Mg ha^{-1}	Mean
Zero tillage	123.27	132.73	133.27	129.76
Minimum tillage	124.73	132.93	137.73	130.80
Conventional tillage	124.67	135.40	135.33	131.80
Deep tillage	125.33	136.60	138.00	133.31
Mean	124.5 B	134.4 A	135.3 A	

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

These results corroborate those of Weil *et al.* (1988) who reported increase in available P due to organic matter accumulation at or near the surface, which decreases P sorption by inorganic colloids. The interactive effect of tillage methods with farm manure on total-P in soil at harvest of wheat was non-significant.

Residual effect of tillage and farm manure on total-K content in soil at harvest of wheat. Data pertaining to the K content in soil at harvest of wheat is given in Table VII, which revealed that the tillage methods have statistically non-significant effect. As in the no-tilled plots, K contents were 129.8 ppm as compared to minimum (130.8 ppm), conventional (131.8 ppm) and deep (133.3 ppm) tillage methods. These results are in agreement with those of Carter *et al.* (2002) who noted that in the soil samples significant differences were not evident among treatments for extractable ions and organic carbon in the plough layer depth. As regard farm manure, it increased the K contents significantly. Higher K contents of soil (135.3 ppm) were observed in case of FM @ 20 Mg ha^{-1} followed by 134.4 ppm in case of FM @ 10 Mg ha^{-1}, which was statistically similar with each other. Least mean value for K contents in soil (124.5 ppm) was observed in the control where no manure was added. Mean increase in K contents observed were 8.0 and 8.7% in case of FM @ 10 and 20 Mg ha^{-1}, respectively as compared to control. These results have some similarity with those of Halvin *et al.* (1990) who reported that more labile organic matter results in short-term influences on soil physical and chemical properties including aggregate stability and nutrient availability. The interactive effect of tillage methods with farm manure on K content in soil at harvest of wheat was non-significant.

CONCLUSIONS

Tillage methods used in seedbed preparation including deep tillage have their impact on nutrients concentration in soil and plants and ultimately on production when compared with zero tillage. K content was significantly increased in wheat shoots, while its effect on K in soil and N and P concentration was statistically non- significant. Farm manure significantly increased total-N content in wheat shoot, total-P content in soil and total-K content in wheat shoot and soil.

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