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Residual effects of different tillage systems, bioslurry and poultry manure on soil properties and subsequent wheat productivity under humid subtropical conditions of Pakistan

Khuram Shahzad[1,2*], Ayub Khan[1], Jo U. Smith[2], Muhammad Saeed[1], Sher Aslam Khan[1], Shah Masaud Khan[1]

[1] *Department of Agriculture, University of Haripur, Haripur, Khyber Pakhtunkhwa, Pakistan*

[2] *Institute of Biological and Environmental Sciences, University of Aberdeen, 23 St. Machar Drive, Aberdeen, Scotland, United Kingdom*

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Abstract

The residual effects of bioslurry and composted poultry manure on soil properties and subsequent crop productivity have not yet been studied in detail under humid subtropical conditions of Pakistan. Therefore, field studies were conducted at Gujjar Seed and Nursery Farm, Haripur, Pakistan, during 2012-2013 to determine the residual effects of different nitrogen (N) sources and tillage systems on soil properties and subsequent wheat crop in a randomized-complete-block-design with split-plot arrangement and four replicates. The tillage systems (minimum, conventional and deep) were distributed in main plots, while N sources (bioslurry, poultry manure and chemical fertilizer) with three percentages of recommended N application rates (100, 50 and 25%) that were applied to previous maize crops, were distributed in sub-plots. The results showed that N treatments significantly ($p \leq 0.05$) affected soil properties (total soil N, available soil phosphorus (P), potassium (K) and soil organic matter (SOM) contents), wheat productivity (plant height, spike length, 1000-grain weight, grain yield and biological yield), and plant N, P and K concentrations in plant shoots at crop harvest. By contrast, tillage systems had a non-significant ($p > 0.05$) effect on all the parameters except SOM contents The interactive effect of tillage systems and N treatments were significant ($p \leq 0.05$) on 1000-grain weight, soil total N, soil available P, K, and SOM contents at wheat harvest. It is concluded that application of bioslurry and composted poultry manure has residual effects on the next crop and has potential to increase yield of subsequent crop by reducing the cost of chemical fertilizer.

* **Corresponding Author:** Khuram Shahzad ✉ s.khuram.50@aberdeen.ac.uk

Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crop grown in Pakistan after maize and rice (Aslam *et al.*, 1988). It is mainly grown in rotation with maize (*Zea mays* L.), both crops being nutrient hungry and depleting the soil of nutrients (Shahzadi *et al.*, 2014). When grown as part of a continuous intensive cereal based cropping system, with frequent cultivation, imbalance in application of chemical fertilizers and inadequate application of organic residues, these crops can severely degrade the soil (Shehzadi *et al.,* 2014).

The soil organic matter (SOM) is important for maintaining soil fertility and productivity. Soils in Pakistan contain low levels of SOM, usually less than 10 g kg^{-1} (GOP, 2013), compared to optimum levels of 25-30 g kg^{-1} for productive soils (Islam, 2006). The application of organic fertilizers together with chemical fertilizer is therefore necessary to sustain soil fertility and the levels of SOM required for sustainable high yields.

The use of bioslurry, the solid residue from anaerobic digestion, as an organic fertilizer is not well known to farmers in Pakistan, and little research has been done to test the effectiveness of bioslurry in improving productivity of different crops and residual effects to subsequent crops in Pakistan. Bioslurry contains available nitrogen (N), phosphorus (P), potassium (K) and micronutrients (Gupta, 2007), and can be used as a soil conditioner to improve soil physical properties by increasing the SOM content (Nasir *et al.*, 2012).
Poultry manure is another potential source of organic fertilizer. The poultry industry is growing rapidly in Pakistan, due to the high demand for chicken products, producing a large quantity of poultry manure as waste. This can be used as an effective organic fertilizer because it contains high levels of all macronutrients required for plant growth and improves the soil physical and chemical properties by increasing SOM content.

Excessive tillage can result in deterioration of the soil structure, accelerating the decomposition of SOM by exposing a higher surface area to the decomposers in the soil (Lal, 1993). In Pakistan, farmers mainly use tractor drawn machinery to cultivate soils to a depth of 8-15 cm. Continuous cultivation to the same depth can lead to the build-up of a hard pan below 15 cm depth. This hard pan is harmful to plant growth by obstructing the movement of air and water and the growth of plant roots below the pan (Iqbal *et al.*, 2005). Therefore, deep tillage to break up this hard pan has potential to improve crop production.

For long term sustainable crop production, it is necessary to increase the SOM content, either by adding organic waste alone or in combination with chemical fertilizers to get maximum benefits from residual effects to improve soil fertility and crop productivity. Shehzadi *el al.* (2014) studied the residual effects of farmyard manure, crop residues, municipal solid waste (MSW) and filter cake on wheat under a wheat-maize crop rotation and concluded that MSW and filter cake had a long term residual effect on crop production. Ghosh *et al.* (2004) investigated the residual effects of farmyard manure, poultry manure and phosphocompost on soybean, sorghum and wheat crop, and observed that application of 75% NPK fertilizer to wheat crops produced high grain yields due to the residual effects of organic wastes on the succeeding wheat crop; this saved 25% of the inorganic NPK fertilizer.

The residual effects of bioslurry and composted poultry manure on wheat production have not yet been investigated under different tillage systems in humid subtropical conditions of Pakistan. Therefore, this study is designed to investigate and compare the residual effect of tillage, bioslurry and poultry manure on soil properties and yield of wheat in the humid subtropical climatic conditions of Pakistan.

Materials and methods

Field Site

The field experiments were conducted during 2012-13 at the Gujjar Seed and Nursery Farm, Mang, Haripur, Pakistan (LAT. 33.90˚N, LONG. 72.91˚E and ALT. 565 m) to study the residual effect of tillage practices (minimum, conventional and deep tillage), and N treatments (chemical fertilizer, bioslurry and poultry manure) on soil properties and productivity of a subsequent wheat (*Triticum aestivum*) crop. The climate of the Haripur in Hazara division is humid subtropical (Köppen Climate Classification), categorized by high temperature and evenly distributed rainfall throughout the year. Meteorological data for the experimental site is given in Figure 1. The soil of the experimental site at 0-30 cm soil depth had a soil texture of silt loam, pH of 7.8, organic matter of 5.1 g kg^{-1}, total N of 0.24 g kg^{-1}, available P of 1.35 mg kg^{-1} and extractable K of 53 mg kg^{-1} prior to organic fertilizer application for the maize crop (Shahzad *et al.* 2015a), while the physio-chemical characteristics of experimental site after harvest of maize are given in Table 1.

Organic Fertilizers

The bioslurry, derived from cattle manure, was collected from a 35 m^3 biogas plant located at Muhammad Siddique Farm, Changi Bandi, Haripur, Pakistan and was air dried under shaded conditions. The poultry manure was also collected from same farm and allowed to decompose naturally by heaping into pits under shade for three months. The bioslurry contained 0.016 g g^{-1} N, 0.0157 g g^{-1} P, 0.0135 g g^{-1} K and 0.59 g g^{-1} organic matter, while poultry manure contained 0.018 g g^{-1} N, 0.0142 g g^{-1} P, 0.0126 g g^{-1} K and 0.62 g g^{-1} organic matter. The N treatments applied to previous maize crop (2012) are described in Table 2.The bioslurry and poultry manure were applied in different treatment plots three weeks before sowing a maize crop as on 8^{th} of July in 2012 and the maize crop was harvested as on 4^{th} of November in 2012.

Field Trials

The wheat variety Atta Habib was sown on the same trial plots, immediately following harvest of the maize crop on 25^{th} November 2012, by an automatic rabi drill with row to row distance 15 cm. The experiment was laid out using a randomized complete block design (RCBD) with a split plot arrangement. The tillage systems were kept in the main plots while N treatments were distributed in sub plots. Each treatment was repeated four times. Net plot size was 4.5 m × 4.5 m. For the previous maize crop, minimum tillage was carried out using rotavator, conventional tillage by tine plough and deep tillage by chisel plough followed by planking. Management by minimum till, conventional tillage and deep tillage was done at the time of wheat sowing. No bioslurry or poultry manure was applied to the wheat crop; therefore differences in soil properties and productivity can be attributed to residual effects of the tillage practices and N treatments applied to the previous maize crop.The recommended rates of N, P and K were applied to the previous maize crop; 135, 125 and 125 kg ha^{-1}, respectively. The recommended rates of N, P and K were applied to the current wheat crop; 60, 50 and 50 kg ha^{-1}, respectively (Table 2). The chemical fertilizer N was applied as urea and di-ammonium phosphate, P as di-ammonium phosphate and K as potassium sulphate. The crop was irrigated at two week intervals whenever needed in addition to the rainfall received during the growing period up until the physiological maturity of the crop. Other agronomic management practices, such as the insecticide application, were equivalent for all treatments. The agronomic parameters (plant height, spike length, 1000-grain weight, grain and biological yield) were measured at wheat harvest on the 13^{th} April 2013. The soil samples (0-30 cm depth) were collected at crop harvest and total soil N was measured by the Kjeldhal digestion method (Bremner and Mulvancy, 1982), available P by a spectrophotometer (Watanabe and Olsen, 1965), available K by using a flame photometer (Knudsen *et al.*, 1982) and SOC contents by the modified Walkley-Black method (Walkley and Black, 1934). Plant samples were also collected at harvest and digested using the approach given by Moore and Chapman (1986). Plant N concentration was measured by the Kjeldhal method, P concentration by Yoshida *et al.*(1976) and K concentrations by flame photo meter.

Statistical analysis

Data collected from crop growth and yield parameters of the crops were analysed separately according to procedure relevant to RCBD split plot design and treatment means were compared by the Tukey's Honesty Significant Difference (HSD) test at $p<0.05$ and used to identify significant components of the treatment means (Steel and Torrie, 1984).

Results

The residual effect of tillage systems was non-significant ($p>0.05$) on plant height, spike length, 1000-grain weight, grain yield, biological yield, plant N, P and K concentrations in the wheat shoot at harvest, and total soil N, available P and available K, while a significant ($p \le 0.05$) effect was observed on the SOM content (Table 3, 4).

Table 1. Physico-chemical characteristics of experimental site after harvesting of maize.

Treatments	Soil organic matter (g kg^{-1})[1]	Soil total N (g kg^{-1})[2]	Available P (mg kg^{-1}soil)[2]	Extractable K mg kg^{-1} soil[2]	Soil bulk density (g/cm^3)[2]
N_1	4.95	0.22	1.26	46.5	1.43
N_2	5.00	0.54	1.63	55.8	1.42
N_3	5.76	0.38	2.27	119.8	1.34
N_4	5.90	0.33	2.50	147.1	1.32
N_5	5.14	0.49	2.23	97.3	1.40
N_6	5.15	0.47	2.35	131.1	1.39
N_7	5.48	0.34	2.49	145.6	1.33
N_8	5.22	0.54	2.18	86.9	1.41
N_9	5.59	0.42	2.26	109.9	1.38
N_{10}	5.64	0.34	2.45	140.4	1.35

Notes: [1]values from Shahzad *et al.* (2015 b), [2] values from Shahzad *et al.* (2015 c), N_1 (no N applied), N_2 (100%N applied as chemical fertilizer to previous maize crop), N_3 (100% N applied as poultry manure to previous maize crop), N_4 (100%N applied as bioslurry to previous maize crop), N_5 (50%N applied as chemical fertilizer and 50% as poultry manure to previous maize crop), N_6 (50%N as chemical fertilizer and 50% as bioslurry to previous maize crop), N_7 (50%N as poultry manure and 50% as bioslurry to previous maize crop) N_8 (50%N applied as chemical fertilizer, 25% as poultry manure and 25% as bioslurry to previous maize crop), N_9 (25%N applied as chemical fertilizer, 50% as poultry manure and 25% as bioslurry to previous maize crop) and N_{10} (25% N applied as chemical fertilizer, 25% as poultry manure and 50% as bioslurry to previous maize crop).

The residual effects of N treatment were significant ($p \le 0.05$) on all parameters under study (Table 3, 4). Maximum values were observed in the wheat crop following treatment N_4 (100% N applied as bioslurry to the previous crop) for plant growth (plant height =104.9 cm and spike length = 10.88 cm), crop yield (1000-grain weight = 54.46 g, grain yield = 3.55 t ha^{-1} and biological yield = 13.90 t ha^{-1}), most plant nutrients (plant N = 4.69 g kg^{-1} and P in wheat shoots at harvest = 1.22 g kg^{-1}) and soil characteristics (total N = 0.38 g kg^{-1}, available P = 2.51 mg kg^{-1}, available K = 149.87 mg kg^{-1} and SOM = 5.9 g kg^{-1}). Maximum plant K in wheat shoots at harvest (24.67 g kg^{-1}) was observed following treatment N_3 (100% N applied as poultry manure to the previous crop).Following treatment N_4, the increases observed over treatment N_1 (where no N was applied to the previous crop) in plant growth were 52% in plant height and 5% in spike length; in crop yield were 15% in 1000-grain weight, 4% in grain yield and 3% in biological yield; in nutrients in the plant were 13% in plant N and 22% in P concentrations in wheat shoots at harvest, and in soil characteristics were 90% in total N, 88% in available P, 178% in available K and 20% in SOM . The wheat crop following treatment N_3 (100% N applied as poultry manure to the previous crop) showed the next best results after treatment N_4 (100% N applied as bioslurry to the previous crop).

The residual effect of tillage systems and N treatments was significant ($p \le 0.05$) on 1000-grain weight, soil total N, available P, available K and SOM contents (Figure 2), while a non-significant (p>0.05) effect was observed on plant height, spike length, grain yield, biological yield, and plant N, P and K contents of wheat shoots at harvest. However, the maximum 1000-grain weight (54.50 g) was observed following deep tillage with treatment N_4 (100% N applied as bioslurry in previous crop), while the maximum soil total N (0.40 g kg^{-1}), available P (2.60 mg kg^{-1}), available K (156.5 mg kg^{-1}) and SOM (5.94 g kg^{-1}) contents were observed following the minimum tillage with treatment N_4 (100% N applied as bioslurry in previous crop).

Table 2. Combinations of organic and inorganic source of fertilizer treatments used in the trials.

	Fertilizer treatment plan for previous maize crop					Fertilizer treatment plan for wheat crop subsequent to maize crop				
	PM (t ha^{-1})	BS (t ha^{-1})	Chemical fertilizer (kg ha^{-1})			PM (t ha^{-1})	BS (t ha^{-1})	Chemical fertilizer (kg ha^{-1})		
			N	P	K			N	P	K
N_1	-	-	-	-	-	-	-	-	-	-
N_2	-	-	135 (100%)[1]	125 (100%)	125(100%)	-	-	60 (100%)	50 (100%)	50 (100%)
N_3	7.5(100%)[1]	-	-	125 (100%)	125(100%)	-	-	60 (100%)	50 (100%)	50 (100%)
N_4	-	8.4(100%)[1]	-	125 (100%)	125(100%)	-	-	60 (100%)	50 (100%)	50 (100%)
N_5	3.8(50%)[2]	-	67.5 (50%)[2]	125 (100%)	125(100%)	-	-	60 (100%)	50 (100%)	50 (100%)
N_6	-	4.2(50%)[2]	67.5 (50%)	125 (100%)	125(100%)	-	-	60 (100%)	50 (100%)	50 (100%)
N_7	3.8(50%)[2]	4.2(50%)[2]	-	125 (100%)	125(100%)	-	-	60 (100%)	50 (100%)	50 (100%)
N_8	1.9(25%)[3]	2.1(25%)[3]	67.5 (50%)	125 (100%)	125(100%)	-	-	60 (100%)	50 (100%)	50 (100%)
N_9	3.8(50%)[2]	2.1(25%)[3]	33.8 (25%)[3]	125 (100%)	125(100%)	-	-	60 (100%)	50 (100%)	50 (100%)
N_{10}	1.9(25%)[3]	4.2(50%)[2]	33.8 (25%)	125 (100%)	125(100%)	-	-	60 (100%)	50 (100%)	50 (100%)

Notes: PM (Poultry manure), BS (Biogas slurry) [1]100% of recommended nitrogen application rate (135 kg ha^{-1}); [2]50% of recommended nitrogen application rate; [3]25% of recommended nitrogen application rate ,N_1 (no N applied), N_2 (100%N applied as chemical fertilizer), N_3 (100% N applied as poultry manure), N_4 (100%N applied as bioslurry), N_5 (50%N applied as chemical fertilizer and 50% as poultry manure), N_6 (50%N as chemical fertilizer and 50% as bioslurry), N_7 (50%N as poultry manure and 50% as bioslurry) N_8 (50%N applied as chemical fertilizer, 25% as poultry manure and 25% as bioslurry), N_9 (25%N applied as chemical fertilizer, 50% as poultry manure and 25% as bioslurry) and N_{10} (25% N applied as chemical fertilizer, 25% as poultry manure and 50% as bioslurry).

Discussion

Increased plant height, 1000-grain weight and grain yield were recorded following the deep tillage compared to the minimum tillage system, while increased biological yield was recorded following the conventional tillage system (Table 2).The increase in all plant growth and yield parameters except the 1000-grain weight was statistically non-significant. The increase of plant growth and yield in deep tillage are likely to be due to increased uptake of soil nutrients. Ozpinar (2005) reported significant effects of tillage systems on 1000-grain weight. Our results are also consistent with the results of Iqbal (2006) who investigated the residual effect of different tillage systems and found a non-significant effect of different tillage practices on wheat growth.

Higher plant N, P and K concentrations were recorded in wheat shoots at harvest following the deep tillage systems. Adeleye and Ayeni (2012) observed that decrease in soil bulk density and improvement in soil pore size distribution and aeration by deep tillage, favored the penetration of plant roots to deeper layers of soil for uptake of nutrients and water. The overall effect of tillage systems on plant N, P and K concentrations was non-significant. Our results are consistent with Iqbal *et al.* (2005) who observed that tillage systems had a non-significant effect on plant N and P concentrations, while our results of plant K concentrations are in contrast to the results presented by Iqbal *et al.* (2005) who observed significantly increased K contents in plant shoots under deep tillage systems.

Table 3. Residual effect of different tillage practice and different nitrogen sources on plant growth and nutrient concentration in wheat shoots at harvest.

	Plant height (cm)	Spike length (cm)	1000-grain weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Plant N (g kg^{-1})	Plant P (g kg^{-1})	Plant K (g kg^{-1})
Tillage Systems								
MT	98.85	10.72	52.44	3.48	13.79	4.55	1.16	24.50
CT	98.85	10.72	52.45	3.48	13.80	4.55	1.15	24.51
DT	98.88	10.72	52.51	3.49	13.79	4.57	1.16	24.52
Nitrogen treatments								
N_1	68.83^{c}	10.33^{c}	47.31^{f}	3.40^{e}	13.48^{b}	4.13^{f}	1^{e}	24.07^{d}
N_2	97.69^{b}	10.37^{c}	49.56^{e}	3.42^{e}	13.68^{ab}	4.27^{e}	1.10^{d}	24.27^{c}
N_3	104.27^{a}	10.83^{ab}	53.88^{ab}	3.53^{ab}	13.83^{a}	4.66^{abc}	1.21^{ab}	24.67^{a}
N_4	104.94^{a}	10.88^{a}	54.46^{a}	3.55^{a}	13.90^{a}	4.69^{a}	1.22^{a}	24.63^{ab}
N_5	101.90^{ab}	10.78^{ab}	52.81^{cd}	3.48^{c}	13.80^{ab}	4.62^{cd}	1.17^{c}	24.55^{ab}
N_6	102.13^{ab}	10.81^{ab}	51.13^{bcd}	3.50^{bc}	13.82^{ab}	4.61^{d}	1.18^{bc}	24.58^{ab}
N_7	102.98^{ab}	10.83^{ab}	53.93^{ab}	3.50^{bc}	13.90^{a}	4.68^{a}	1.20^{ab}	24.61^{ab}
N_8	100.65^{ab}	10.76^{b}	52.43^{d}	3.45^{d}	13.79^{ab}	4.60^{d}	1.12^{d}	24.50^{b}
N_9	102.34^{ab}	10.81^{ab}	53.45^{bc}	3.50^{bc}	13.84^{a}	4.63^{bcd}	1.20^{ab}	24.60^{ab}
N_{10}	102.88^{ab}	10.81^{ab}	53.70^{abc}	3.50^{bc}	13.87^{a}	4.67^{ab}	1.20^{ab}	24.60^{ab}
HSD 5%								
TS	NS	NS	NS	NS	NS	NS	NS	NS
NT	5.76	0.119	0.896	0.029	0.335	0.042	0.029	0.155
TS X NT	NS	NS	1.52	NS	NS	NS	NS	NS

Note: Means in a column not sharing the same letters differ significantly from each other at $p \leq 0.05$ (n=4). NS (non significant), TS (tillage systems), NT (nitrogen treatments), MT (minimum tillage), CT (conventional tillage), DT (deep tillage), N_1 (no N applied), N_2 (100%N applied as chemical fertilizer to previous maize crop), N_3 (100% N applied as poultry manure to previous maize crop), N_4 (100%N applied as bioslurry to previous maize crop), N_5 (50%N applied as chemical fertilizer and 50% as poultry manure to previous maize crop), N_6 (50%N as chemical fertilizer and 50% as bioslurry to previous maize crop), N_7 (50%N as poultry manure and 50% as bioslurry to previous maize crop) N_8 (50%N applied as chemical fertilizer, 25% as poultry manure and 25% as bioslurry to previous maize crop), N_9 (25%N applied as chemical fertilizer, 50% as poultry manure and 25% as bioslurry to previous maize crop) and N_{10} (25% N applied as chemical fertilizer, 25% as poultry manure and 50% as bioslurry to previous maize crop).

The application of bioslurry and poultry manure increased plant N, P and K concentrations in wheat shoots at harvest. The highest values were observed following N_4 (100% N applied as bioslurry in previous crop) and N_3 (100% N applied as poultry manure in previous crops). Adenawoola and Adejoro (2005) reported that the agronomic values of some organic manures are increased more than five times in the year after application as compared to values that are determined during the year of application. Singh *et al.* (1997) and Castellanos and Pratt (1981) recorded higher plant N concentrations in shoots due to the residual effects of farmyard manure and observed that 60% of the total N applied as farmyard manure was available to first year crop, the remaining N becoming available to subsequent crops. Our results are also supported by Iqbal *et al.* (2005) who investigated the residual effect of farmyard manure and found a significant increase in plant N and K concentrations in shoots in plots treated with farmyard manure.

The total soil N, available P and available K at wheat harvest was not significantly affected by tillage system but the combined use of tillage system and different N treatments was significant. Balesdent *et al.* (2000) observed two times more labile N in untilled soils as compared to conventional tillage; this might be due to a slow turnover rate of manure in reduced tillage systems (Germon *et al.*, 1991). Our results are consistent with Iqbal *et al.* (2005) who studied the residual effect of farmyard manure (0, 10 and 20 t ha^{-1}) under different tillage systems (zero, minimum, conventional and deep tillage) and found that tillage systems did not significantly affect the soil nutrients, while dairy manure significantly affected the available P and K in the soil. Our results are also supported by Weill *et al.* (1990) who observed highest available P contents in soils where more SOM was accumulated at or near the soil surface, reducing the sorption of soil P into inorganic soil colloids.

Table 4. Residual effect of different tillage practice and different nitrogen sources on different soil properties at wheat harvest.

	Soil total N (g kg^{-1})	Soil available P (mg kg^{-1})	Soil available K (mg kg^{-1})	Soil organic matter (g kg^{-1})
Tillage Systems				
MT	0.28	2.15	113	5.43^{a}
CT	0.28	2.15	112	5.42^{a}
DT	0.27	2.14	109	5.37^{b}
Nitrogen Treatments				
N_1	0.20^{f}	1.33^{h}	53.86^{g}	4.91^{g}
N_2	0.20^{f}	1.67^{g}	61.92^{f}	4.94^{g}
N_3	0.33^{b}	2.36^{bc}	134.70^{b}	5.82^{b}
N_4	0.38^{a}	2.51^{a}	149.87^{a}	5.93^{a}
N_5	0.24^{e}	2.20^{ef}	108.17^{d}	5.19^{e}
N_6	0.28^{d}	2.24^{de}	120.92^{c}	5.26^{e}
N_7	0.32^{bc}	2.37^{b}	136^{b}	5.70^{c}
N_8	0.22^{ef}	2.17^{f}	96.42^{e}	5.06^{f}
N_9	0.30^{cd}	2.10^{cd}	121.1^{c}	5.59^{d}
N_{10}	0.30^{cd}	2.31^{bc}	130.8^{b}	5.65^{cd}
HSD 5%				
TS	NS	NS	NS	0.057
NT	0.029	0.063	6.37	0.073
TS X NT	0.057	0.116	11.41	0.132

Note: Means in a column not sharing the same letters differ significantly from each other at $p \leq 0.05$ (n=4).

NS (non significant), TS (tillage systems), NT (nitrogen treatments), MT (minimum tillage), CT (conventional tillage), DT (deep tillage), N_1 (no N applied), N_2 (100%N applied as chemical fertilizer to previous maize crop), N_3 (100% N applied as poultry manure to previous maize crop), N_4 (100%N applied as bioslurry to previous maize crop), N_5 (50%N applied as chemical fertilizer and 50% as poultry manure to previous maize crop), N_6 (50%N as chemical fertilizer and 50% as bioslurry to previous maize crop), N_7 (50%N as poultry manure and 50% as bioslurry to previous maize crop) N_8 (50%N applied as chemical fertilizer, 25% as poultry manure and 25% as bioslurry to previous maize crop), N_9 (25%N applied as chemical fertilizer, 50% as poultry manure and 25% as bioslurry to previous maize crop) and N_{10} (25% N applied as chemical fertilizer, 25% as poultry manure and 50% as bioslurry to previous maize crop).

Table 5. Cost economics for the N fertilizer applied to wheat crop**.**

Treatments	Grain yield (kg ha^{-1})	Yield increase over control (kg ha^{-1})	Value of increased yield (Rs.)	Cost of fertilizer (Rs.)	Value: Cost ratio
N_1	3400	-	-	-	-
N_2	3420	20	625.00	1950	0.32
N_3	3530	130	4062.50	1950	2.08
N_4	3550	150	4687.50	1950	2.40
N_5	3480	80	2500.00	1950	1.28
N_6	3500	100	3125.00	1950	1.60
N_7	3500	100	3125.00	1950	1.60
N_8	3450	50	1562.50	1950	0.80
N_9	3500	100	3125.00	1950	1.60
N_{10}	3500	100	3125.00	1950	1.60

Note: Urea @ Rs.32.5 kg^{-1}, Wheat Grain @ Rs. 31.25 kg^{-1}

N_1 (no N applied), N_2 (100%N applied as chemical fertilizer to previous maize crop), N_3 (100% N applied as poultry manure to previous maize crop), N_4 (100%N applied as bioslurry to previous maize crop), N_5 (50%N applied as chemical fertilizer and 50% as poultry manure to previous maize crop), N_6 (50%N as chemical fertilizer and 50% as bioslurry to previous maize crop), N_7 (50%N as poultry manure and 50% as bioslurry to previous maize crop) N_8 (50%N applied as chemical fertilizer, 25% as poultry manure and 25% as bioslurry to previous maize crop), N_9 (25%N applied as chemical fertilizer, 50% as poultry manure and 25% as bioslurry to previous maize crop) and N_{10} (25% N applied as chemical fertilizer, 25% as poultry manure and 50% as bioslurry to previous maize crop).

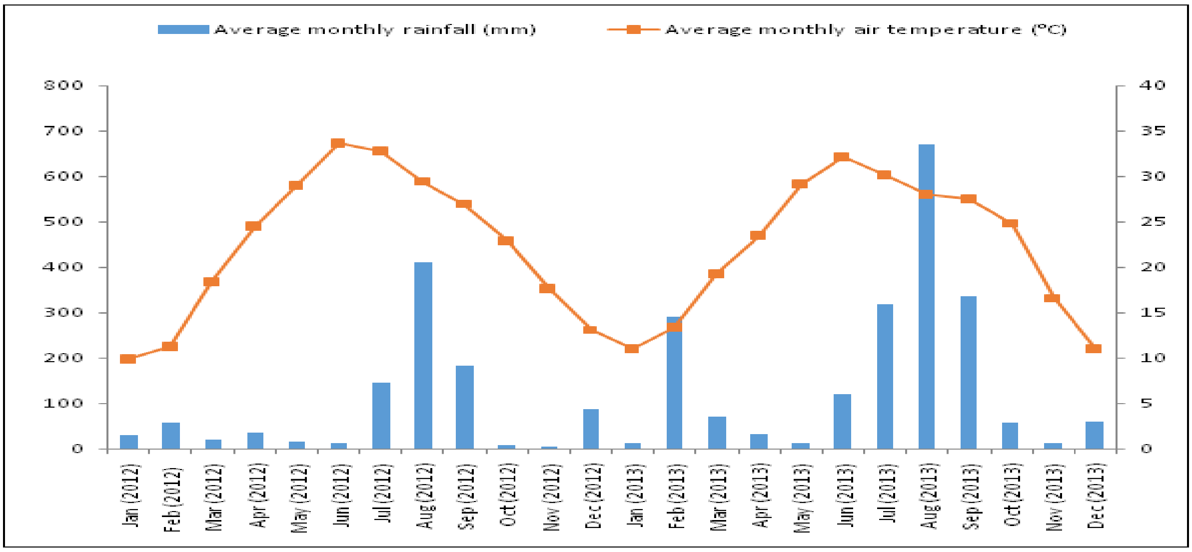

Fig. 1. Meteorological data of the experimental site.

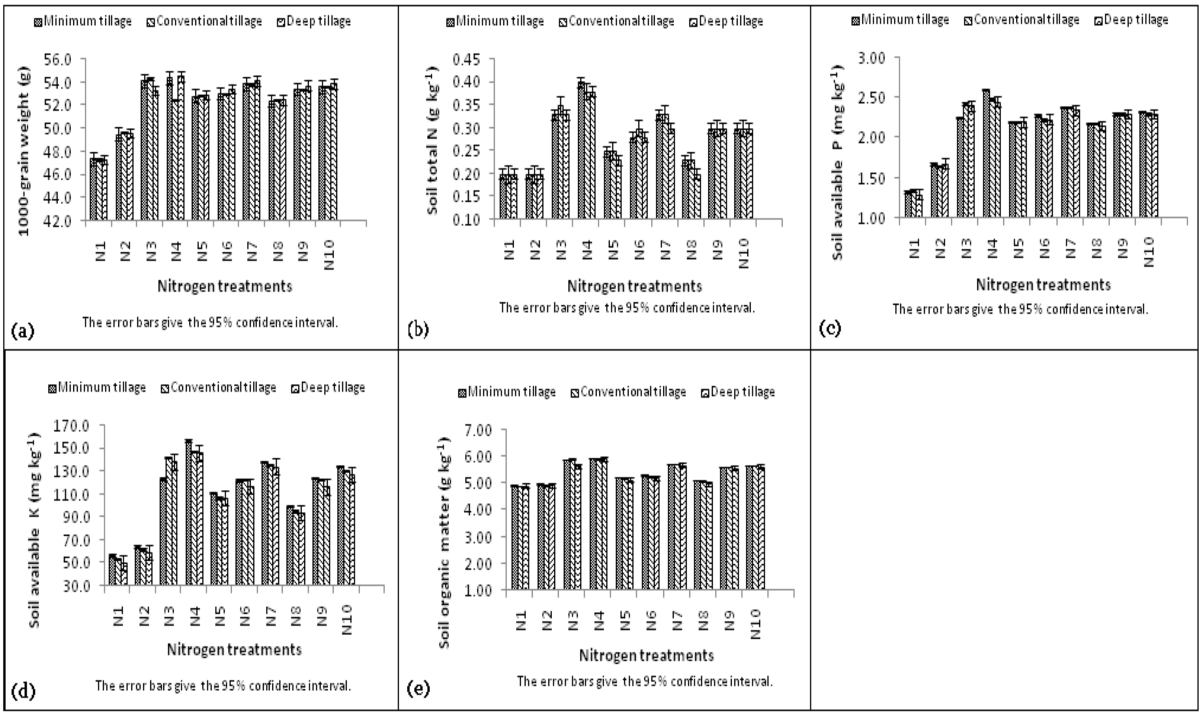

Fig. 2. Residual effect of tillage practices and nitrogen treatments on different crop growth and soil parameters at wheat harvest.

In agreement with Adeleye and Ayeni (2012), we observed that SOM contents were significantly affected by tillage system, N treatment and their interactions. Increased SOM contents were recorded following minimum tillage as compared to conventional and deep tillage systems. One mechanism for this observation could be decreasing soil temperature by intercepting incoming solar radiation and increasing soil water retention of soil treated with bioslurry and poultry manure under a reduced tillage system, which in turn increases SOM contents. Deep tillage also accelerates the decomposition of SOM by increasing exposure to decomposers in the soil (Shepherd *et al.*, 2001).

The cost analysis given in Table 5, shows that the treatment N_4 (100% N applied as bioslurry to previous maize crop) was the most economically profitable treatment due to residual effects of bioslurry and produced a high value cost ratio, while the treatment N_3 (100% N applied as poultry manure to previous maize crop) gave second highest value to cost ratio of fertilizer.

Conclusion

It is concluded on the basis of this study that application of bioslurry and composted poultry manure as a bio-fertilizer improves SOM contents and availability of soil nutrients (N, P and K) to the subsequent crop, which in-turn increases crop productivity and reduces the cost of fertilizer to subsequent crop.

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References

Adeleye EO, Ayeni LS. 2012. Interaction effect of tillage and poultry manure on soil physical properties, nutrient contents and yield of yam on alfisol in southwestern Nigeria. International Journal of Agriculture Food Science and Technology **2,** 164-168.

Adenawoola AR, Adejoro SA. 2005. Residual effects of poultry manure and NPK fertilizer residues on soil nutrients and performance of Jute (*Corchorusolitorus* L).Nigerian Journal of Soil Science **15,** 133-135.

Aslam M, Javed HI, Tareen AK. 1988. Spring Maize Cultivation. Progressive Farming **8(2)**.

Balesdent J, Chenu C, Balabane M. 2000. Relationship of soil organic matter dynamics to physical properties and tillage. Soil and Tillage Research **5,** 215-230.

Bremner JM, Mulvaney CS. 1982. "Total nitrogen", In: Page AL, Miller RH, Keeny DR (Eds.). Methods of Soil Analysis, American Society of Agronomy and Soil Science Society of America, Madison, 1119-1123 P.

Castellanos JZ, Pratt PF. 1981. Mineralization of manure correlation with laboratory indexes. Soil Science Society of America Journal **45,** 354-357.

Germon JC, Taureuend JC, Thomas JM. 1991. Effects dcs methods simplifies de travail du slsur les transformations de l' azote leursconsequencesse le lessiuage des nitrate.Simplificantion du sol, Paris (France).16 Mai 1991,ef.InraDaris 1994 (Les colloques,No.65). 125-154.

Ghosh PK, Ramesh P, Bandyopadhyay KK, Tripathi AK, Hati KM, Misra AK, Acharya CL. 2004. Comparative effectiveness of cattle manure, poultry manure, phosphocompost and fertilizer-NPK on three cropping systems in vertisols of semi-arid tropics. I. Crop yields and system performance. Bioresource Technology **95(1),** 77-83.

GOP. 2013. Economic Survey of Pakistan 2012-13. http://finance.gov.pk/survey/chapters_13/02-Agriculture.pdf

Gupta MK. 2007. Handbook of Organic Farming and Biofertilizers, 1st Ed. ABD Publishers, Jaipur, India.

Iqbal M, Hassan A, Ali A, Rizwanullah M. 2005.Residual effect of tillage and farm manure on some soil physical properties and growth of wheat.International Journal of Agriculture and Biology **7,** 54-57.

Iqbal M. 2006. Soil physical properties and growth of maize and wheat as affected by tillage, farmyard manure and mulch. Ph.D. thesis. Uni. Agri., Faisalabad.

Islam S. 2006. Use of bio-slurry as organic fertilizer in Bangladesh agriculture. Proc. International workshop on the use bio-slurry for domestic biogas programmes 27th-28th September, Bangkok, Thailand.

Knudsen D, Peterson GA, Pratt PF. 1982. Lithium, sodium and potassium. In: Page, A.L. *et al.*, Methods of Soil Analysis, Part 2, Second Edition. Agronomy **9,** 225-246.

Lal R. 1993. Tillage effects on soil degradation, soil resilience, soil quality and sustainability. Soil and Tillage Research **27,** 1–8.

Moschler WW, Marteus DC. 1974. Nitrogen, phosphorus and potassium requirements in no–tillage and conventionally tilled corn. Soil Science Society of America Proceedings **30,** 886–91.

Moore PD, Chapman SB. 1986. Methods in Plant Ecology. 2nd edition. Blackwell Scientific Publications. Oxford, UK.

Nasir A, Khalid MU, Anwer S, Arslan C, Akhter MJ, Sultan M. 2012.Evaluation of bio-fertilizer application to ameliorate the environment and crop production. Pakistan Journal of Agriculture Sciences **49,** 527-531.

Ozpinar S. 2005. Effect of tillage on productivity of winter-vetch rotation under dryland Mediterranean conditions. Soil and Tillage Research **89,** 258-265. http://dx.doi.org/10.1016/j.still.2005.07.009

Shahzad K, Khan A, Smith JU, Saeed M, Khan SA. 2015 a. Response of maize to different nitrogen sources and tillage systems under humid subtropical conditions. The Journal of Animal and Plant Sciences **25,** 189-197.

Shahzad K, Khan A, Richards M, Smith JU. 2015 b. The impact of treatment of organic waste on soil carbon sequestration in Pakistan. Geoderma, under review.

Shahzad K, Khan A, Smith JU. 2015 c. Impact on soil properties of different nitrogen sources and tillage systems under humid subtropical conditions and subsequent physiological growth of maize. The Journal of Animal and Plant Sciences, under review.

Shehzadi S, Shah Z, Mohammad W. 2014 Residual effect of organic wastes and chemical fertilizers on wheat yield under wheat-maize cropping sequence. Soil and Environment **33(2),** 88-95.

Shepherd TG, Newman RHS, Ross CW, Dando JL. 2001. Tillage induced changes in soil structure and soil organic matter fractions. Australian Journal of Soil Research **39,** 465-489.

Singh B, Singh Y, Maskina MS, Meelu OP. 1997. The value of poultry manure for wetland rice grown in rotation with wheat. Nutrient Cycling in Agroecosystems **47,** 243-250.

Steel RGD, Torrie JH. 1984. Principles and procedures of statistics. 2nd Ed. McGraw Hill Book Co. Inc. Singapore. 172-178 P.

Walkley A, Black IA. 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science **37,** 29-38.

Watanabe FS, Olsen SR. 1965. Test of an ascorbic acid method for determining phosphorus in water and NaHCO3 extracts from soil. Soil Science Society of America Proceedings **29,** 677 – 678.

Weill AN, Mehuys GR, Mckyes E. 1990. Effects of film mulch on physio-ecology and yield of spring corn. Acta Agriculturae Boreali Sinica **24,** 348-553.

Yoshida S, Forno DA, Cock JH, Gomez KA. 1976. Laboratory Manual for Physiological Studies of Rice.3rd Ed. IRRI, Manila, Philippines.