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Organic sources, nitrogen and tillage systems improve wheat productivity and profitability under semiarid climates

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Abstract
Tillage, organic sources and nitrogen play a great role in improving soil fertility and crop productivity. To investigate the impact of organic sources and nitrogen levels on the productivity and profitability of wheat under tillage systems, a field experiment was conducted at Agronomy Research Farm of The University of Agriculture Peshawar, during winter 2015. The design used was randomized complete block design with split plot arrangement, using three replications. The results showed that the treatments had significant effect on the productivity of wheat. Among the organic sources, application of poultry manure improved yield components (spike m^{-2}, grains $spike^{-1}$ and thousand grains weight), grain yield and net returns (poultry manure>sheep manure>cattle manure). Application of N at the rate of 125 kg N ha^{-1} (urea) was more beneficial in terms of yield components, grain yield and net returns (125≥ 150 >100 >75>0 kg N ha^{-1}). Similarly, the plots ploughed with deep tillage system (mould board plough) produced higher yield components, grain yield and net returns than conventional plough. On the basis of results we concluded that application of poultry manure, nitrogen at the rate of 125 kg N ha^{-1} with deep tillage could improve wheat productivity and profitability in the semiarid condition.

Keywords: Organic sources; Nitrogen; Tillage systems; Wheat; Productivity, Profitability: Semiarid climate

Introduction
Many organic materials (sheep, cow, and poultry manure) are used in crop production as a substitute to synthetic fertilizers and their role in crop productivity cannot be ignored (Abbas *et al*., 2012). Among the different organic manures, poultry manure has remarked increase in the growth and crop production (Tambone *et al*., 2007; Hirzel *et al*., 2004; Sharpe *et al*., 2004) [61, 54]. Izunobi (2002) reported that poultry manure, is richest known manure source, which supply a great amount of soluble plant nutrients. Mineralization of poultry manure is faster than other animal manures and contributes more in enhancing growth and yield of crops (Brady and Weil, 1999; Sharply and Smith, 1991). Other than poultry manure several other sources like cattle manure, farm yard manure, pig dung and refuse compost have been recommended to increase crop yield in different parts of the world as a slow releasing fertilizer having long residual effect (Adepetu *et al*., 2005) [1].
Nitrogen is the most limiting nutrient and its effective use in crop production is more than other major nutrients, however, abundant application of N may cause environmental concerns such as nitrate leaching, eutrophication, greenhouse gases emissions and reduce crop yield (Malhi *et al*., 2001) [38]. Therefore, appropriate use of N is recommended to improve crop yield and reduces environmental pollution. Optimum nitrogen application plays a vital role in improving soil fertility and crop productivity (Habtegebrial *et al*., 2007). It was estimated that 40% - 60% of N-applied is used by wheat crop, which decreases as the N-input increases, ensuring in more residual soil N that can be freely leached (Guarda *et al*., 2004) [21]. (Ogola *et al*., 2002) [40] reported that N fertilization increased grain yield by 43% to 68% and biomass production by 25% to 42%. Moreover, N fertilization contributes to increase (18 to 34%) soil residual N contents (Yang *et al*., 2007) [62].
Tillage is considered the most effective farm practice for the management of soil texture and structure (Bahadar *et al*., 2007) [7]. It is the most effective way for reducing soil compaction (Daniells, 2012) [14]. Under the conventional tillage system a plough pan layer is developed that may impose changes in soil physical properties and may lead to a decrease in soil physical quality (Bertolino *et al*., 2010) [10].

It was reported that deep tillage reduced soil strength and soil bulk density (Laddha and Totawat, 1997) [34], increased water holding capacity in the soil, improved root growth (Holloway and Dexter 1991) [24] and crop yield (Ghosh *et al*. 2006) [20]. Deep plough resulted in the highest moisture content as compared to shallow plow (Makki and Mohamed, 2008) [37]. Khan *et al*. (2006) [31] reported that field prepared with deep plow once plus cultivator twice and moldboard plus cultivator twice give rise to higher moisture content, lower bulk density and soil strength.

As nitrogen and organic matter are some of the key limiting factors in crop production. The present study is therefore designed to investigate the best organic source (poultry, sheep and cattle manure) and nitrogen levels for wheat productivity and profitability under deep and convential tillage systems.

Materials and methods

Experimental Material and Treatments

Field experiment was conducted at Agronomy Research Farm of The University of Agriculture Peshawar, during winter 2015 with the objectives to investigate the effect of Organic sources and nitrogen levels on growth, yield and profitability of wheat under tillage systems. Organic sources cattle manure, poultry manure and sheep manure (5 t ha^{-1}) and tillage system deep plough (Mould board plough) and conventional plough (cultivator) were allotted to main plot, while nitrogen levels (0, 75, 100, 125 and 150 kg n ha^{-1}) as subplot factor.

The present experiment was laid out in randomized complete block design with split plot arrangement, having three replications. Tillage systems (conventional and deep system) and organic sources (poultry, sheep and cattle manure each applied at the rate of 5 ton ha^{-1}) were used as main plot factors. Nitrogen levels were applied to subplots. A subplot size 3 x 2.5 m, having 8 rows, 2.5 m long and 30 cm apart was used. Different nitrogen levels were applied from urea in two equal splits, that is, half at sowing and half at tillering stage. Wheat cultivar Pirsabak-2013 was used as a test crop. All other agronomic practices (Phosphorus, weeding, irrigation, chemicals, harvesting etc.) were uniform for all the treatments.

Data Collection and Statistical Analysis

Data on spikes per meter was recorded by counting number of spikes in 1meter long row at four different places and then averaged. Grains spike^{-1} data were noted by counting the number of grains from randomly selected 10 spikes in each subplot and then averaged. Thousand grains from seed lot of each subplot were taken and weighed with the help of electronic balance to record thousand grains weight. Grain yield were recorded by threshing the harvested materials of each treatment, dried, weighed and converted by using the following formula:

$$\text{Grain yield} = \frac{\text{Grain yield (kg)}}{\text{Row- Row distance x Row length (m) x No. of rows}} \times 10000$$

Harvest index for each treatment was calculated with the help of formula.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Economic analysis

The profitability of wheat was calculated by the procedure out lined by Amanullah *et al*., 2010.

Statistical analysis

Data were statistically analyzed according to Steel *et al*. (1996) [57] and means were compared using LSD test ($P \leq 0.05$).

Results

Spike m^{-2}

Data concerning spike m^{-2} was significantly affected by organic sources, nitrogen levels and tillage systems (Table 1). Application of poultry improved spike m^{-2} (285), which was statistically similar to sheep manure, while lower spike m^{-2} was obtained from cattle manure (278). Similarly, increased in spike m^{-2} was recorded from nitrogen at highest levels 150 (291), which was similar to 125 kg N ha^{-1}, while the lowest spike m^{-2} (268) was recorded from control plot. The deep tillage system produced highest spike m^{-2} (289) than the conventional tillage system (275).

Grains spike^{-1}

Data pertaining grains spike^{-1} are presented in Table 1. The mean data indicated that organic sources, nitrogen levels and tillage systems had significant effect on grains spike^{-1} of wheat. Application of poultry and sheep manure improved grains spike^{-1} (53), while lower grains spike^{-1} was obtained from cattle manure (51). Similarly, increased in grains spike^{-1} was recorded from nitrogen at highest levels 150 and 125 kg N ha^{-1} (54), while the lowest grains spike^{-1} (49) was recorded from control plot. The deep tillage system produced highest grains spike^{-1} (53) than the conventional tillage system (51).

Thousand grains weight (g)

Data pertaining thousand grains weight are given in Table 1. The revealed that organic sources, nitrogen levels and tillage systems had significant effect on thousand grains weight of wheat. Application of poultry improved thousand grains weight (42.9g) as compared to cattle manure (41.4g). Similarly, increased in thousand grains weight was recorded from nitrogen at highest levels 150 and 125 kg N ha^{-1} (44.1 and 43.7 g), while the less thousand grains weight (39.6g) was recorded from control plot. The deep tillage system produced highest thousand grains weight (42.8g) than the conventional tillage system (41.4g).

Grain yield (kg ha^{-1})

Data concerning grain yield (kg ha^{-1}) are given in Table 1. The mean data showed that organic sources, nitrogen, tillage systems, OS x N had significant, while the rest of interactions had non-significant effect on grain yield (kg ha^{-1}) of wheat. Application of poultry manure improved grain yield (3918 kg ha^{-1}), while lower grain yield (3505 kg ha^{-1}) was recorded from cattle manure. Similarly, increased in grain yield (4129 kg ha^{-1}) was produced from highest N levels 150 kg N ha^{-1} which was statistically similar to 125 kg N ha^{-1} (4087 kg ha^{-1}), while the lowest grain yield (3066 kg ha^{-1}) was obtained from control plot. The deep tillage system produced highest grain yield (3788 kg ha^{-1}) than the conventional tillage system (3620 kg ha^{-1}). Application of poultry manure (5 t ha^{-1}) with the higher dose of nitrogen (150 kg N ha^{-1}) improved grain yield of wheat (OS x N).

Harvest index (%)

Perusal of the data reported in Table 1, showed that organic sources and nitrogen had significant, while tillage systems and interactions had non-significant effect on harvest index of wheat. Application of poultry manure improved harvest index

(38.0 %), while lower harvest index (35.8 %) kg ha^{-1}) was obtained from cattle manure. Similarly, increased in harvest index (38.8 %) was recorded from nitrogen at highest levels 150 kg N ha^{-1} which was comparable to 125 kg N ha^{-1} (38.3 %), while the lowest harvest index (33.9 %) was recorded from control plot.

Economic analysis

It is evident from the economic analysis that organic sources, nitrogen levels and tillage systems increased both gross and net income of wheat crop (Table 2). Application of poultry manure was more economical in terms of higher gross income than sheep and cattle manure (Figure 1). Application of higher rate of 125 and 150 kg N ha^{-1} was more economical in terms of higher gross and net income than control (Figure 2). Ploughing of wheat with deep tillage resulted in about 26985 PKR ha^{-1} than plots ploughed with conventional tillage (Figure 3).

Discussion

Yield components of wheat (spike m^{-2}, grains spike^{-1} and thousand grains weight) were significantly affected by organic sources, nitrogen levels and tillage systems. Among organic sources poultry manure improved yield components of wheat over sheep and cattle manure. The increase in yield components was greatly due to more availability of plant essential nutrients on decomposition throughout the growing season. The increase may also be due to nutrients supply in a variable manner depending on their source quality, which ultimately increase yield components (Ahmad *et al*., 2007) [2]. Tahir *et al*. (2011) [59] and Sarwar *et al*. (2007) concluded that the yield components of wheat crop were significantly affected by organic manure over control. These results are in line with Iqbal *et al*. (2002) [26] and (Zeidan and Kramany, 2001) [63], who concluded that poultry manure improved yield components. Different levels of organic fertilizer application significantly increased number of grains per spike (Hossian *et al*., 2002; Ma *et al*., 1999: Shah and Arif (2000); Farooqi (1999) [25, 35, 50, 18], they also observed increased in yield components due to manure application. In current study thousand grains weight was significantly affected by poultry manure the reason behind this could be the balance supply of plant nutrients in the grain fill duration (Garg and Bahla, 2008; Ma *et al*., 1999; Sevaram *et al*., 1998) [19, 35, 49]. Application of nitrogen at higher rates (125 and 150 kg N ha^{-1}) significantly increased yield components of wheat than control (0 kg N ha^{-1}). The formation of spikes m^{-2} is totally depend on N supply, thus more spikes m^{-2} may be due to the increased in nitrogen application to wheat crop compared to control (Iqtidar *et al*., 2006) [27]. More grains spike^{-1} at higher N may be due to excess availability of N (Cantero-Martınez *et al*., 2003) [13]. The increase in number of grains ear^{-1} was more in treated plots as compared to control (Patel *et al*., 1995) [42]. The maximum utilization of solar energy, more assimilates production ultimately improved grains weight and yield, because N plays important role in increasing dry matter of grains (Derby *et al*., 2004; Al-Abdulsalam, 1997) [16], than that of control due to severe nutrient stress that resulted in lower grains weight (Stratilakis and Goulas, 2003) [58]. Similarly, Akhtar (2001) [4] and Arif *et al*. (2010) [6] reported that yield components of wheat increases with N fertilization, which was also in line with the results of (Maqsood *et al*., 2001; Samira *et al*., 1998) [39, 46]. In the study deep tillage performed better in terms of yield components (spike m^{-2}, grains spike^{-1} and thousand grains weight) as compared to conventional tillage system. The increase of growth and yield in deep tillage are likely to be due to increased uptake of soil nutrients. The improvement in yield components under deep tillage system might be due to the efficient uptake of plant nutrients, which finally increased the thousand grains weight (Ozpinar, 2005) [41].

Grain yield of wheat were significantly affected by organic sources, nitrogen and tillage systems. Maximum grain yield were recorded from poultry manure with higher nitrogen levels under deep tillage system. Poultry manure performed better in terms of higher yield than sheep and cattle manure. The increased in yield due to manure application might be because poultry manure increase soil physical properties, plant nutrients and grain yield (Shirani *et al*., 2002) [55]. The maximum content of NPK in poultry manure than other manures that might be the cause of increased in grain yield (Khaild *et al*., 2011; Boateng *et al*., 2006; Kramer *et al*., 2002) [28, 11, 33]. Similarly, Mahajan (1996) [36] concluded that manure at the rate of 5 ton ha^{-1} was beneficial in improving yield by 20%. Similar results were also found by Tamayo *et al*. (1997) [60] and Das *et al*. (1992), who reported that integrated use of chemical and organic source produced the maximum grain yield, because they improve soil permeability to air and water, reduce N losses and improve nutrients uptake and finally the yield (Bayu *et al*., 2006; Satyanarayana *et al*., 2002; Yadav, 2001) [8, 48]. Higher nitrogen rates (125 kg N ha^{-1}) increased wheat grain yield, while lower yield was obtained from control (0 kg N ha^{-1}) plots. Zeidan and Amany (2006) [64] reported that N fertilization increases the vegetative growth and yield. Grain yield of wheat increased with the higher levels of nitrogen than lower levels and control (Haileselassie *et al*., 2014; Bereket and Yirgalem, 2012) [23, 9]. Shirazi *et al*. (2014) [56] concluded that highest grain yield was obtained from 120 kg N ha^{-1} as compared to 80 kg N ha^{-1}. Shah and Ahmad (2006) [27] also reported that maximum grain yield was recorded from the higher N levels at both sources (organic and inorganic fertilizers) (Khaliq *et al*., 2004) [29]. This increment in yield at higher N rate could be due to light interception which improves growth rate, leaf area and leaf area index and ultimately the yield (Kibe *et al*., 2006) [32]. In the current study deep tillage operation increased grain yield of wheat than convential plough. Convential plough (cultivator) makes the soil very fine but up to few inches and compact the lower portion which adversely effects crop productivity, while deep tillage break sub-soil compaction, promote root development, thus increase crop production (Shaheen *et al*., 2014) [53]. This increase in yield under deep ploughing may be due to more water absorption capacity of the soil, root growth and development is enhanced due to the breaking of hard pan (Shaheen *et al*., 2010) [52]. Similar results were also observed by Hada and Arora (2006) [22], Akhtar *et al*. (2005) [3] and Busscher *et al*. (2000) [12]. According to Polthanee and Wannapat (2000) [44] that tillage operation improves soil aeration, increase number of seeds and yield. The increase in maize yield under tillage operation was also reported by Rashidi and Keshavrzpour (2007) [45] the increase may be due to less soil compaction, more root growth, water use efficiency and yield of the crop (Pikul and Kristian, 2003) [43].

Harvest index is the physiological efficiency of dry matter into the grain yield. In the current study harvest index was significantly affected by organic sources and nitrogen levels, while tillage had no significant effect on the harvest index of wheat. Among organic sources poultry manure application gave the highest harvest index than sheep and cattle manure. Farhad *et al*. (2009) [17] and Khaliq *et al*. (2004) [30] reported that application of manure and inorganic fertilizers had produced more harvest index than control treatment. More harvest index was recorded from higher N rates (125 kg N ha^{-1}), while lower was recorded from control. Application of synthetic N fertilizers improved harvest index of maize due to more dry matter production through the process of photosynthesis by enzyme activation (Khaliq *et al*., 2004) [30]. Delfine *et al*. (2005) [15] reported that higher N application and organic sources had improved biological yield, grain yield and harvest index of the crop (Al-Abdulsalam, 1997).

Table 1: Spike m^{-2}, grains spike^{-1}, thousand grains weight (g), grain yield (kg ha^{-1}) and harvest index (%) of wheat as affected by organic sources, nitrogen levels and tillage systems.

Organic sources (ton ha^{-1})	**Spike m^{-2}**	**Grains spike^{-1}**	**Thousand grains weight (g)**	**Grain yield (kg ha^{-1})**	**Harvest index (%)**
cattle	278 b	51 c	41.4 b	3505 c	35.8 b
sheep	282 a	52 b	42.0 b	3688 b	36.6 b
poultry	285 a	53 c	42.9 a	3918 a	38.0 a
LSD	4	1.0	0.8	111.1	1.5
Nitrogen (kg ha^{-1})					
0	268 d	49 c	39.6 d	3066 d	33.9 d
75	278 c	51 b	40.8 c	3510 c	35.8 c
100	284 b	52 b	42.4 b	3727 b	37.2 b
125	289 a	54 a	43.7 a	4066 a	38.3 ab
150	291 a	54 a	44.1 a	4150 a	38.8 a
LSD	3	1.0	0.7	96.8	1.0
Tillage					
Conventional	275 b	51 b	41.4 b	3620 b	36.6
Deep	289 a	53 a	42.8 a	3788 a	37.0
LSD	3	0.8	0.6	90.7	ns
Interactions					
T x OS	ns	ns	ns	ns	ns
T x N	ns	ns	ns	ns	ns
OS x N	ns	ns	ns	*	ns
T x OS x N	ns	ns	ns	ns	ns

Table 2: Net income (PKR ha^{-1}) and valve cost ratio (VCR) of wheat as affected by organic sources, nitrogen levels and tillage systems.

Tillage practices	**Gross income (PKR ha^{-1})**	**VCR**
Conventional	20472	1.32
Deep	26985	1.64
Organic sources		
Cattle	16517	1.10
Poultry	31370	1.85
Sheep	23284	1.46
Nitrogen (kg ha^{-1})	Net income (PKR ha^{-1})	
0	0	0
75	2281	1.16
100	8841	1.57
125	21440	2.30
150	22081	2.26

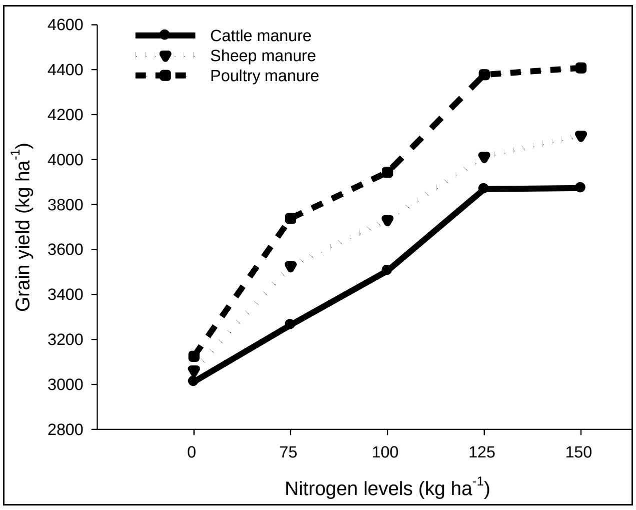

Fig 1: Interactive effect of nitrogen levels and organic sources on grain yield (kg ha^{-1}) of wheat.

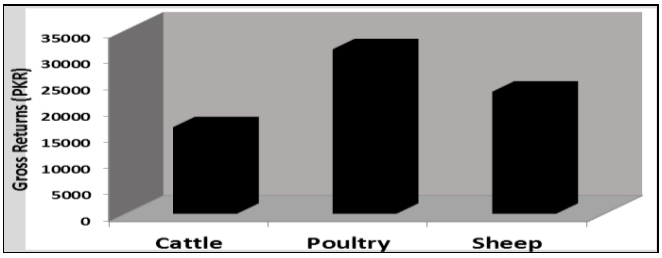

Fig 2: Gross income of organic sources.

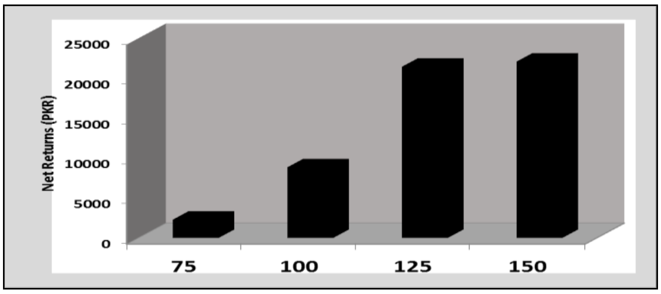

Fig 3: Net income of nitrogen levels (kg ha^{-1}).

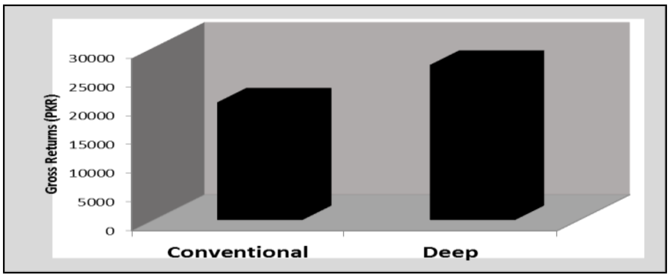

Fig 4: Gross income of tillage system.

Conclusions

Poultry manure was a better organic source for improving yield, yield components and net returns of wheat as compared to sheep and cattle manures. Higher nitrogen level (125 kg N ha^{-1}) was found more beneficial in terms of higher yield, yield components and net returns. Plots ploughed with deep tillage system were found more beneficial in terms higher yield, yield components and net returns over conventional tillage system. We recommend a combination of inorganic N with organic sources and deep tillage to maximize not only productivity but also profitability of wheat crop in semiarid climates.

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