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Effect of Organic and Chemical Nitrogen Fertilizers on Grain Yield and Yield Components of Wheat and Soil Fertility

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ABSTRACT
Effects of organic manure (poultry manure) applied alone and integrated with inorganic fertilizer (urea) on yield and yield component, N-uptake and soil fertility in wheat-maize cropping system was evaluated in a field experiment at Nuclear Institute for Food and Agriculture, Peshawar, Pakistan. Poultry manure was applied alone and were integrated in different proportions with mineral nitrogenous fertilizer to supply 120 $kg.ha^{-1}$ N. The organic fertilizers were applied at sowing time and mineral fertilizer was applied in three splits, sowing, tillering and booting stages. The experiment was laid out according to RCBD with 6 treatments and 4 replications. The plot size was 4m x 3.5 m with twelve rows of wheat. Nitrogen was applied at the rate of 120 $kg.ha^{-1}$ to wheat from organic and Chemical N sources i.e poultry manure (PM) and urea applied alone and in combination recommended rates of P and K at the rate of 75 and 60 $kg.ha^{-1}$ respectively, were applied in the form of single super phosphate and potassium sulphate as basal application to all treatments at sowing time. The results showed that integrated use in different proportion increased the biological yield, grain yield, grain per spike, 1000-grain weight, and over control. After crop harvest soil was analyzed for total N, organic matter and available P and was found higher in treatments where poultry manure was applied alone and in integration with chemical N. Application of poultry manure proved beneficial and improved yield and improve soil fertility.

Keywords: *Chemical Nitrogen, Grain yield, Poultry manure, Wheat.*

INTRODUCTION
Among plant nutrients, nitrogen is considered as a major element required for good economic yield of wheat. Nitrogen is closely linked with the control of vegetative growth in the plants and hence determines fate of reproductive cycle. Researchers have found increase in number of spikes; grain weight (Ragheb *et al*., 1993; Geleto *et al*., 1995) and grain yield (Singh *et al*., 1996, Verma *et al*., 1993) with increased level of the N fertilizer.

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With wheat, most commonly grown cereal, soil must supply around 30 $kg.ha^{-1}$ N for each tone of grain produced. The problem being faced by the farmers in Pakistan is that capacity of their soils to supply the required quantities of N (30 to 80 $kg.ha^{-1}$) decline rapidly with continued cropping and the soil organic matter need to be supplemented from other sources such as animal manures (Doyle *et al*., 1988, McDonald, 1992). The soils of Khyber Pakhtunkhwa are deficient in organic matter, nitrogen, phosphorus and zinc (Izhar, 1997). Balanced application of mineral fertilizers plays a significant role in boosting crop production on alkaline calcareous soils of Pakistan (Ahmad, 2000). Despite increase rate of chemical fertilizers, crop yield hasn't (Ali, 2000). According to Zia *et al*. (2000), continuous use of chemical fertilizers even in balanced proportions won't be able to sustain crop productivity due to deterioration of soil health. No single source of nutrients such as, chemical fertilizers, animal manures and bio-fertilizers can meet the nutrient needs of the cultivated soils for sustainable crop productivity. The basic goal of integrated plant nutrition system is the maintenance or adjustment of soil fertility to an optimum level for sustaining the desired crop productivity. This may be achieved by optimizing the benefits from all possible sources of plant nutrients, depending upon the system of land use and ecological, social and economic conditions prevailing in a given agro climatic zone. Unlike chemical fertilizers addition of organic fertilizers improve the soil humus content, water holding capacity, cation exchange capacity, water infiltration rate, aeration and porosity of the soil (Bhagat and Verma, 1991, Burgo, 1995, Saleem, 2000). Organic material also promotes the biological activities as it provides carbon as an energy source, enhances seed germination, root initiation, growth, yield and nutrient uptake and thus, fertilizer and water use efficiency (Elmer and Wichman, 1990, Singh *et al*., 1991, Beare *et al*., 1994). The dropping of poultry birds are rich in nutrients and if it is properly collected it can contribute about 101 thousand tones of N, 58 thousand tones of P_2O_5, and 26 thousand tones of K_2O_5 (Bari, 2003). Nutrient concentrations of poultry manure depend on the type and amount of feed used. Organic fertilizers contain both macronutrients and the micronutrients. Several scientists have studied the beneficial effects of poultry manure on soil physical and chemical properties. Toor and Beshoni (1996) concluded that poultry manure is more effective than farmyard manure for available N and P, however, the concentration of available K is the same in both sources. Wood *et al*. (1996) observed that application of poultry litter increased soil organic carbon and nutrients. Vezquez *et al*. (1996) observed the beneficial effect of plant residue and animal manure on soil aggregation. If poultry manure are recycled and returned to soil it will improve soil organic matter and thus will provide essential plant nutrients for sustainable crop productivity (Krishna, 2004). Considering the importance of integrated plant nutrients for sustained soil fertility and crop productivity, this study was conducted to assess the effect of the application of organic materials i.e. poultry manure (PM) applied alone or in combination with a N fertilizer on yield components of wheat, nutrient uptake and selected soil properties.

MATERIALS AND METHODS

Field and treatment information

Two-year field experiments were conducted at Nuclear Institute for Food and Agriculture (NIFA) (longitude $71^0 50$, latitude $34^0 01$), Peshawar, Pakistan. To assess the influence of chemical N fertilizer (urea) applied alone and in combination on yield and yield component of wheat and on total N, available P and organic matter of soil. Soil of the experimental site was clay loam soil classified as *Fine, mixed, hyperthermic, Udic Haplustepts, Taru* Soil Series. A two year experiment was carried out on effects of integrated N management on wheat crop at NIFA research farm under irrigated condition from 2005-07. Nitrogen was applied at the rate of 120 $kg.ha^{-1}$ to wheat from organic and mineral N sources i.e Poultry Manure (PM) and urea applied alone and in combination. The experiment was laid out according to RCBD with 6 treatments and 4 replications. The plot size was 4m x 3.5 m with twelve rows of wheat.

Crop Management

Recommended rates of P and K at the rate of 75 and 60 $kg.ha^{-1}$ respectively, were applied in the form of single super phosphate and potassium sulphate as basal application to all treatments at sowing time. Their rates were adjusted on the basis of P and K present in the organic sources. All PM were applied at sowing time and urea in treatment of 100% chemical N and 75% chemical N were applied in three split application i.e sowing, tillering and booting stage. While 50% chemical N and 25% chemical N were applied in two split applications i.e tillering and booting stage. Wheat was sown at the seed rate of 100 $kg.ha^{-1}$ with planting distance of 30 cm. Wheat variety Fakhr-e-sarhad was sown for two years and two wheat crop grown on the same piece of land.

Traits measure

The treatments at the experiment are given in table (1). The chemical composition of PM and chemical properties of the soil are given in Table (2) and Table (3) respectively. Soil texture of the soil samples collected from the experimental site was determined by hydrometer method as described by Moodi *et al.* (1959). The pH and E.C in soil was determined by water suspension (1:2.5) using pH and conductivity meters according to method outlined by Richard (1954). Organic matter was determined by Walkley and Black method (Black, 1965). Total nitrogen was determined by Kjeldhal digestion method and available P was determined by $NaHCO_3$ extractable Method. Total nitrogen content of PM was determined by Kjeldhal digestion method and total P and K were determined by methods given by A.O.A.C (1979) (Table 2). At maturity the crop was harvested and biomass was recorded and straw and grain were separated with mini thresher. Samples of straw and grains of wheat were collected and oven dried at 70 C^0 ground to 40-mesh powder in the Wiley mill Nitrogen concentration in grain and straw were determined by Kjeldhal digestion method. The N-uptake and N-use efficiency were calculated as follows. N concentrations in treatment sample x Grain/ straw dry matter yield per plot.

Statistical analysis

The data collected were statistically analyzed using MSTATC statistical package.

RESULT

Yield and Yield Component

The data for biological yield as affected by integrated application of PM and Chemical N are presented in Table 4. Average of two years showed those statistically similar biological yields were obtained in treatments received 100 % Chemical N and in treatment where 25% N applied from PM and 75% from Chemical N were applied. Individual year data showed that highest biological yield of (10749.99 kg.ha^{-1}) during 2006-07 was obtained in treatment receiving 100% N from Chemical N. Almost similar trend in response was observed during 2005-06 however during at 2005-06, an overall comparatively lower biological yield was obtained. Grain yield is an important component for a crop. The data on this trait as affected by the application of PM and Chemical N applied alone and in different combinations are presented in Table (4). Statistical analysis of the data showed that the effect of treatments on the grain yield was significant ($P<0.05$). Data showed those statistically similar grain yields were obtained in treatments received 25% N from PM and 75% from Chemical N and in the treatment where only 100% Chemical N was applied. Similar trend was observed during both years. Data analysis showed a non-significant effect of the treatments for 1000 grain weight in 2005-2006. But all fertilizer treatments produced more 1000-grain weight than the control (Table 4). Data showed that maximum 1000 grain weight was obtained in the treatment where 50% N was applied from PM and 50% from Chemical N followed by the treatment where 100% N applied from Chemical N. Number of grains.spike^{-1} is an important yield component of wheat and is positively correlated with economic yield. The data for this trait as affected by integrated management of organic N (PM) and Chemical N are depicted in Table (5). Average of two years showed that statistically similar number of grain per spike were obtain in treatments received 100 % Chemical N and in treatment where 25 % N applied from PM and 75% from Chemical N. Similar trend were observed during both years. Data analysis revealed that different treatments had significant affect on N uptake in wheat grain and straw table 5. Maximum wheat N uptake in grain and straw was observed in treatment where 25% N was applied from PM and 75% from Chemical N followed by treatment where only Chemical N was applied.

Table 1. Treatments of the with Poultry Manure (PM) and urea Chemical N applied alone or in combination

1	Control (No fertilizer)	4	25% Chemical N+ 75% PM
2	100% Chemical N	5	50% Chemical N+ 50% PM
3	100% PM	6	75% Chemical N + 25% PM

Table 2. Composition of Poultry manure (PM)

Organic manure	Poultry manure
N (%)	2.87
P (%)	1.30
K (%)	1.75
O.C (%)	33.8
C:N	11.7
pH 1:5	6.60
EC 1:5 (ds.m^{-1})	5.50

Table 3. Physicochemical properties of soil.

Soil texture	Silty clay loam
pH	8.10
EC (ds.cm^{-1})	0.62
Organic matter (%)	0.89
Calcium carbonate (%)	18
N (%)	0 .05
AB-DTPA P (mg.kg^{-1})	3.5

Table 4. Effect of PM applied alone and in combination with chemical N on the Yield and yield components of wheat

Treatments	Biologic yield ($Kg.ha^{-1}$) 05-06	Biologic yield ($Kg.ha^{-1}$) 06-07	Mean	Grain yield ($Kg.ha^{-1}$) 05-06	Grain yield ($Kg.ha^{-1}$) 06-07	Mean	1000 grain weight (g) 05-06	1000 grain Weight (g) 06-07	Mean
Control	4124^{d}	3803.5^{d}	3963.8^{d}	1290^{d}	984.39^{c}	1138.4^{d}	34.02^{b}	36.22^{d}	35.12^{c}
100% chemical N	8902^{a}	10749.9^{a}	9826.2^{a}	3075^{a}	3342.7^{a}	3208.9^{a}	38.15^{a}	38.72^{ab}	38.4^{ab}
100% PM	7630^{b}	6071.42^{c}	6850.7^{c}	2560^{b}	2046.1^{b}	2303.1^{c}	37.10^{ab}	38.55^{abc}	37.8^{b}
25% PM+75% chemical N	9152^{a}	10232.1^{ab}	9692.3^{a}	3120^{a}	3375.4^{a}	3247.7^{a}	38.12^{a}	37.85^{bc}	37.9^{b}
50% PM+ 50% chemical N	7700^{b}	9053.56^{b}	8376.8^{b}	2625^{b}	3049.7^{a}	2837.4^{b}	40.92^{a}	39.50^{a}	40.2^{a}
75% PM+ 25% chemical N	6107^{c}	6642.85^{c}	6375.2^{c}	1962^{c}	2195.3^{b}	2078.9^{c}	38.40^{a}	37.40^{cd}	37.9^{b}
$LSD_{0.05}$	1091.3	1191.93	1015.	449.2	361.891	327.80	3.840	1.310	1.897

LSD test: means within each column, followed by similar letter indicates no significant difference between treatments ($P < 0.05$).

Table 5. Effect of PM applied alone and in combination with chemical N on the grain $spike^{-1}$ and N-uptake in wheat grain and straw.

Treatments	Grain/ Spike 05-06	Grain/ Spike 06-07	Mean	N-uptake grain 06	N-uptake grain 07	Mean	N-uptake in straw 05-06	N-Uptake in straw 06- 07	Mean
Control	29.50^{c}	30.15^{c}	29.82^{d}	20.22^{e}	14.24^{d}	17.23^{d}	13.02^{d}	6.48^{d}	9.75^{c}
100% chemical N	44.25^{ab}	47.15^{a}	45.70^{a}	59.02^{a}	66.28^{a}	62.65^{a}	28.85^{ab}	23.33^{a}	26.09^{a}
100% PM	37.00^{b}	41.07^{b}	39.03^{c}	44.22^{c}	37.75^{c}	40.98^{c}	25.0^{bc}	11.81^{c}	18.43^{b}
25% PM+ 75% chemical N	44.50^{a}	45.17^{ab}	44.83^{a}	58.62^{a}	72.18^{a}	65.40^{a}	33.15^{a}	21.73^{a}	27.44^{a}
50% PM+ 50% chemical N	41.00^{ab}	45.10^{ab}	43.05^{ab}	51.42^{b}	58.08^{b}	54.75^{b}	25.55^{bc}	18.09^{b}	21.82^{ab}
75% PM+ 25% chemical N	39.75^{ab}	41.95^{b}	40.85^{bc}	34.37^{b}	39.24^{c}	36.80^{c}	21.20^{c}	12.71^{c}	16.95^{b}
$LSD_{0.05}$	6.548	4.822	3.9193	7.163	7.11	6.39	4.579	3.368	5.82

LSD test: means within each column, followed by similar letter indicates no significant difference between treatments ($P < 0.05$).

Table 6. Effect of PM applied alone and in combination with chemical N on the Soil total N, organic matter and available P.

Treatments	Soil N (%) 05-06	Soil N (%) 06-07	Mean	O.M (%) 05-06	O.M (%) 06-07	Mean	Avail P (ppm) 05-06	Avail P (ppm) 06-07	Mean
Control	0.048^{f}	0.046^{f}	0.047^{d}	0.960^{e}	0.920^{e}	0.940^{d}	4.220^{f}	8.10^{c}	6.160^{a}
100% chemical N	0.051^{d}	0.051^{d}	0.051^{c}	1.030^{cd}	1.080^{b}	1.055^{b}	5.120^{e}	8.230^{b}	6.675^{a}
100% PM	0.052^{b}	0.054 ^{b}	0.053^{a}	1.050^{b}	1.10^{a}	1.075^{ab}	5.88 ^{b}	8.820^{a}	7.353^{a}
25% PM+ 75% chemical N	0.051^{e}	0.050^{e}	0.051^{c}	1.020 ^{d}	1.020^{d}	1.020^{c}	5.82^{d}	7.730^{e}	6.775^{a}
50% PM+ 50% chemical N	0.052^{c}	0.052^{c}	0.052^{b}	1.040^{bc}	1.070^{c}	1.055^{b}	6.010^{a}	8.02^{d}	7.015^{a}
75% PM+ 25% chemical N	0.053^{a}	0.054^{a}	0.054^{a}	1.067^{a}	1.10^{a}	1.083^{a}	5.870^{c}	7.430^{f}	6.650^{a}
LSD $_{O.O5}$	0.000087	0.00016	0.00076	0.0112	0.0077	0.0219	0.0133	0.0108	1.5096

LSD test: means within each column, followed by similar letter indicates no significant difference between treatments (P < 0.05).

Effect of poultry manure and mineral nitrogen on soil properties

Soil total N as affected by the application of PM, Chemical N in combinations are presented in Table 6. Statistical analysis of data showed that the effect of treatments on Soil N was significant (P<0.05). The average of two years showed that statistically similar soil N were obtain in treatments received 75% N from PM and 25% from Chemical N and in the treatment where only 100% PM was applied. Individual year data showed that highest soil N during 2006-07 and 2005-06 respectively was obtained in treatment receiving N 75% from PM and 25% from Chemical N followed by the treatment where only PM was applied. Data showed that the effect of treatments on Soil organic matter was significant at $a = 0.05$ (Table 6). The average showed that statistically similar soil organic matter were obtain in treatments received 75% N from PM and 25% from Chemical N and in the treatment where only 100% PM was applied. Individual year the data showed that highest soil N during 2006-07 and 2005-06 respectively was obtained in treatment receiving N 75% from PM and 25% from Chemical N. Statistical analysis of the data showed that the effect of treatments on Soil available P was non significant table (6). The average of two years showed that statistically non significant effects were found among different treatments. Individual year data showed that highest available P during 2005-06 was found in treatment where 50% PM and 50% Chemical N was applied while in 2006-07 maximum available P was found in the treatment where 100% PM was applied. The average of two years showed that statistically non significant effects were found among different treatments. Individual year data showed that highest available P during 2005-06 was found in treatment where 50% PM and 50% Chemical N was applied while in 2006-07 maximum available P was found in the treatment where 100% PM was applied.

DISCUSSION

Yield and yield component

Maximum biological yield were found in the treatments where only Chemical N was applied and in the treatment where 25% N applied from PM and 75 % from Chemical N during both years. It seems that the higher biological yield attained in only Chemical N applied treatment and 25:75 PM and Chemical N ratios may have arisen from an adequate supply of nitrogen throughout the growth period. The possible reason could be better utilization of excess nutrients in plots having combination of higher doses of nitrogen fertilizer and organic manure, which enhanced the photosynthetic activity of the plants. Similarly, organic manure in combination with N fertilizer was easily decomposable and provided early availability of nitrogen to the crop. Singh and Agarwal (2001), Zeidan and Kramany (2001), Abbas *et al*. (2006), Negi and Mahajan (2000) also reported significant increases in wheat grain and straw yield with addition of organic and inorganic fertilizer. This might be due to carry over effects from the previous organic manures applied. Highest biological yield might be due to efficient use of available resources for plant and roots because of continued supply of nutrients as well as more water absorption as reported by Jagadeeswari and Kumaraswamy (2000), Swarup and Yaduvanshi (2000). Grain yield or economic yield is an important character and the ultimate output of any crop depends on grain yield. The grain yield usually depends upon various factors such as soil fertility status, water availability, crop management, agronomic practices, environmental factors, and plant genetic characteristics. The results of our study showed that treatments which received N from PM and Chemical N in the ratio of 25:75 respectively, produced higher grain yield. Yield improvement under these treatments may be due to enhanced availability and use of N, water and other associated soil improvement benefits due to organic sources, which made plants more efficient in photosynthetic activity. Wang *et al*. (2001) reported that low inorganic N applications (0 or 31 $kg.ha^{-1}$) resulted in low yields even with combinations of fertilizer with high levels of organic fertilizer (Corn Stover + Cattle manure> 4500 kg) and the yield was also limited by lack of organic fertilizer application in spite of inorganic fertilizer at the rate of 105 $kg.ha^{-1}$. The difference in grain yield among different levels of manure was also significant. The difference in nutrient absorption greatly influences growth and yield potential Ahmad *et al.* (2008). These findings are in support of previous findings of Bajpai *et al*. (2002) and Pooran *et al*. (2002) who concluded that manure application improved all growth parameters. The fertilizer nitrogen serves not only as a nutrient source but also energy for microbial activities in order to mineralize the organic nitrogen of organic manure and makes it available to crop. Maximum 1000 grain weight was obtained in the treatment where 50% N was applied from PM and 50% from Chemical N followed by the treatment where 100% N applied from Chemical N. Similar results have been reported by Zeidan and Kramany (2001) who revealed higher 1000 grain weight using organic manure and mineral N. Highest 1000 grain weight may be due to large accumulation of proteins and other reserved food in the seed because of high availability of nitrogen and other soil nutrients from organic manures and mineral source. Better utilization of readily available fertilizer nitrogen from treatment having organic and inorganic combination of 50:50 may have made plants more efficient in photosynthetic activity, which led to higher 1000-grain weights. Grains become a dominant sink at their maturity stage and the entire photo-assimilate deposited in the grains has resulted in an increase in 1000-grain weight. These results are supported by Alam *et al.* (2005) who reported an increase in 1000-grain weight of wheat through integrated use of organic and chemical fertilizer. Higher $grain.spike^{-1}$ may be due to the fact that Chemical N and mineralization of PM kept the nutrient stress arrested through the entire growing period of the plants and eventually resulted in higher grain production. This might have lead to accumulation of higher quantities of seed components like calcium carbonate and increased lipid metabolism, which helps to increasing the protein content in seed. Our results are in close conformity with those of Singh and Agarwal (2001), Iqbal *et al.* (2002) and Arif *et al.* (2006). Maximum wheat N uptake in grain and straw was observed in the treatment where 25% N was applied from PM and 75% from Chemical N. The organic and mineral fertilizer applied at the ratio 25:75 had equal N-uptake where only mineral nitrogen was applied at the rate of 120 $kg.ha^{-1}$. These results are in agreement with the Metwally and Khamis (1998), Iqbal *et al.* (2008), Shah and Ishaq (2006), Idris *et al.* (2001) who reported that combinations of organic N and inorganic N resulted in greater N-uptake than sole nitrogen application. Soil fertility-building in organic systems improves soil biological properties, which subsequently influence N availability to crop (Watson *et al.*, 2002).

Effect of poultry manure and mineral nitrogen on soil properties

Maximum soil N were obtained in treatments received 75% N from PM and 25% from chemical N and in the treatment where only 100% PM was applied. Total nitrogen was higher in the soils during 2007 after the wheat harvest. This may be due to the built up effects of the fertilizer and manure applied to the soil. Total N contents in the organic manure and their combinations with mineral N were higher than in the NPK and control treatments. Similar results were reported by Formali and Prasad (1979), Singh *et al.* (1980) and Prasad and Singh (1980) who revealed that the application of FYM increased organic carbon, available NPK when compared with control treatment. Organic matter was increased with the application of organic manures after crop harvest. This may be due to the composition of PM and chemical N where some N sources were comparatively more quickly mineralized than other sources because of difference in organic compounds. The significance of manure in improving the physical, chemical properties and biological quality of soil are also well documented (Meek *et al.*, 1982, McGill *et al.*, 1986, Sharpley and Smith, 1995). Jiang *et al.* (2006) reported an increase of 80% in organic matter over use of FYM for 20 years compared to only 10% with NPK. These findings are in agreement with Yadvinder *et al.* (2004) who reported that the application of FYM and wheat straw increased soil organic matter when compared with the treatment of urea which is due to the organic matter input from the manure. Organic matter content in treatments having 25% PM and 75% chemical nitrogen source have lower level of organic matter than other treatments due to the high mineralization rates, and the produced maximum crop yield and nutrient uptake from these ratio of organic and chemical source. Non significant effect was recorded in available P after crop harvest. This showed that there is continuous increase in available phosphorus in each treatment. The available P in soil after each crop harvest was higher due to applied P from either source. Similarly, phosphorus was applied to all crops regularly at each sowing time. These results are in agreement with Krishna (2004), Yaduvanshi (2003), Ibrahim *et al.* (2008). They reported an increase in available P in soil where P was applied alone from different sources or integrated with organic manures this indicates that organic manure reduces P adsorption and solubilize insoluble P in soils.

CONCLUSION

It is concluded from the present study that integrated use of PM and urea is good source for wheat crop. Integrated use of organic and inorganic nitrogen improved biological yield, grain yield, grains.spike^{-1}, 1000-grains weight when applied at the ratio of 25:75 PM and chemical N. Integrated use of PM and chemical N also improve organic fertility of soil after crop harvest. Poultry manure applied alone or in combination with the mineral nitrogen greatly enhanced the residual soil fertility in terms of increase in organic matter, total N and available P over control.

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